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Asymmetric Information Resolution (AIR) Models

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Abstract: There are three types of decision problems, (i) best outcome based, given external states are not controllable, (ii) best path, given states are known, and (iii) decision assist, given that an exact solution is not achievable, and reduce the complexity of the decision-making problem. The selection of the decision model is dependent on the type of context at issue. A theoretical structure is introduced to clearly distinguish best-outcome and best-path. However, the key to decision-making is a rigorous decision-context. Asymmetric Information Resolution (AIR) multiplayer model is introduced as a best path decision model. AIR models provide a new language and a new formalism for decision theory. These include three properties not found in current decision theory, perspective, barriers, and private information. Examples of how AIR models can be used in business, finance, and medicine are provided. AIR models enable the inference of private information about competitors, in a rigorous context, that would otherwise not be available, and vital for negotiations and strategy formulations. AIR models redefine business strategy and are used to analyze how Microsoft came to dominate the software industry with the remarkable finding that it is not the IBM deal that made it happen. AIR models work with qualitative, quantitative, and statistical distributions depending on the context used. Two brief examples of the use of quantitative information in AIR models are given. One is the use of AIR models to model financial statements (tested on about 50 companies across 4 industries), and the other to be proposed in medicine for diagnosis-assists. Finally, a short discussion is provided with respect to Artificial Intelligence.

Keywords: *Decisions, Strategy, Private Information, Context, Microsoft, Microcomputers, Rosenzweig, Porter, Competition, Interpretation, Perspective, States, Outcomes, Bayesian, Expectancy-Value, Case-Based.*

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I. INTRODUCTION

As humans, we are constantly making decisions. In effect one can infer that humans are the sum total of their decisions in the context of other human decision outcomes, that include controllable and uncontrollable factors. In modern times, technology has progressed to the point where our context now includes decisions, not just from other humans, but from algorithms embedded in software, and hardware. Previously known as "rule of thumb" and culture, algorithms have been around for millennia, and guide the decision-making of a participant, either individually or as a collective. The purpose is to improve, maintain or exacerbate the participant's own or counterparty's context. That means, a context can take on one or more states, but these states may or may not be clearly defined, and similarly, a counterparty may or may not be clearly defined.

A. *Therefore, decision making requires:*

➢ *A Context or Domain that Exhibit States. These States may or may Not Change.*

- It is pointless to make decisions within a context that cannot change states.
- A context which changes states despite a participant's decision is not controllable.
- Therefore, one is only interested in decision-making in a context that is amenable to a participant's decisions.

➢ *A Purpose that can Result in Positive, Negative, or Null Effects.*

- Not having a purpose is not the same as having null effects.
- That is, an action is required to carry out a specific purpose.
- For action to exist, it requires intention. Without intention action cannot exist.
- However, intention requires a decision to act. Therefore, no intention demonstrates the lack of a decision.

Therefore, to make good decisions requires a clearly defined decision-context. From this decision-context, one can then identify whether decision-assist or decision-making is required to either make progress or to solve for the decision required. Decision-assist reduces the complexity of the decision problem by either eliminating some states and therefore outcomes, or by restructuring the decision problem. For example, a manufacturing process that has a highly variable defect rate is not able to provide reliable on-time

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delivery. The initial solution would decision-assist to stabilize and reduce defect rates. Only then can the primary problem, the decision-making scheduling problem be solved.

Decision-making models can be classified as either the best outcome as in current decision theory or the best path when outcomes are known but how to get there is not. This paper uses many real-world examples (Accountant, Car Purchase, Hole, Wife and Work) to illustrate the properties required of a well-defined decision-context. These include barriers, perspective, state selection, other known or hidden participants, decision cycling, decision horizon, utility bifurcation, interpretation and consequences as opposed to actions.

The key to decision-making is to rigorously define the decision-context. With an eye towards Artificial Intelligence, one could suggest that decision-context is constructed from associated "knowledge vectors & scalars" as opposed to knowledge graphs also known as Semantic Networks, Woods (1975). Knowledge vectors provide information about the phenomenon investigated. Knowledge graphs are directed graphs to structure data, Vinay et al (2021). However, unlike knowledge graphs, (i) knowledge vectors represent factors (vectors), states (scalars), actions (vectors) that are structured by their conceptual relationships to define a decision-context to facilitate structured decision making, and (ii) do not associate the structured data with a directed link. Asymmetric Information Resolution (AIR) Models are a collection of maps or visual representation of this decision-context, that enables one to select the direction of subsequent decisions.

The sections in the paper can be grouped into 4 parts (i) current decision theory, (ii) requirements of decision-making and context structure, in the real-world (iii) AIR models and its real-world application in the business strategy context, using Microsoft as an example, and (iv) decision-assist at Texas Instruments.

➢ *Structure of Decision Theories:*

Decision theory (Hansson, 1994) is concerned with goal-directed behavior in the presence of alternatives and can be divided into two groups, (i) Normative, a theory about how decisions should be made, and (ii) Descriptive, a theory about how decisions are actually made.

- *Mintzberg, Raisinghani, and Théorêt (1976) Proposed Three Major Phases in Decision-Making,*

✓ Identification: To identify problems and opportunities, and to clarify and define issues.
✓ Development: Finding ready-made solutions and/or develop new solutions or modify existing ones.
✓ Selection: To shortlist a set of feasible solutions and then to select the most viable from this shortlist.

- *Mainstream Decision Theories are Structured into Four Components,*

✓ Alternatives, Options or Actions: The mutually exclusive choices that are available to a participant.
✓ Outcomes: The consequences of the decision made.
✓ State or Events: The various unrelated factors that can alter the decision to be made.
✓ Payoffs or Utility: What a participant expects to gain from taking action.

Many of these theories are focused on the use of statistics to model uncertainty and estimations to model utility. Some examples are, Wigfield & Eccles (2004) with the expectancy-value models, Parmigiani (2001) with Bayesian models, and Rahul Bhui (2018) case-based decision theory models. These models are prone to statistical estimations.

This decision theory structure which requires expected utilities, Briggs (2019), leads to two decision-matrices of (i) Outcomes, Table 1(a) where $O_{i,j}$ is descriptive, and (ii) Utilities Table 1(b), where $U_{i,j}$ is numeric for $1<i<n$ & $1<j<m$. This example is for a $i=4$ Actions and $j=3$ States, producing in total $ixj=12$ Outcomes and 12 Utilities.

Table 1(a): Decision-Matrix of Outcomes when State Transition is Unknown

Selection Outcome	**External State 1, S_1**	**External State 2, S_2**	**External State 3, S_3**
Action 1, A_1	$O_{1,1}$	$O_{1,2}$	$O_{1,3}$
Action 2, A_2	$O_{2,1}$	$O_{2,2}$	$O_{2,3}$
Action 3, A_3	$O_{3,1}$	$O_{3,2}$	$O_{3,3}$
Action 4, A_4	$O_{4,1}$	$O_{4,2}$	$O_{4,3}$

Table 1(b): Decision-Matrix of Utility When State Transition is Unknown

Utility	**External State 1, S_1**	**External State 2, S_2**	**External State 3, S_3**
Action 1, A_1	$U_{1,1}$	$U_{1,2}$	$U_{1,3}$
Action 2, A_2	$U_{2,1}$	$U_{2,2}$	$U_{2,3}$
Action 3, A_3	$U_{3,1}$	$U_{3,2}$	$U_{3,3}$
Action 4, A_4	$U_{4,1}$	$U_{4,2}$	$U_{4,3}$

Thus, the total outcome Opportunity Set O_A can be represented by,

$$O_A = \{O_{i,j} | U_{i,j}\} \text{ for all } i \text{ and } j \quad (1)$$

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However, note that the States are not complete as the current state of the decision maker is not included, and therefore, termed External States. For Decision Cycling, the state in which the participant X occupies, needs to be included. For example, in the context of gambling, this state would be "Not Gambling" if the participant has not placed his/her bets or not started gambling. Thus, the 3-State decision-matrix would become 4-state with say state S_1 representing the "Not Gambling" state. See Table 2(a) & 2(b).

Table 2(a): Decision-Matrix of Outcomes when Optimum State is Known

Selection Outcome	**State 1, S_1**	**State 2, S_2**	**State 3, S_3**	**State 4, S_3**
Action 1, A_1	$O_{1,1}$	$O_{1,2}$	$O_{1,3}$	$O_{1,4}$
Action 2, A_2	$O_{2,1}$	$O_{2,2}$	$O_{2,3}$	$O_{2,4}$
Action 3, A_3	$O_{3,1}$	$O_{3,2}$	$O_{3,3}$	$O_{3,4}$
Action 4, A_4	$O_{4,1}$	$O_{4,2}$	$O_{4,3}$	$O_{4,4}$

Table 2(b) Decision-Matrix of Utility when Optimum State is Known

Utility	**State 1, S_1**	**State 2, S_2**	**State 3, S_3**	**State 4, S_3**
Action 1, A_1	$U_{1,1}$	$U_{1,2}$	$U_{1,3}$	$U_{1,4}$
Action 2, A_2	$U_{2,1}$	$U_{2,2}$	$U_{2,3}$	$U_{2,4}$
Action 3, A_3	$U_{3,1}$	$U_{3,2}$	$U_{3,3}$	$U_{3,4}$
Action 4, A_4	$U_{4,1}$	$U_{4,2}$	$U_{4,3}$	$U_{4,4}$

Table 3 Probability of States

	State 1, S_1	**State 2, S_2**	**State 3, S_3**	**State 4, S_3**
Probability of State	P_1	P_2	P_3	P_4

The Bayesian methodology can be handled by an additional table, Table 3, that provides the statistical probability P_i of State S_i, which can be updated as new information comes in. That is, different formalisms lend themselves to different treatments/analytics with similar or different objectives.

➢ *Solving the Decision-Making Context:*

Therefore, consider the case when the states are known in such a manner that one knows the full characteristics of the mechanics behind the state. The inferences are,

- *Completeness:* A set of states are complete when it includes the current state of the participant.
- *Optimal State:* When an optimal State is known, the Opportunity Set reduces to a column matrix.
- *Single Option:* When there is only one Action, the Opportunity Set reduces to a row matrix.
- *Secondary Decision:* Given a specific Action, the secondary decision D_S is the migration from one state to the next. This decision may not be a voluntary one if the states are, for example, concerned about weather conditions.
- *Primary Decision:* Given multiple Actions, the primary decision D_P is the selection of an Action given a set of secondary decisions D_S.

Note from the perspective of the current decision-making problem definition, solving the decision problem is about solving for an optimal solution given that a State S_i has occurred. Therefore,

➢ *When there are more States than Actions then an Optimal Outcome may Not be Found as,*

- Null States: Some States may not have any Outcomes and are null. These null States do not belong to the decision problem.
- Non-Unique States: Actions are not unique in their ability to handle many different Outcomes which implies that either the States are too narrowly defined, or the Actions are too broadly defined.

➢ *When there are more Actions than States then Multiple Optimal Outcomes can be Found, from Actions that Pertain to the State S_i that has Occurred, as*

- Null Actions: Some Actions may not have any Outcomes and are null. These null Actions do not belong to the decision problem.
- Non-Unique Actions: There are multiple Actions for the same State. There are many unique Actions that result in many Outcomes for a given State. This may arise when Actions are too narrowly defined, or States are too broadly defined.

➢ *Using a Convention S_1 is the Current State of the Participant, given,*

- The Secondary Decision $D_{S,i}$ is the transition from O_1 to O_k where k is the realized State $S_{j=k}$
- A subset of Actions A_i with i from 1 to d Actions available to the realized State S_k.
- There are a total of m States S_j

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The Opportunity Set O_S of Secondary Decisions, is given by the Outcomes available for Actions that are feasible to State S_k, illustrated by Table 2(a), and a subset of all possible Outcomes O_A (1), is given by,

$$O_S = \{O_{1,k}, O_{2,k}, O_{3,k}, \dots O_{d,k}\} \subset \{S_{i=1\to n, j=k}\} \subset O_A \quad (2)$$

And each secondary decision $D_{S,i}$ is determined by

$$D_{S,i}|S_k: O_{i,k}|U_{i,k} \to O_{i,j}|U_{i,k} \quad (3)$$

The primary decision $D_{P,i}$ belongs to the set of secondary decisions $D_{S,i}$ of up to d available Actions,

$$D_P = \{D_{S,1}, D_{S,2}, D_{S,3}, \dots D_{S,d}\} \quad (4)$$

Therefore, the maximization utility (assuming all utilities are positive) can be written two ways, (i) the straight maximization of the end State utility (5),

$$D_{P,i}: max\{U_{i,j}|D_{S,i}\} \quad (5)$$

Or the maximization of the change in utility (5) from State S_1,

$$D_{P,i}: max\{(U_{i,j} - U_{i,1})|D_{S,i}\} \quad (6)$$

Therefore, the optimal Action A_O required is given by,

$$A_O: max\left\{max\{(U_{i,j} - U_{i,1})|D_{S,i}\}, max\{U_{i,j}|D_{S,i}\}\right\} \quad (7)$$

Or simply put,

$$A_O|D_{P,i}: f(U_x) \quad (8)$$

Given the Primary Decision $D_{P,i}$ the Opportunity Set O_S reduces to Opportunity Set O_P,

$$O_P = O_{i,j=k}|D_{P,i} \subset O_S \subset O_A \quad (9)$$

That is, when the State S_j is known, the available Actions A_i are known, the decision-making process reduces to a *n+1* parse problem of selecting from *d* Actions. This approach is a much stricter version of Mintzberg, Raisinghani, and Théorêt (1976) selection phase, and is equivalent to Goal Programming, Hall (2013), where the optimal outcome is constructed from a set of suboptimal outcomes.

This decision-making problem is to determine an optimum decision (7) given a State, i.e. to determine the best outcome. When one knows one's State, then one knows one's decision and the required action. However, these decisions are very much dependent on externalities. What if, the decision problem was to select the State one wants to transition to?

➢ *Alternate Decision-Making Context:*

Schipper (2016) proposes that decision theory is silent on how to clearly define States, ". . . *for an element of a set to qualify as a state, it should describe a possible resolution of uncertainty. Making this precise would require a language with which possible resolutions of uncertainty can be described. The vocabulary of the language should be rich enough to describe possible actions, possible consequences, and their possible relationships. If a state could not be described with such a language, then it is not clear what exactly it is supposed to represent in the decision context. Nevertheless, decision theory remained largely silent about the internal structure of states. It seems that the internal structure of states is not perceived to be an issue except for some special problems* . . ."

Therefore, addition requirements for the definition of States are required. In this paper these are handled by how the States are constructed in a later section, thereby satisfying Schipper's (2016) requirements. However, that is not where the power of decision theory lies, as three components are missing,

- Barriers, B_x: These are hurdles, a participant needs to overcome to be able to take action. In other words, if there exists a barrier B_x that a participant X needs to overcome, it can be expressed as a function of Utility and Barriers,

$$A_{i,x}|D_{S,i,x}: U_x > B_x \quad (10)$$

However, this is by no means the only approach to implementing Barriers B_x.

- Private information: This is the information that is hidden or not overtly obviously without a rigorous context structure. Information that can be inferred about participants from problem structure.
- State Selection: Current decision theories require that States are external to our control and therefore, Actions are about seeking Outcomes conditional upon States and Utility. However, an alternative decision-making structure is the selection of desired States where Utility and Outcomes are difficult to estimate within any degree of reason.
- Perspective: Perspective is important as it alters how one optimizes the problem at hand. For example, if one is managing a company, the alternative goals are to maximize profits, revenue, cash flow or shareholder equity.

Rosenzweig (2014) adds another layer of structure to components, that does not have a dire need for statistics,

- Making routine choices and judgments: The goal is to do well, not to finish first in a competition. Control is low. Performance is absolute. However, if one does not have the intention to finish first, it is unlikely that one can do well.
- Influencing outcomes: Based on judgment we can control. Where we have the ability to influence outcomes, optimism can be very important. However, a realistic understanding of one's accessible resources is required.

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- Placing competitive bets: Success depends on how well you do relative to others. The best decisions must anticipate the moves rivals can make.
- Making strategic decisions: We can actively influence outcomes, and success means doing better than rivals. Therefore, it is vital to do better than rivals.

That is, current theories on decision-making are focused on optimal decisions given a context as described by States, Actions and Outcomes. However, how does one know if this context is correct or complete? And if one is optimizing for the right context? This paper's thesis is different, that a rigorous context definition is a primary requirement for decision-making. Thus, several opportunities arise,

- Decision Domain Space, C_{DD}: The decision-making context is defined by its decision domain space C_{DD} that is defined by all possible decision D_i, for up to n possible decisions, and formalized as,

$$C_{DD} = \{D_P, D_{S,i}\} \quad (11)$$

- Decisions Available: Rigorously defining the decision-making context enables one to determine what decisions are available to any participant. Decisions are arrived by a 2-parse process. The 1st parse shortlists secondary decisions and the 2nd parse picks the best from this list.
- Multiplayer Context: Being able to view the decision-making context with multiple players is a necessary general approach, as the presence of other participants can alter the final optimal decision for each. The trivial example is that there is one umbrella and two people who require this umbrella. Each participant X has the same Opportunity Set O_A (as is the case with weather), however, their individual utilities $U_{i,j}$ may differ by participant.
- Private Information: To enhance the decision-making process it is necessary to infer private information about each player from this decision-making context. With AIR models the mechanics of States S_j are known, two sources of private information are available.

✓ Current State: Shows the mechanics of why a participant is in that state.
✓ Future State: Shows how the mechanics will change for the participant to migrate to the next state, and therefore, reveal the participants' intentions.

II. NOTEWORTHY CONSIDERATIONS

➢ *There are Several Noteworthy Properties of a Decision-Making Process when States are Not Random:*

- Context: A context is clearly defined decision domain space pertaining to the decisions at hand. However, a context (for example the strategic environment) can be affected by a different but loosely connected (for example the operations of a company) context, and vice versa. That is, for example the strategic context may lead one to an optimal solution in the competitive environment that is infeasible in the manufacturing context.

The context can also be ill-defined, as parts of the problem to be solved are missing. Problems are multivariate and exist in more than two dimensions. A poorly defined context is more likely than overly defined when there are too many irrelevant pieces added to the context of interest.

For example, Solomon (2002) had shown that push and pull manufacturing systems are equivalent, but the selection of either depends on the number of types of machines versus the number of types of products. Therefore, trying to migrate a semiconductor push manufacturing system to a pull system, which the industry tried in the 1980s-1990s, is incorrect and failed. Push/pull was an irrelevant consideration. (The author was employed by Texas Instruments during this period.)

- Participants: In this paper the author prefers to use the term "participants" as this paper is focused on a multiplayer decision-making process. Participants are members of the context in which the decision-making process is active. Not all participants need be present or actively involved. Participants can be hidden. The anticipation that your wife will give you "that look" is indicative that she neither may have been present, nor actively involved but is somewhere there in the background biasing your decisions.

- Decision Cycling: One infers that decision making is a self-sustaining process, until a participant recuses himself from the context, otherwise one decision leads to another, and to another, and so forth. Life is like a chess game.

Therefore, the need for a decision-making process that cycles through the decisions, and therefore, outcomes, within the boundaries of that specific context. In substantially complex decision environments, one already understands what outcomes one wants, and the decision-making process is about how to achieve this set of outcomes.

That implies the need to look ahead as Dixit and Nalebuff (1991) and Rosenzweig (2014), among others, had pointed out. Additionally, that the current decision does not force one to make poor decisions subsequently. That is, an optimal decision for the current decision cycle may lead to suboptimal decisions in future decision cycles. In some cases, it is more valuable to be able to make better decisions later than to make the best decision for today.

Note, goal programming, the optimal decision for the current state is derived from optimal decisions of previous states is an approach to optimizing Decision Cycling.

- Decision Horizon: Decision Horizons play an important role. From an investment decision perspective, growth that leads to increased investments and requires one to look ahead to future outcomes, requires decision cycles in a longer-term horizon. However, harvesting, the reduction of capex, requires one to look to today as tomorrow may not come, therefore, decision cycles may not be needed for shorter-term horizons.

- Decisions are Qualitative: For example (Wife Example), "I am committed to my wife". It says nothing more. At least not about the relationship, but it does suggest that the context of the speaker has probably changed, and most probably in a situation when he has to justify his relationship. It begs the question "Until when or until what?"

This qualitative statement can be further qualified as "I am committed to loving my wife" and implies the presence of any number of possible conditions:

- ✓ Only if she is faithful to me or even if she is not.
- ✓ Only if she flirts with me or even if she flirts with others.
- ✓ Only if she does not turn against me or even if she does. However, what does "turn against me" mean? Being unfaithful? In some cultures, it is and in others it is not, but this misses the point. In this example, decision-making is about the participants and not about their population characteristics.

Damasio showed, Gardiner Morse (2006) and Jason Pontin (2014), that patients with damage to the emotion processing prefrontal cortex often struggle with making even routine decisions. Therefore, it is imperative that successful decision modeling be presented visually as emotions like intuition, gutfeel, fear, satisfaction, etc. are enabled to come to the fore. That is, for non-trivial successful decision modeling, the decision domain space presents optimal and suboptimal decisions, not answers.

- Boundaries & Hidden Participants: You want to buy a car (Car Purchase Example). Walk into a car dealership where you are enthusiastically greeted by the salesperson, who, having facilitated your car selection, takes you on a test drive. You are back at the dealership and sit at his/her desk to negotiate price and accessories.

Both of you have negotiation boundaries. You have your family and friends who have already filled you with "advice" about how to negotiate but they are not present. The salesperson is answerable to his sale managers, but you do not see them. Your family, friends, and sales managers are hidden participants and counterparties who impose boundaries on your decision-making process.

- Knowledge Bias: The Car Purchase example illustrates knowledge bias as (i) The sales managers, because of their substantial experience, always understand the negotiating decision-context better than the prospective buyer. (ii) The buyer's hidden participants may have given the buyer bad information and bad advice.

A second example (Accountant Example) is that of a business owner who needs to expand into a new market segment. He asks his accountant to study his proposal. An optimistic account may produce a financial proforma that shows 500% growth and a 1,000% increase in profitability, in 5 years. A pessimistic account may produce a financial proforma that shows that the company goes bust in 2 years. The proposed decision is biased by the accountant's outlook.

However, if the accountant is only interested in his immediate well-being, then he/she will seek clues as to what the business owner is seeking. If the business owner suffers from confirmation bias, Nickerson (1998), the business owner is either looking to make the move as it is his project or to squash the proposal as it is not his preference. This is a reason why clinical trials are double blind.

Even if it can, knowledge bias cannot be fully addressed without a rigorous context structure for making decisions, and as can be seen from the Accountant Example, financial proforma alone is an insufficient tool for making business decisions.

- Private Information: Returning to the Car Purchasing example, the salesperson does not know how high the prospect is willing to go to acquire the car the prospect just test-drove and needs to find out. On the other hand, the prospect does not know how low the salesperson is willing to go to part with the car and the prospect needs to find out.

This is a cat and mouse game as any statement of price too early in the game, by the prospect implies that the prospect can go higher, and that by the salesperson states than salesperson can go lower. This is an example of private information that cannot be determined until the onset of the price decision-making negotiation.

- Probability Distributions: Both proposals, by Savage & Jeffry, require probability distributions. Are there alternative methods to making decisions without the use of probability distributions? This paper proposes that the AIR model is one such approach that does not require statistical distributions.

- Intention: This is not addressed in current decision theories proposed by either Savage or Jeffrey, Steele & Stefánsson (2016). Savage proposed that outcomes are derived from desire, and states are derived from beliefs. Jeffrey on the other hand proposed that the desirability of a proposition (Action or State) depends both on the desirability of the different ways in which the proposition can be true, and the relative probability that it is true in these respective ways.

However, if one assumes that the correct process, given a state and utility, is, belief leads to desirability, desirability to motivation, motivation to intention (combined with resourcefulness, capability, and determination), intention to decision, decision to action, action to outcome then both beliefs and desire are several steps removed from action or outcomes.

Therefore, it is not necessary to understand the probabilistic behavior of either beliefs or desires, but to understand intention and whether this intention is realizable

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or not i.e., if it is backed by resourcefulness, capability, and determination.

- Bifurcation & Indeterminate Outcomes & Utility: Current decision theory requires that both outcomes and utility can be, at least, sufficiently well estimated. What if this is not true or does not exist?

For example, (Work Example) your supervisor at work, has a record of not promoting anyone in his/her department, and is known for seeking his/her own self-interest, promotions, over and above the needs of the organization. One day your supervisor comes over and ask you to solve a business problem. Is there any utility in it for you? Probably not. Your first thoughts probably are, (i) Why does he/she want me to do this? (ii) What resources do you have at your disposable? Given your supervisor, probably not much. (iii) Can it be solved? You have no idea. (iv) Is this a project to fire me? (v) Most likely if you succeed your supervisor with get the credit because he/she "supervised" you. If you fail, you take the blame. A no-win, heads I win, tails you lose situation.

This context illustrates 2 problems that undermines decision theories based on Utility and Outcomes,

- ✓ Bifurcation: There is no upside to your utility. The perceived utility only has a downside, but you still need to do the project. That is, you are "selecting" an Action that is against your perceived best interest. Your choices are not based on your own utility but on that imposed by another participant.

There is a bifurcation of utility. When outcomes are good, the positive utility is assigned to the supervisor, the more powerful participant. When outcomes are bad, the negative utility is assigned to the subordinate, the less powerful participant. This is the bifurcation of utility. Therefore, one infers bifurcation of utility occurs when the environment is a zero-sum game.

- ✓ Indeterminate: The outcome is indeterminate, i.e., outcomes are not definable until well into the project, as you do not know whether you can or cannot solve the business problem.

Like the car purchase problem, the information that you need, the final price, is hidden in the problem and cannot be accessed until much later in the negotiations. The outcomes are unknown, and your decision-context only has two states, (i) Accept the project or (ii) Don't accept the project. Your choices are not based on outcomes but based on states and it is dependent on one's intention and not one's immediate utility.

Therefore, one infers that intention not utility, emerges as the primary motive for decisions when choices are about states and not outcomes. That is, in this case, decision-making is at least one step removed from utility.

- Interpretation: (Hole Example) Many years ago, when the author was living in the greater Denver area, he met a physicist friend at King Sooper's supermarket. At the back of the store, near the refrigerated milk section, there was this hole in the concrete floor, about 3 inches in radius and deep. By this hole was a sign. It had a paper notice stuck over the sign which said, "Do Not Remove". His first words were, how does one remove a hole?

Knowledge and interpretation are difficult subjects to structure, Ichikawa, Jonathan Jenkins and Steup, Matthias (2018). Yes, the inferential question is correct, but the knowledge context is not. Had he asked his other friend about it, his other friend would have said that paper note referred to the sign, as the sign made customers aware of the hole in the concrete, and thus would not injure themselves.

The lesson here is that, to derive good answers requires good interpretation of the context, and a good fit of the context to the problem (how to interpret the situation) at hand. For example, would a supermarket employ only PhDs? Evidently not, therefore the other friend's context was a better fit to the problem at hand than the first friend.

➢ *Some Additional Considerations:*

Returning to Karni's (2015) conditions, these produce a unique canonical state space but do not eliminate incoherent acts that assign to some state an outcome that is inconsistent with the internal structure of that state. Schipper (2016) proposed 3 remedies but considers them unsatisfactory,

- Ad Hoc Restrictions on State Space: Restrict the analysis in an ad hoc manner to a suitable subset of states so that all acts are coherent on this restricted space, but it produces decision theories that are "incomplete".
- Restricting to the Set of All Coherent Acts: Restrict the set of acts to coherent acts only. The drawback is that the restricted set of coherent acts is considerably smaller than the set of all acts and thus provides much less structure to reveal beliefs from the decision maker's behavior.
- Simply Allow for Incoherence: The question then is how to design choices among such acts and how to interpret such choices.

In a later section, this paper shows how to implement (ii) by structuring the decision-making context.

Both Karni (2015) and Schipper (2016) use "consequence" as outcomes (as used in this paper). Aumann and Savage (1971) discuss that "consequence" can be confused with Actions and/or States, and thus its attendant fuzzy interpretations, construction of nonsensical acts, the inability to construct something whose 'value' is state-independent, states of the person as opposed to states of the world.

In this paper Consequence $C_{Q,i}$ is a byproduct of Outcomes, $O_{i,j}$ when a Decision $D_{O,i}$ is taken. Therefore, Outcome O_{ni} is what one expects from the decision-making process, however, the Consequence $C_{Q,i}$ is one of many alternatives from the set of possible Consequences C_Q and is the result some time period later of the Outcome O_{ni} sought. Such that,

$$C_Q = \{C_1, C_2, C_3 \dots\} \tag{12}$$

$$C_{Q,i} \subset \{C_Q\} \tag{13}$$

$$C_{Q,i}: [A_i | D_{O,i}: O_{i,j=1} \rightarrow O_{i,j=n_i}] \tag{14}$$

Note that it is not necessary that the desired Outcome O_{ni}, occur immediately. In that sense, the decision-making process generates the Outcome O_{ni} sought, that is an objective or strategy for further action, and whether that action eventually materializes is left to be seen. What eventually materializes is the Consequence $C_{Q,i}$ as a result of multiple players in the decision domain context, C_{DD}. Thus,

$$C_{Q,i} \subset \{C_Q, O_{i,j=n_i}\} \tag{15}$$

And that Consequence $C_{Q,i}$ maybe the Outcome O_{ni} sought when multiplayer interference is nominal or maybe at least one-step removed from Outcome O_{ni} sought when multiplayer interference is not nominal.

➢ *Structuring the Decision-Making Context Using AIR Models:*

Solomon's (2002) proposed a specific type of model, Asymmetric Information Resolution (AIR) model for making decisions in a clearly specified context or decision domain space C_{DD} for business operations and strategy. It is not Normative as in how decisions are to be made, but Descriptive in that all factors and conditions are presented and the participant can then choose (i) not to make a decision, or (ii) make a specific set of decisions, and as a result see how other participants can or are likely to interact with his/her decision sets. As will be seen, AIR models lend themselves to obtaining a best path solution.

Unlike current decision theory where states are determined by external events, in AIR models, states are defined by their decision-context and therefore, the point of decision-making is to select a state to either remain in or to move to, in a context where states form frameworks and frameworks form maps. With an eye towards Artificial Intelligence, AIR Models do not require massive amounts of data to support decision making. Per Schipper (2016) requirement of a new "language" AIR models have several important properties. They are,

- *State Based Decisions: Current decision theories describe Actions as function (8) of Outcomes and Utilities given a set of States. With AIR models, the reasons are given above, Actions are Intentions, that initiate a migration between States within a Framework N, when Outcome and Utilities cannot be realistically determined (16),*

$$A_N | D_{S,N}: S_{N,j} \rightarrow S_{N,j\pm1} \tag{16}$$

- *Navigating the Decision Domain Context:*

✓ Restructure the decision domain space, C_{DD} (map) into subdomains (frameworks).
✓ Thus multiple subdomains provide multiple Secondary Decisions $D_{S,i}$, and the Primary Decision $D_{P,i}$, is derived by considering all Secondary Decisions $D_{S,i}$.
✓ Lends itself to a Goal Programming approach to finding an optimal solution.

- *Guaranty States are Non-Trivial. This is closer to Jeffrey's, Steele & Stefánsson (2016), in that only those Action & States the participant considers to be possible be included. Thus,*

✓ Select 2 independent factors, knowledge vectors, from the knowledge domain of that specific field.
✓ Construct co-factors, additional knowledge vectors, that reinforce the 2 independent factors to enhance the robustness of the subdomain decision-context.
✓ Determine the operating range of each factor and co-factors.
✓ Construct the States from these factors & co-factors within their operating ranges. This ensures that States are feasible and prevents infeasible solutions. Given the high H and low L of the operating range of each factor f_y (y-axis) & f_x, (x-axis) the Framework of States F_S (see Fig. 1), consists of 4 States defined as (23),
✓ These four States are the quadrants of the Framework. One can construct j^2 (i.e. 4, 9, 16, . . .) Outcomes from j States but in a complex qualitative field, 4 is most productive.

- *Guaranty Actions are Coherent,*

✓ As Action is determined by the migration between States.
✓ Since States are non-trivial, Actions cannot be incoherent.

- *Eliminate infeasible Outcomes and Actions*

✓ Introduce barriers to change in the decision-making process.
✓ Thus, no decision (i.e., remain in the same State) is a valid outcome as a no-decision is a consequence of not being able overcome barriers, and thus prevents infeasible decisions.

- *Barriers are Missing in Current Decision Theory.*

✓ Unlike business strategy, Michael Porter (1985), where barriers prevent entry, with AIR models, barriers prevent exit.
✓ There are several possible interpretations, that Barriers,

▪ Reduce the Utility of the Outcome.
▪ Prevent the exercise of an Action until it is known how to overcome this hurdle.

This approach addresses Schipper's (2016) second point, "Restricting to the Set of All Coherent Acts", however, there are specific rules (below) on how to do this.

➢ *Defining AIR Models Rigorously:*

An AIR model consists of a series of Maps M_m each consisting of 5 Frameworks, F_N where N (see Fig. 1) is the Framework in a Map M. Each map M describes a specific aspect of the decision-making process C_{DD} (17).

$$C_{DD} = \{M_1, M_2, M_3, \ldots M_m\} \tag{17}$$

The author's experience suggests that 3 to 4 Maps and 5 Frameworks for each Map, is the ideal structure but this can be different depending on the complexity of the decision-making context.

$$M_m = \{F_1, F_2, F_3, F_4, F_5\} \tag{18}$$

A Framework F_G (21) is a 2-dimensional graphical representation (see Fig. 1) constructed from 2 factors that form the outer horizontal f_X and vertical axes f_Y and co-factors that form the inner horizontal f_x and vertical f_y axes. These divide the Framework into 4 Quadrants Q_i (19) and each Framework has a name that describes its decision subdomain. See Fig. 1. F_G (21) and F_D (22) describe different presentations of a specific Framework, graphical and decision-making, respectively.

$$F_G = \{Q_1, Q_2, Q_3, Q_4, f_Y, f_X, f_y, f_x\} \tag{19}$$

Framework F_D (20) presents a Secondary Opportunity Set O_S, the 4 States S_j, the 8 Actions A_i, and the 8 Barriers B_i that define this specific decision-making context.

$$F_D = O_S = \{S_1, S_2, S_3, S_4, A_1, \ldots, A_8, B_1, \ldots, B_8\} \tag{20}$$

Such that (22) can be more clearly represented as a Framework of States by (21),

$$F_S = \{S_1 = \{f_{y,H}, f_{x,L}\}, S_2 = \{f_{y,L}, f_{x,L}\}, S_3 = \{f_{y,L}, f_{x,H}\}, S_4 = \{f_{y,H}, f_{x,H}\}\} \tag{21}$$

Each Quadrant Q_j is a graphical representation of a State S_j of the decision-context based on these two factors and co-factors. The Quadrants are labeled with a State name and a short State description. This description is short and gets to the heart of the concept of the State but is not precisely defined so that its interpretation is open to that of the decision maker's capability, experience, and opinions (i.e., the participant's hidden private information). The migration, both ways, between States i.e. Quadrants, is an Action A_i available to the participant. The decision $D_{S,i}$ to migrate is the Secondary Decision to select Action A_i of that Framework.

The inner axes are co-factors f_x & f_y that strengthen the rigor of the logic used to define the context. The decision subdomain will change if these factors are changed even though the co-factors remain the same. See Fig. 1 & 2. The inner sides of each Quadrant are labeled with the Barriers B_i to exit and prevent migration between adjacent States. The Framework of Barriers F_B, is represented as,

$$F_B = \{B_1 = \{B_{y,H}, B_{x,L}\}, B_2 = \{B_{y,L}, B_{x,L}\}, B_3 = \{B_{y,L}, B_{x,H}\}, B_4 = \{B_{y,H}, B_{x,H}\}\} \tag{22}$$

And the secondary Opportunity Set O_S is defined by the Framework F_A with 8 possible Actions, is given by,

$$F_A = \{A_{i,j}: S_i \rightarrow S_j\} \; for \; i = 1 \; to \; 4 \; \& \; j = 1 \; to \; 4 \tag{23}$$

The decision Framework consists of F_S (21), F_B (22) and F_A (23),

$$F_D = \{F_S, F_B, F_A\} = \{S_i, B_i, A_{i,j}\} \; for \; i = 1 \; to \; 4 \; \& \; j = 1 \; to \; 4 \tag{24}$$

The total map (18) consist of 5 frameworks F_D, representing a 5-dimensional decision problem that is easy to navigate. The Frameworks are numbered 1 to 5, (see Fig. 5) in the following sequence, top-left, bottom-left, bottom-right, top-right, and top-middle.

One can define the Perspective P_N of a Map as the placement of Framework N at position 5. That is, one participant's Framework 2 is in the same position as another's 5 as the Frameworks have been rotated clockwise by 2 Frameworks.

Note, when the top-middle Framework has been replaced by an alternate structure, for example, a high-level process map (see Operations Map, Figure 5) or a matrix (see Revenue Transaction Map, Figure 6), then the 4 Frameworks are are not interconnected by adjacent factors.

➢ *Rules for Developing AIR Models:*

There are some rules to follow when developing Maps & Frameworks,

- Factors, Co-factors, States, Barriers, Actions, & Frame Names need to be consistent with each other and preferably constructed in that sequence.
- A Framework is a subdomain of the specific decision domain as laid out in the Map.
- The complete decision-context may consist of several Maps.
- Deconstructing a decision domain, a Map, into subdomains, Frameworks, requires neighboring Frameworks to share common factors & co-factors. See Fig. 5.
- Factors and co-factors cannot be correlated else it is not possible to determine private information, and the Framework becomes trivial.
- Within a Framework, one can only move to neighboring States. Diagonal motion is not allowed and requires one horizontal and one vertical move to effect a diagonal move.
- A Map is designed so that,

✓ The worst State of each Framework is in the middle of the Map. These 4 worst States form the "Death Square" or "Critical Square" of the Map i.e., the worst place to be in.

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- ✓ The best State of each Framework form the outer States of the Map.
- ✓ This reinforces the need to step outside of our comfort zone to reach good decisions.

- Decision Cycling is determined by the direction of the Action arrows. The participant can change direction at any time per his/her preferences and private information.
- Actions may be intentions, market forces, or a participant's feasible strategy, depending on the decision-context, and select what is most appropriate.
- When using a Map, start with what you know,

- ✓ Place a star in the Framework which matches your knowledge.
- ✓ Repeat for other Frameworks if possible.
- ✓ Then move (or add stars) horizontally or vertically to neighboring Frameworks while remaining in the same column or row of the previously completed Framework.
- ✓ Repeat and change star positions until the Map makes sense.

➢ *Constructing a Real-World Example of a Framework:*

Using Rosenzweig's description to illustrate, Fig. 1 details the basic structure of a framework. Rosenzweig proposed control and influence. These are set up as the two primary co-factors. Given that Rosenzweig referenced strategic management, the corresponding factors for control and influence are standardization and branding, respectively. Control requires standardization of man, machines, materials, and methods, as a random process is not controllable. Influence requires branding, whether personal, corporate, service or product to draw interest from the demographic as when the demographic is listening, influence is achievable.

Alternatively, as Rosenzweig referenced betting, Fig. 2 illustrates the new Framework in terms of games, and the corresponding factors for the co-factors control and influence are, randomness and skills, respectively.

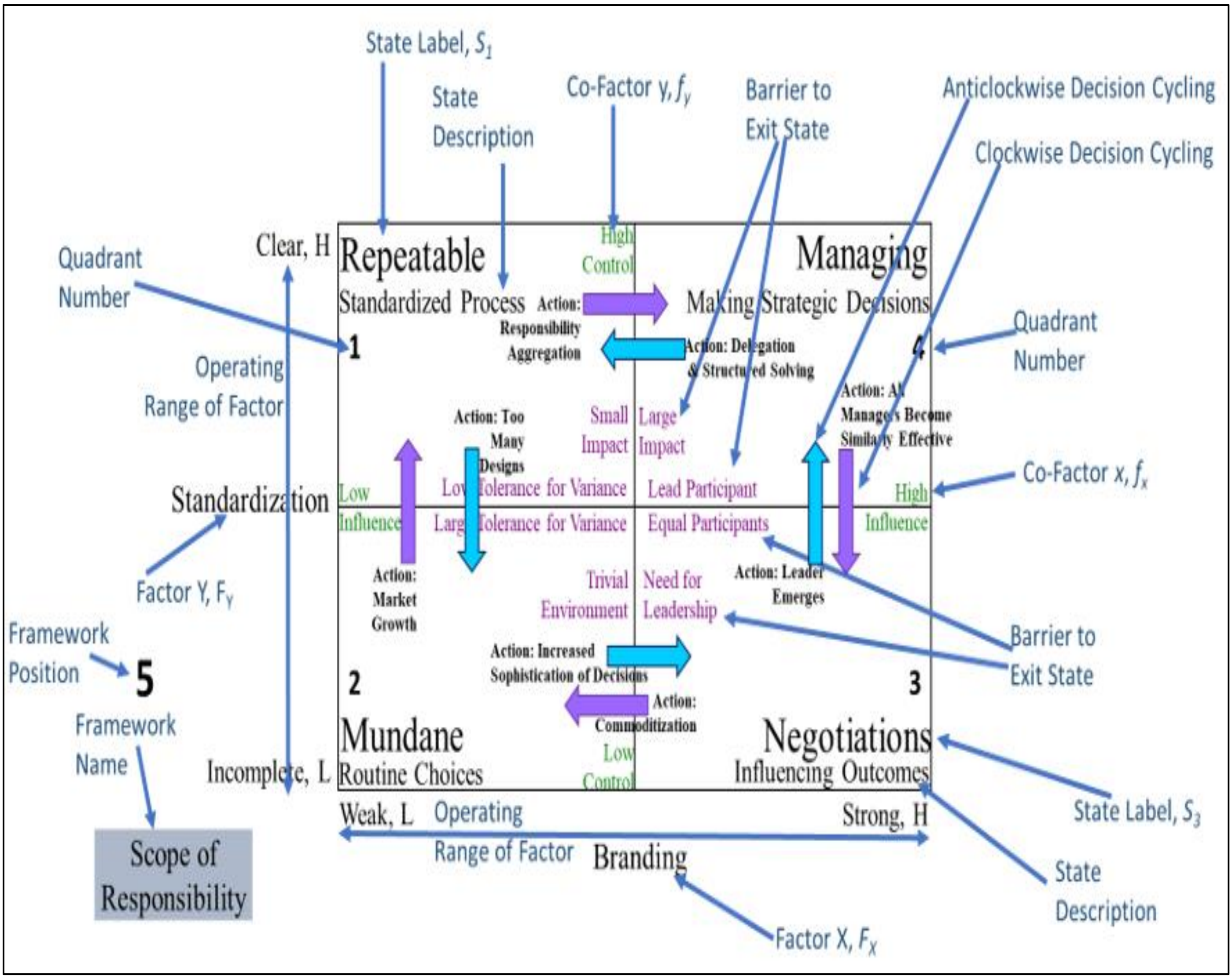

Fig 1 Illustration of a Framework & its Components in a Management Context

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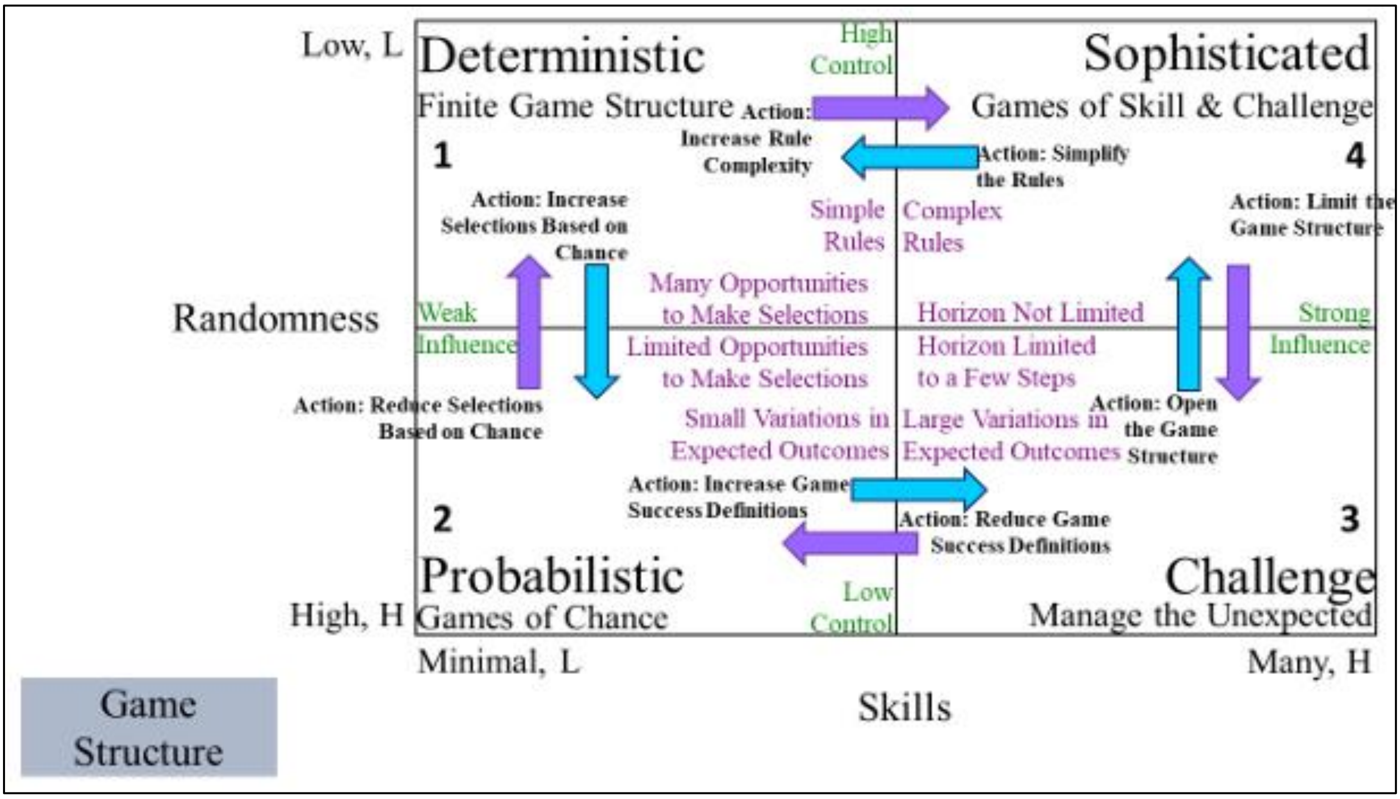

Fig 2 Illustration of a Framework & its Components in a Game Context

Notice how different Rosenzweig's description is compared to the Framework description (see Fig. 1) given a structured approach to defining a decision domain space. Notice also, like the Hole Example earlier, how changing the factor definitions from Management (Fig. 1) to Games (Fig. 2) substantially alters the decision domain space being described.

- *Solving the AIR Model:*

Given the structure of the Map and Frameworks, the optimum solution for any Map is always the Framework in the 5th position as required by the participants' Perspective P_N and is given by,

$$C_{DD} = \{M_1|F_{1,5}, M_2|F_{2,5}, M_3|F_{3,5}, \ldots M_m|F_{m,5}\} \quad (25)$$

The optimum solution, Secondary Decision $D_{S,N}$ for each Framework F_N is the outer most Quadrant of the Framework with respect to its Map because that is how the Map was designed.

$$D_{S,N}|F_N: S_j \rightarrow S_N \quad (26)$$

And the Primary Decision, $D_{P,5}$ of the Map (25) can be rewritten as,

$$D_{P,5}|F_5: S_j \rightarrow S_4 \quad (27)$$

That is, by designing the decision-context structure correctly, one knows the optimal decisions for each Framework and the Map. Since the starting States S_j are different for each Framework F_N, the optimization problem is not about finding the best Primary Decision D_P, as that is known, but about finding the best path or the set of Secondary Decisions D_S, given Barriers $B_{i,j}$.

This is the Rainbow Problem, knowing that the end of the rainbow is "over there" but not knowing how to get "there". Similarly, in medicine, one knows that the solution is a cure for the disease, but one does not know how to get to the cure.

The individual segments of the path are defined by (26) and one wants to know if there is an optimum path, a set of segments, such that, the optimum path for a Map M_m is given by

$$D_P|M_m: min\{D_{S,1}|F_1, D_{S,2}|F_2, D_{S,3}|F_3, D_{S,4}|F_4, D_{S,5}|F_5\} \quad (28)$$

Given,

$$D_{S,N}|F_N: (S_i \rightarrow S_j)|\min(B_{i,j}) \quad (29)$$

That is, the best path is not necessarily the path that consists of standalone Secondary Decisions based on only minimum barriers, as these individual Secondary Decisions may not be feasible as a Map. One could replace barriers with some other basis, but barriers illustrate the point.

- *Lessons from Texas Instruments – Decision Assists:*

Decision-assist models, as opposed to decision-making, identify States within a decision-context that need to be addressed. As a result, reduce the complexity of the decision-making problem by (in this case) eliminating these States from the decision-making problem. The work done at Texas

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Instrument in the 1980s-1990s provides a good example of decision-assists.

During the author's time at Texas Instruments (TI), the Daily Factory Starts (DFS) Scheduling system was proposed by TI Malaysia and authorized by TI Corporate, for TI's Assembly/Test plants in Asia. The management at these operations was organized into Departments of Product Engineering (the author was a proprietary systems developer reporting to this department), Repair & Maintenance (there were several hundred machines), Quality Assurance, Planning, Production, Financial Planning and Management Information Systems (MIS).

DFS was a joint development between TI Malaysia (TIM) and TI Philippines (TIP) under TI Corporate's MIS watch. The author's role was to construct a database structure, define the theoretical framework for DFS, select the scheduling algorithm, and define the DFS SQL Writer (DSW), an interpretive language to generate SQL code, as at that time SQL databases were either not sophisticated enough to handle such problem definitions, or we were not well versed enough in SQL. Stanley Oh, from TIM, wrote the scheduling engine in C for the then state-of-art IBM 386 PC. Rey Chan, from TIP, implemented the relational database and wrote the interpreter for DSW. The late Joseph Saw, from TIM, was the primary lead between the team and TI Corporate MIS. Shan, from TIM, was the Planning Manager responsible for implementing DFS schedules at TIM.

Both TIM & TIP were $500 million to $1 billion revenue companies operating in Free Trade Zones (operating in a tax reduced campus) in their respective countries. TIM produced between 3,000 to 6,000 SKUs a month that had to pass through 9 to 16 different stages of manufacturing. These stages include Die Prep, Die Attach, Bond, Mold, Symbol, Trim/Form, Solder Dip, Visual/Mechanical and Test.

The problem addressed by DFS was how to determine what SKUs to start production for the week, as the SKUs would spread (Fig. 3) across the manufacturing process. This large variability led to large variability in on-time delivery. That is, given available equipment capacities and Work-In-Progress (WIP) in the factory, how does one minimize this variability while maximizing factory capacity utilization, by controlling which SKU to issue at the beginning of each week.

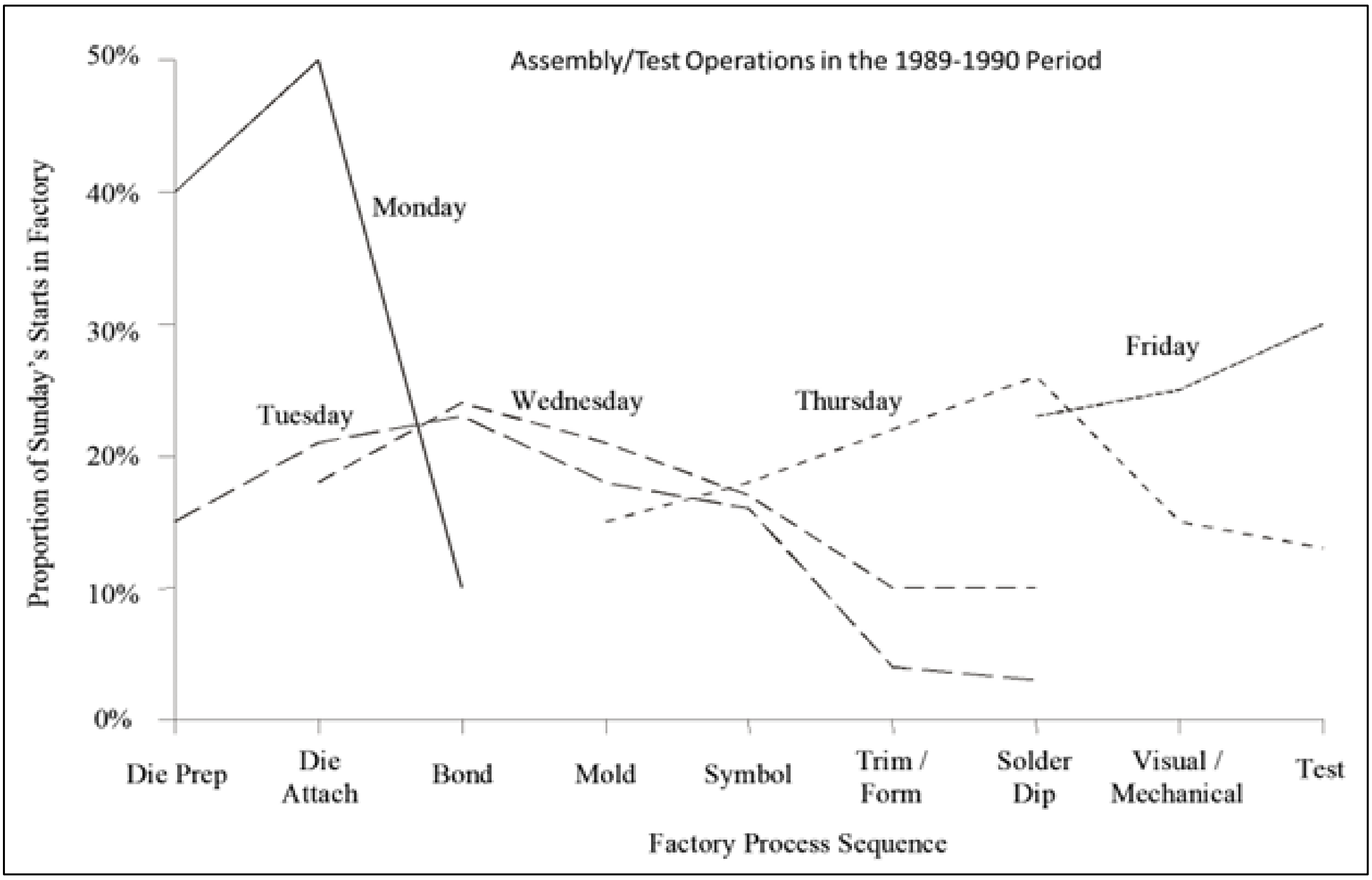

Fig 3 Spreading of SKUs Across the Manufacturing Process
(Source: Solomon, 2002)

The decision domain space was structured in terms of (i) number of units of each SKU even though each SKU was handled by lots varying in size between 500 units to 6,000, and (ii) equipment capacity at Bond and Test, as these stages were the operational constraints of the whole manufacturing process. Integer programming was the algorithm used to solve this problem.

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DFS brought the WIP down from 5-days to 3-days in 6 months. Initially, during the first 3 months of implementation, a systems dynamic perturbation in WIP was observed rising to 6 days before settling to 3 days.

➢ *Several lessons were learned about decision-making,*

- Only a Good Solution is Needed: The problem was historical. It was not possible to generate optimal solutions because it would take about a day between getting TI Corporate's allocation of SKUs to build (sometime around midnight) to implementing the schedule on the factory floor at Die Prep.

Good solutions are a viable approach especially if Decision Cycling is feasible in the decision domain context, as is with repeated scheduling.

- Impact of Neighboring Decision Domains: For the Scheduling Decision Domain to be effective, it is dependent on the Maintenance, Product and Production Decision Domains to be generating good or optimum results. These are neighboring decision domains.

✓ Maintenance Decision Domain: TIM had previously adopted programs that had reduced equipment set-up times and failure rates from several hours (sometimes up to a day) to usually less than 15 minutes.
✓ Product Decision Domain: Low product yields were one source of on-time product delivery. Exception reporting of products below a threshold yield level was implemented to focus product engineers on how to prioritize what should be solved. This focus raised Assembly/Test yields from below 85% to above 99% in a period of less than 3-years.
✓ Production Decision Domain: Other than scheduling, the main cause of variability of on-time delivery was the hidden participants. Fig. 4 shows that even though in theory cycle-time increases with lot size, in practice it does not. As production operators were paid by "piece parts" it was in their interest to select high yielding, smooth running, large lots whose set-up times were small compared to production run time. This biased production schedule implementation towards larger lots, causing the WIP to spread across the manufacturing process (see Fig. 3).

- Domain Deconstruction: Exception Reporting is a means to deconstructing the production utilization problem into specific subdomains (product yields, equipment uptime and lot control) to solve the much bigger factory capacity utilization and scheduling reliability problem.

- Decision Assists: In this real-world situation, the primary decisions were not made on behalf of participants. Decision tools were provided to assist in the participants' decision-making process. These are decision-assist tools, not decision-making tools.

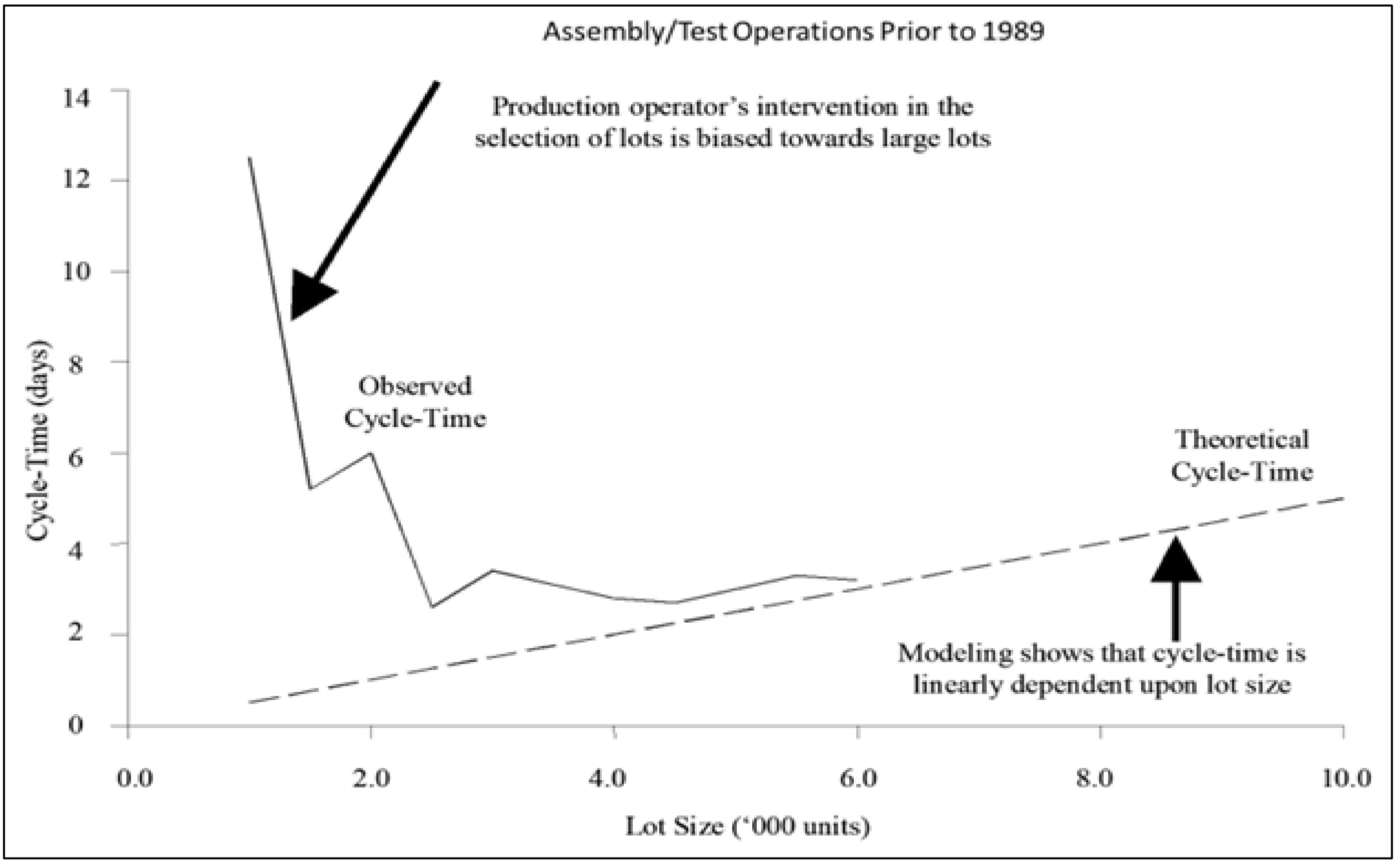

Fig 4 Practical Cycle-Times are Different from Theory
(Source: Solomon, 2002)

➢ *Brief Comparison with Porter's Strategies:*

The Holistic Business Model (HBM), see Figures 5 - 8, consists of 4 Maps, (i) Operations Map, (ii) Revenue Transaction Map, (iii) Structural Strategy Map & (iv) Migration Strategy Map. The HBM is an operations, revenue and strategy, business AIR model, thus the terms and names related back to business nomenclature of Michael Porter's competitive strategy and his Five Forces Model, where applicable.

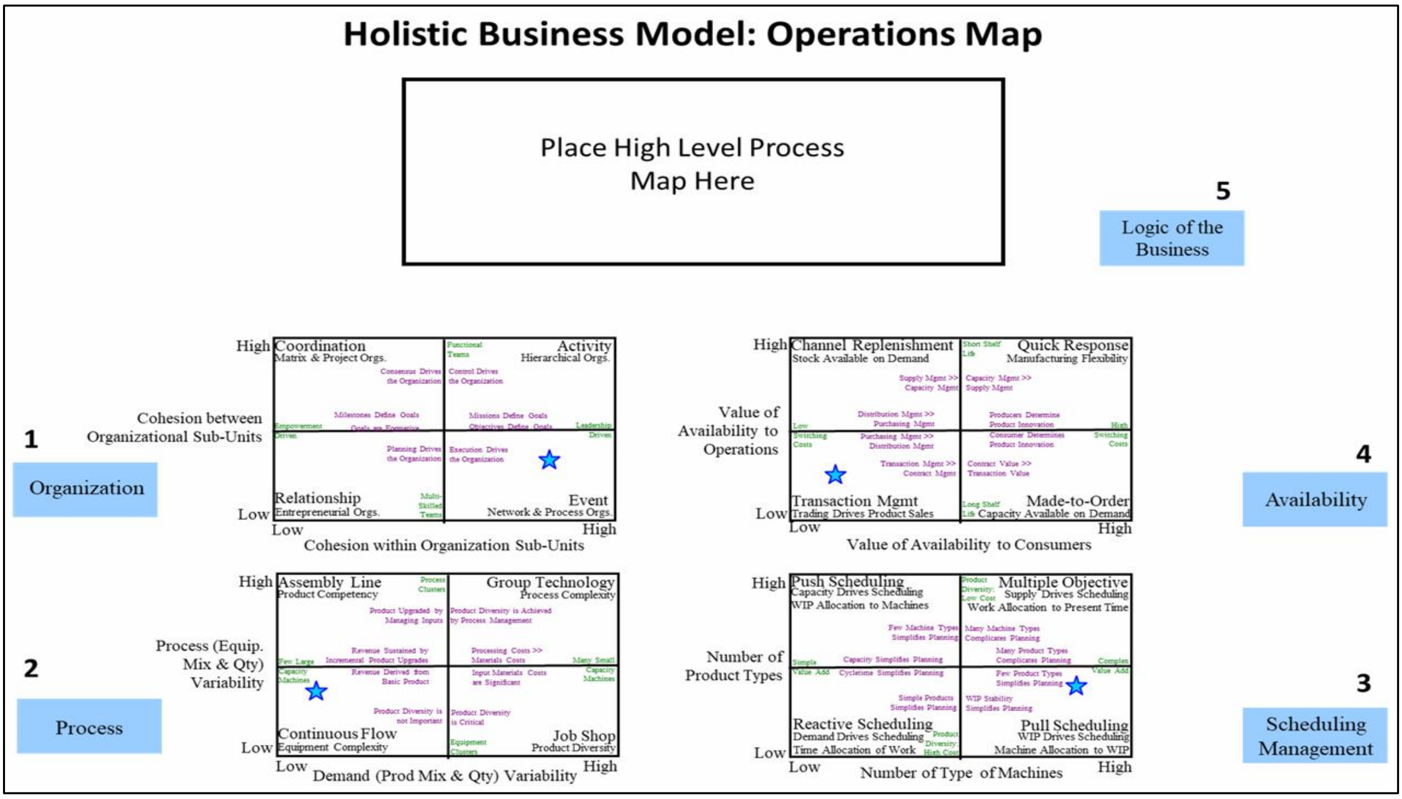

Fig 5 HBM Operations Map
(Source: Solomon, 2002)

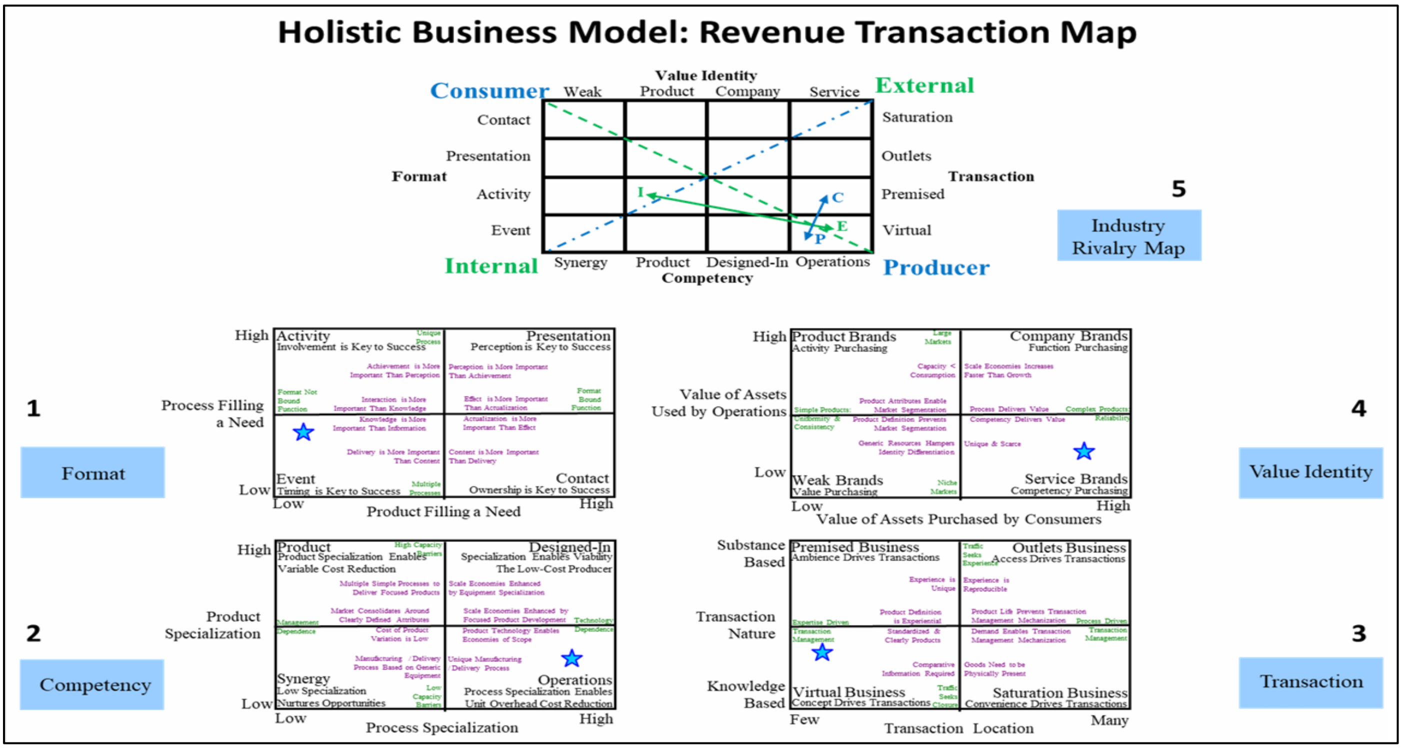

Fig 6 HBM Revenue Transaction Map
(Source: Solomon, 2002)

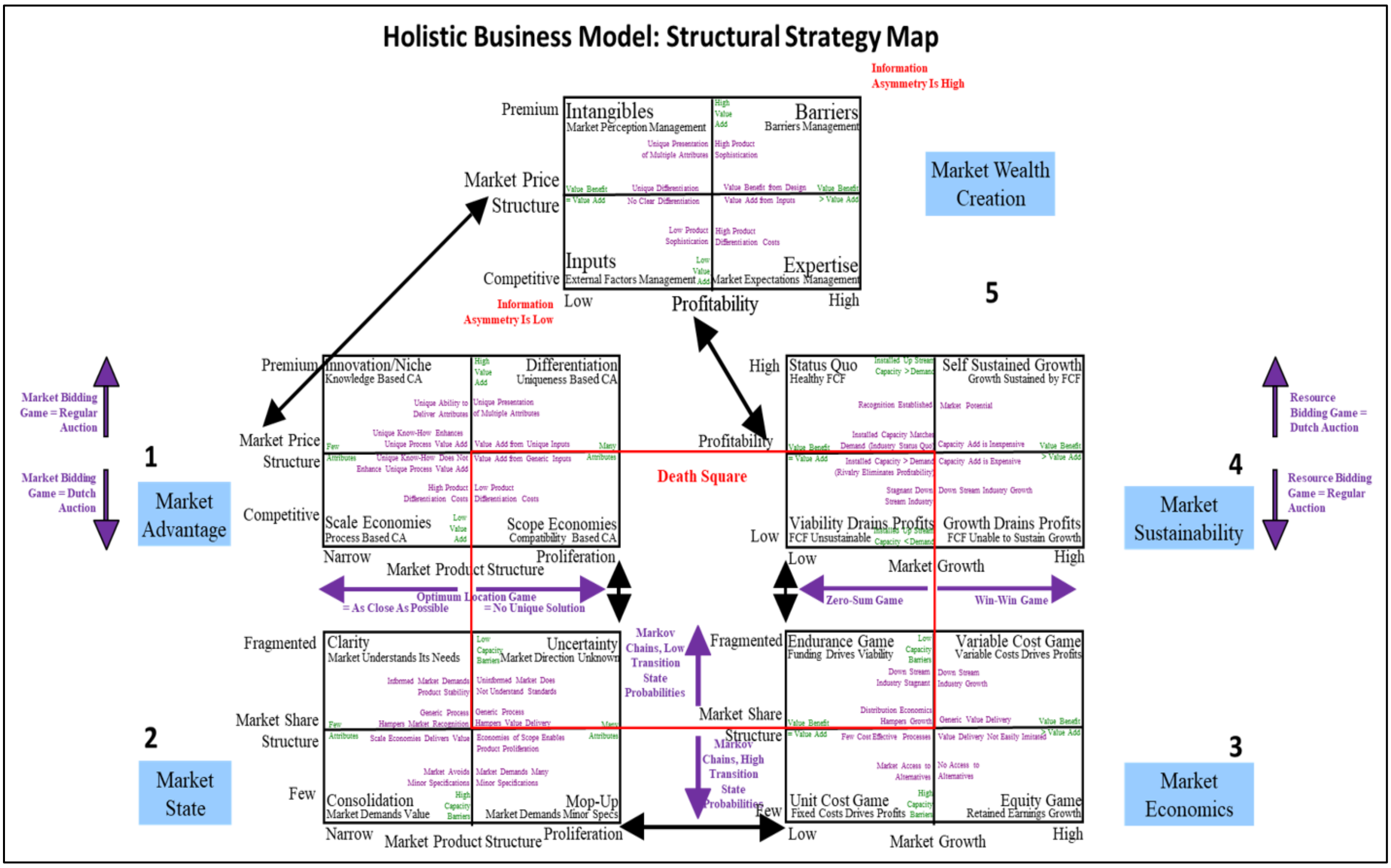

Fig 7 HBM Structural Strategy Map Depicting Barriers
(Source: Solomon, 2002)

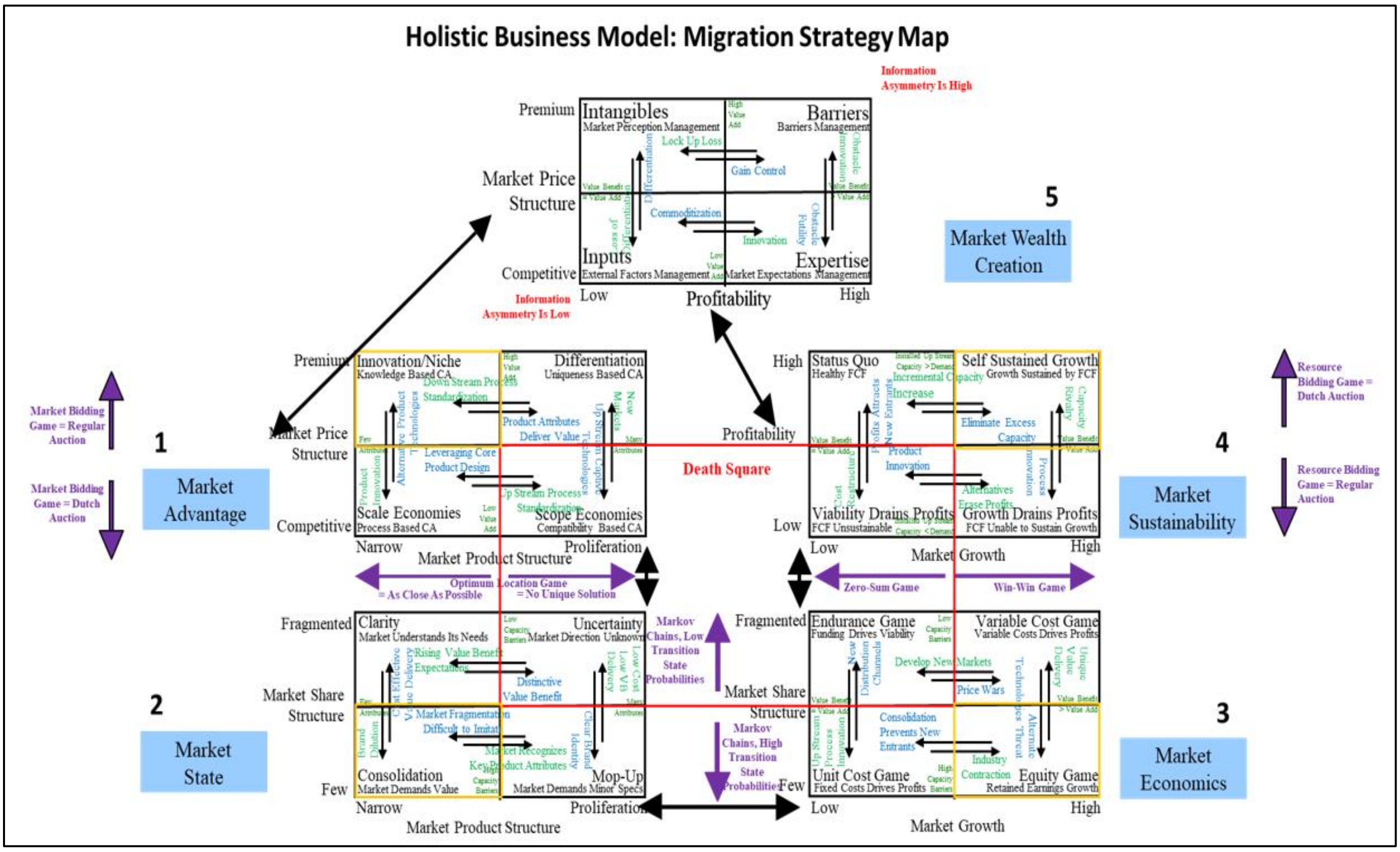

Fig 8 HBM Migration Strategy Map Depicting Migration Strategies
(Source: Solomon, 2002)

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In effect management determine Operations Map and Revenue Transaction Map, while they work within the context of the Structural & Migration Strategy Maps.

The difference between Porter and the AIR model is that strategy is no longer limited to three, Niche, Differentiation and Low Cost. In HBM the States are Structural Strategies and business strategies are Migration Strategies. Structural (iii) and Migration (iv) Maps (see Figures 7 & 8) are the same map split into two as it is too crowded to put all the information on a single map. Before considering a business case study, the essential differences between HBM AIR model and Michael Porter's industry competition structure are presented in Table 4, below.

Table 4 A Comparison Between Porter & AIR Models

	Porter's Definition	**Porter**	**HBM AIR Model**
1.	Competitive advantage:	Derived from the value a firm can create, that exceeds its cost of creating it. There are 2 types, (i) cost leadership & (ii) differentiation.	Derived from the ability of the firm to build barriers to entry or exit
2.	Competitive Position:	A firm's position relative to its industry.	A State in the decision-context Framework. These are Structural Strategies of where the firm is or wants to be.
3.	Strategy:	Strategy is the search for a favorable competitive position in an industry.	Is an Action or Migration Strategy the firm imposes on itself, Intention, to change its State or Structural Strategy.
4.	Market Forces:	These determine industry competition.	Are Actions or Migration Strategies that is imposed on the firm by external conditions or participants.
5.	Barriers:	Barriers prevent entry into a market.	Barriers prevent exit from a State.
6.	The Low-Cost Producer:	One of the strategies of the competitive environment. What one can work with.	A State in the Competency Framework of the Revenue Transaction Map. What one has designed into one's business and therefore, cannot easily change.

➢ *Note:*

- Low Cost: The lowest cost producer is not the one with the lowest marginal cost per unit, but given the same price, is the one with the highest profit. Therefore, at times it maybe be difficult to determine who the true low-cost producer is. This requires consideration of the Cost of Goods produced, Indirect Costs, and Financing which is built into the company structure.
- Intention: In the AIR model, Intention is the beginning of an Action that has not been realized. Therefore, business strategy requires the search for a set of goals, actions and metrics that puts into motion the Intention that was selected.
- Imposition: An Action is participant's intention/strategy when it is self-imposed upon the participant. When an Action is imposed on a participant from an external origin it is a market force.
- Value Add (VA): This is the total cost of product development, marketing, and distribution costs to the producer, divided by the number of units sold. As the market size increases, given all other factors constant, the value-add per unit should decrease.
- Value Benefit (VB): This is the total value derived by a customer. As market size increases, the product novelty reduces, and it becomes a necessity. Thus, the perceived benefit reduces. One should compare incremental value-add V_{IA} (per product upgrades) with incremental value benefits V_{IB}.
- Market Ready versus Dominance: A product is market ready when $V_{IB} > V_{IA}$ and a product can dominate a market if $V_{IB} >> V_{IA}$.

➢ *Microsoft as a Case Study:*

Bearing in mind that most startups begin in the Death Square, Microsoft's history (see Fig. 9) shows how its business evolved. In the early years (Source: The History of Computing Project & The History of Microsoft (2009), unless otherwise noted):

Table 5 Pre-Microsoft & Microsoft Numbers

	1975	**1976**	**1977**	**1978**	**1979**	**1980**	**1981**	**1982**
Revenue	$16,005	$22,496	$381,715	$1,355,655	$2,390,145	$8,000,000	$17,331,000	$24,486,000
Headcount	2	6	9	13	28	40	129	220

➢ *Some Historical Background (1975-1977):*

- 50 different Microcomputers: These include MITS Altair 8800, Scelbi 8H, Mark-8, IMSAI 8080, IBM 5100, Commodore, etc., were mostly based on the Intel 8080 microprocessor.
- Microcomputer buyers were IT geeks, not end users as is today.

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- *From Scope Economies to Differentiation to Niche in Market Advantage:*

In 1975 Bill Gates and Paul Allen, while in Scope Economies, converted BASIC, Hall & Zachary (2020) then a popular mainframe programming language, for use on an early microcomputer, the Altair.

As an advantage to a business, Scope Economies is about transferring a specific set of competencies to other market segments. However, this is a two-edged sword. If the market forces come together to enable a dominance of a specific set of competencies, as did the Intel 8080 with CP/M, then any early masters of this competency had an opportunity for rapid market access and growth. That is, Scope Economies can be both a strength and a weakness.

The HBM Migration Strategy was Upstream Captive Technologies (UCT), by targeting geeks' upstream needs, i.e., what to do with a nice fancy machine? UCT here was to provide an existing mainframe language, Basic, to the fragmented microcomputer market, targeted at geeks who could use Basic to develop their own products. A friend of the author pointed out that there were other companies who were also providing Basic, but their delivery method was to provide it as part of the firmware. That is, UCT is a necessary but insufficient requirement for Differentiation.

The competitive strategy was to piggyback off the dominant player with a distribution arrangement with Micro Instrumentation and Telemetry Systems (MITS), McFadden (2020). MITS was the company that built the Altair 8800 microcomputer. Note, the competitive strategy AIR model is in development.

Differentiation was provided by three factors, (i) A high-end product from a different market segment i.e., product familiarity & recognition need not be built from ground up, (ii) Easy product access as computer stores were just being invented, and (iii) A necessary product for upstream market segment (geek product development) whose downstream market was exploding.

By 1978 Microsoft had established its position as the leading producer of programming languages for microcomputers with Basic, Fortran & Cobol.

The private information here is that Gates & Allen, as a team (and maybe individually) had the uncanny knack of recognizing business opportunities in their business, as the formal field of business strategy was still in its infancy. That is, they would be formidable opponents if they were successful.

- *From Uncertainty to Clarity in Market State:*

This was the time Americans used typewriters, History.com (2020), and the consumer potential of microcomputers was not understood. The dominant operating system at that time was CP/M, written for the dominant chip, Intel 8080. Microcomputers had not yet been standardized, and there were many different hardware platforms. The market for this business was fragmented and unknown.

By 1978 Microsoft had established itself as the leading producer of programming languages for microcomputers, thus becoming one of the participants that were standardizing this industry segment.

- *From Endurance Game to Variable Cost Game in Market Economics:*

Presumably, Microsoft was substantially funded by shareholders and not company cash flow, as revenues were nominal in 1975 & 1976 The private information here is that Microsoft was backed by available wealth, if and when it was needed.

By 1978 Microsoft had migrated to a Variable Cost Game as can be seen in the arithmetic increase in head count versus a geometric increase in revenue.

- *From Viability Drains Profits to Status Quo in Market Sustainability:*

Revenues jumped by 17x between 1975 and 1976. Until the MITS deal, Microsoft was in the Viability Drains Profits State as the company cash flow would not have been able to cover real salaries. By 1977 revenue had reached $382k for a head count of 9 (compare starting salaries, Koncz, 2016) migrating Microsoft to Status Quo.

- *From Inputs to Intangible to Barriers in Market Wealth Creation:*

Therefore, Microsoft's wealth creation migrated from Inputs to Intangibles, i.e., from just another Basic application to an easy access, upstream market, high-end product, and finally to Barriers.

The key to Microsoft's success in the 1975-1977 period is that it exited the Death Square by differentiating itself from other competitors. In the later early years (1978-):

- *Some Historical Background (1978-1980):*

- ✓ Before 1980 Microsoft was primarily a supplier to hardware manufacturers, Encyclopedia.com (2020).
- ✓ In 1980, Microsoft didn't have an operating system of its own. It knew about QDOS, from Seattle Computer Products, which was similar to CP/M and made by Digital Research.
- ✓ In the summer of 1980, IBM was developing a personal computer but needed an operating system to run on it. After failing to reach an agreement with Digital Research, the makers of an operating system CP/M, IBM enlisted Microsoft's help, Belanger (2018).

- *From Clarity to Consolidation in Market State:*

As Microsoft was a dominant player in the microcomputer market, when Digital Research would not agree to a deal with IBM, IBM turned to the only respectable player in this market, Microsoft.

IBM's credibility standardized the microcomputer market with its hardware design, based on the other credible chip player in this market, Intel, and consolidated the market into the personal computer market. This facilitated the development of the consumer-based personal computer market.

- *From Variable Cost Game to Equity Game in Market Economics:*

The consolidation into the personal consumer market moved Microsoft from a Variable Cost Game to Equity Games where it could focus on building its equity, in an unhampered manner.

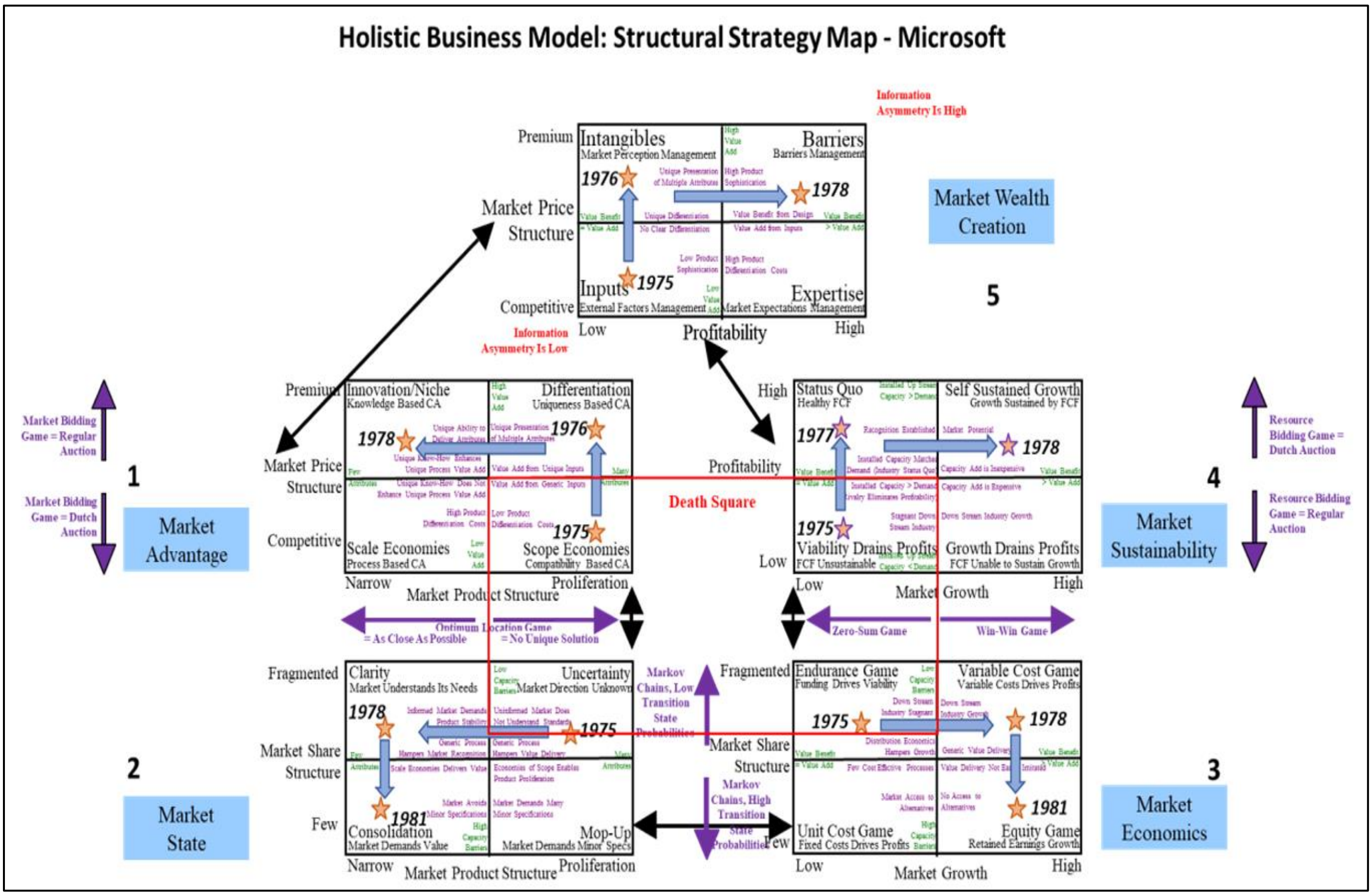

Fig 9 A Reconstruction of Microsoft' Success Between 1975 and 1981

Therefore, one observes, that even though Microsoft's IBM deal was credited with transforming the company into the global software powerhouse it is today, this was not the critical turning point as some would think. The 1975 MITS decision was. There were several decisions and events that enabled this,

- Early Market Differentiation (EMD): The 1975 MITS deal was critical to the microcomputer industry's eventual acceptance of Microsoft as the "go to" provider of software and hardware for technology. The MITS deal enabled Microsoft to develop the organization level competencies in both software and hardware. Without this early market differentiation, nothing else would have been possible.

- Established Business Resource (EBR): By having developed organization level competencies in both software and hardware, Microsoft had proven itself as an established business resource to accomplish relevant innovation that the microcomputer market could depend upon. Otherwise, why would an established powerhouse like IBM approach Microsoft if Microsoft had not become an established business resource?

- Other People's Missteps (OPM): By inferring the private information, three missteps were present,

  - ✓ Big Fish Failure (BFF): One infers that in the microcomputer industry, a small pond at that time, Digital Research, the inventor of the then dominant CP/M operating system, thought of itself as the big fish. Therefore, its belief that it was the big fish led it to consider that there was no need, let alone urgency, to team up with an industry powerhouse such as IBM.
  - ✓ Decision Horizon Failure (DHF): Digital Research failed to consider its belief that its perceived decision horizon could be changed by external participants. This led to the inappropriate decision, with hindsight, to reject the IBM deal.
  - ✓ Internal Company Failure (ICF): Even though IBM was *the* dominant player in the computer industry, its culture condescended the microcomputer segment. As a result, despite its internal resources, was not able to muster the

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marketing and project resources required to develop a microcomputer operating system for this industry. Therefore, the need to negotiate with an external participant. IBM only went as far as setting the hardware technical standards that led to the microcomputer standardization and transformed the industry into the Person Computer segment.

- Ready, Right, Right, Recognition (RRRR): Opportunity can be summed up by the 4 Rs, (i) Ready resources, (ii) Right time, (iii) Right place & (iv) Recognize the opportunity. That is, because Microsoft had the first 3Rs, IBM came calling when its negotiations with Digital Research fell apart. Unlike Digital Research, Microsoft had the presence of mind to recognize the opportunity. The superstitious would consider the 4Rs luck but this is not the case.

Sometimes, the right resources need not be what one has, but what one has suitable access to. In this case IBM required a microcomputer operating system which Microsoft did not have but was able to acquire QDOS within a very short period from Seattle Computer Products.

Returning to Outcomes & Utilities, clearly Microsoft had no idea how to quantify how large a payoff the IBM deal would turn out to be, even though they may have had some idea of what their utilities would be.

The critical take-aways here from a business strategy perspective are (i) IBM standardized the microcomputer industry, and (ii) that sometimes to gain dominance in a downstream market one must take control of an upstream industry segment. Note that it was IBM that required this of Microsoft by insisting on dealing with an operating system provider.

➢ *Other Types of AIR Models:*

To illustrate the scope of AIR models, Fig. 10 & 11 present AIR model Maps in finance and in medicine, respectively. They illustrate how quantitative data can be incorporated into AIR models. Both these models are not complete and are expected to be published soon.

The financial AIR Model consists of 4 Maps of which one is presented in Fig. 10 and illustrates how quantitative data is used with AIR models in finance. It is based on the financial analyses of 4 industries, Apparel, Banks, Retail, and Semiconductor industries as of January 2019.

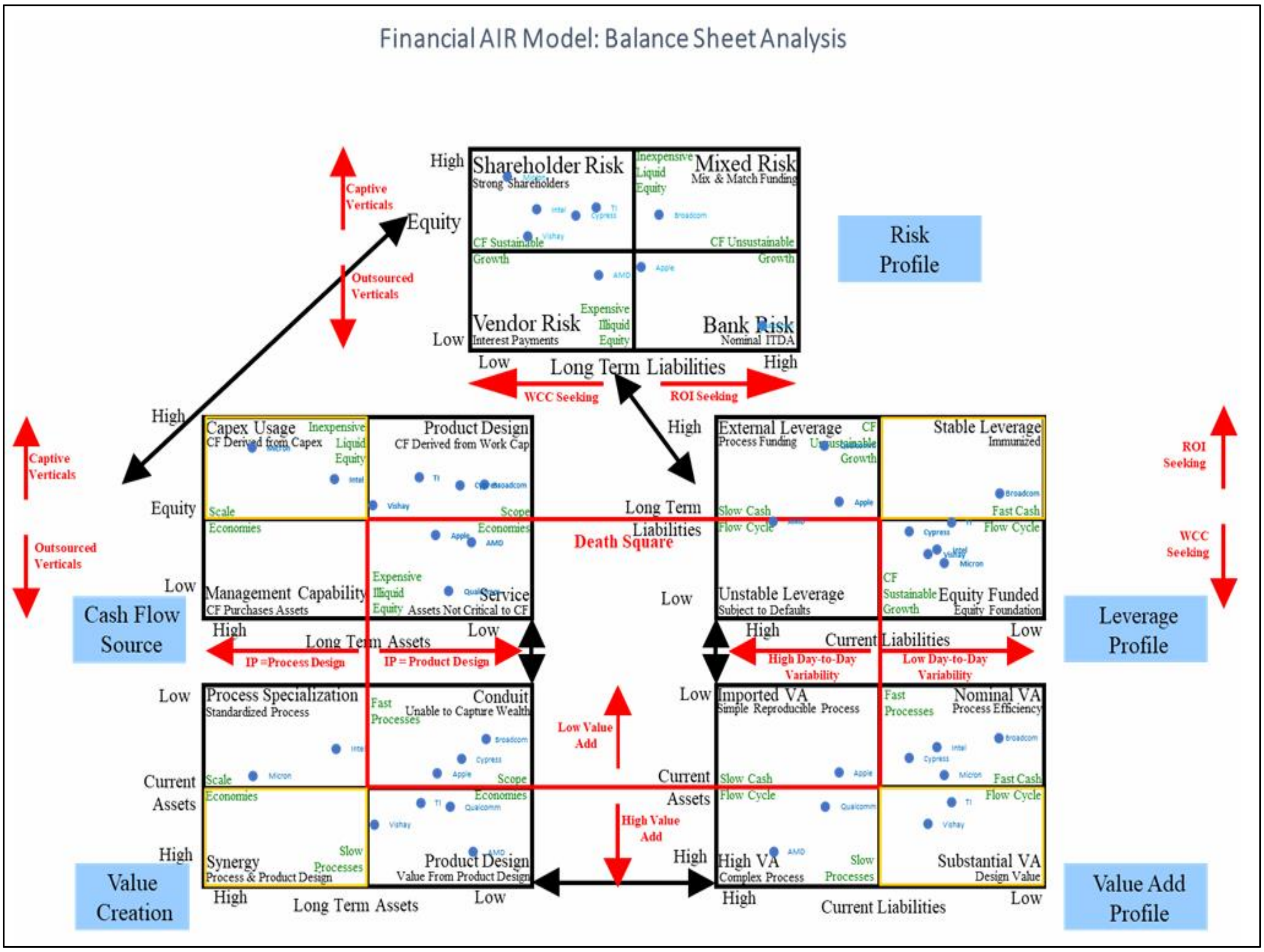

Fig 10 The Balance Sheet AIR Model for Decision-Assists in Financial Analysis

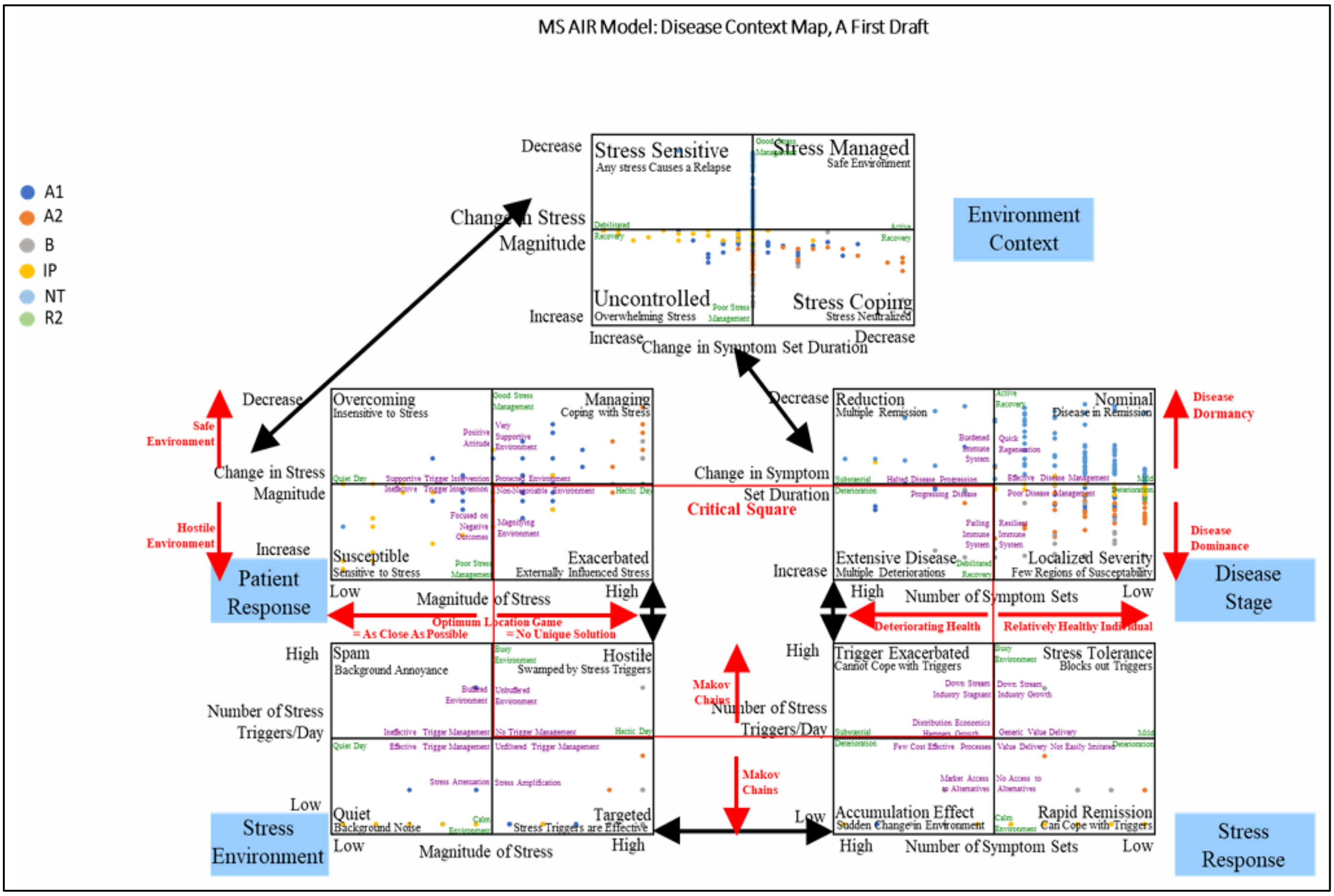

Fig 11 The Multiple Sclerosis AIR Model for Decision-Assists in Medical Diagnosis & Treatment

The Multiple Sclerosis AIR model is still under development. Fig. 11 illustrates, having determined the underlying disease processes, AIR models can be used for decision-assist in diagnosis and treatment. Note that, this Multiple Sclerosis AIR model is still under development and the final version may be substantially different from the one presented in Fig. 11.

➢ *The Power of the AIR Model Lies in its Ability Enable One to,*

- Model both qualitative data and quantitative data. See Fig. 10 & 11.
- Determine the intention of participants.
- Check if press releases or anecdotes are hype, truth, or decoy.
- Determine reliable private information from Factors, Barriers, and State information.

➢ *A Note with Respect to Artificial Intelligence:*

Some initial cautions,

- Prove Anything?: Mathematics (Morris Klein, 1982) has become so sophisticated that it could be used to prove anything.
- Inference Engines: John Searl's (1980) The Chinese Room, proposed that any symbolic manipulation system that can be operated on with a clearly defined set of rules, i.e. syntax, is an inference machine and not artificial intelligence.
- Blind spots: From this I infer that all mathematics is syntax, but mathematics has blind spots. For example, a non-integrable calculus equation cannot be solved but many times one has to resort to numerical integration to solve such an equation, and therefore, I use the term "blind spot".
- Independence: There are thousands of languages with their own syntax, but they are represent the same knowledge. Thus, knowledge is independent of syntax.

Thus, AIR Models are knowledge constructs, i.e. using knowledge relationships to connect knowledge elements, in a manner to facilitate decision making. Knowledge relationships are related to meaning, and different from object-oriented relationships that are related to attributes, therefore, enable better Artificial Intelligence systems.

III. CONCLUSION

This paper presented a structured approach to solving real-world decision problems, by showing that the best outcome is not necessarily the only type of decision problems there are. Using many real-world examples, the three types of decision problems are (i) best outcome, (ii) best path and (iii) decision assists. Best outcome decision models are based on the premise that external States are not controllable. Best path

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decision models are based on the premise that States exist in a definitive manner.

Decision-assist models are based on the premise that an exact solution is not necessary as the decision-context is constantly changing. These models reduce the complexity of the decision-making problem by either eliminating States and/or by restructuring the decision problem.

Finally, this paper derives the theoretical basis for AIR models, describe how these can be constructed and provides examples on how these should be used. AIR models provide very useful results, and in some cases surprising results. They also provide a mechanism to discover gaps in our knowledge that need to be addressed.

The selection of which type of decision model one uses is dependent on the type of context one is dealing with. Finally, it is hoped that this paper will spur further research into best path decision models.

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