Information Envelope and its Information Integrity Implications: For a complex, changing environment, modeling a generic business process as an integral to a closed loop information and control system characterized by uncertainty

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Abstract: Physical and informational works are strongly interrelated in a business process. This paper facilitates a control's interpretation of model of business process as an integral part of a closed loop information and control system. Various uncertainties (due to 5Cs) affect this model and raise the Information Integrity issue for the same. This complex information and control system delivers a flexible information decision to control business process in a changing environment. The paper argues that a more useful view of information decision is as a process of information gathering and processing rather than the conventional view of decision as 'choice between various alternatives'. This flexible decision process should have the stages viz. Operable goal setting, Definition of complexity criteria, Construction of opportunity and constraint spaces, Development of information structure dynamics model, Customized planning and design of alternatives and, finally, the Choice of alternative. The conclave of information bases for these information gathering and processing stages characterized by their respective contexts is normally not considered for business process IS modeling. It is this conclave that the paper defines as 'Information Envelope', and shows it to be central to the information and control system to which the business process is integral. And more importantly, the paper shows that it is each of these information bases that is affected by further uncertainty of the type not encountered earlier; thereby resulting in further loss of Information Integrity for a business process operating in a complex and changing environment.

1. Introduction

The research investigations on Information Flow Model (IFM) for Integrity Analysis presented at IQ 1999 [5] studied the Information Integrity (I*I) problem in the context of 'errors in networked computerized information systems that are made but not corrected.' The investigations categorized these error components in IS in terms of errors with deterministic descriptions caused by singular events like software failure, and errors with stochastic descriptions caused by general, judgmental, and systems factors. In the process, the investigation proposed a workable approach to developing IFM with capability for information accuracy, consistency and reliability, i.e. Integrity Analysis and Improvement Plan (IAIP), by viewing IFM in its totality. The total view of IFM includes Data Origin Stage activities, Data Conversion Stage activities and Output Stage activities, each of them having further sub-activities. Accordingly, for each of these sub-activities of a computerized information system, the investigation proposed IFM for achieving I*I through IAIP implementation.

Though they provide a basis for generating error databases for implementing integrity analysis leading to integrity technologies discussed in literature [3], understandably, these information flow models constitute only core IS views for respective IS sub-stages for integrity analysis and improvement. This, in turn, calls for developing a systematic methodology for developing a structural model for gathering information to be processed by them and for studying the totality of I*I implications as emerging consequently.

Traditionally, the business enterprise had computerized information systems (IS) developed in isolation, but there was no effort to optimize data or information for improved decision making. The requirement was in terms of automation of functions of 'hard 'components, i.e. of 'mechanical' or 'physical' work, so as to add value to the product produced. However, with data-driven technologies keyed to the flow of digital data throughout an enterprise and on the Net and with pressures of achieving business objectives of effectiveness and efficiency, business enterprise has a further requirement for utilizing data/information decisions 'smarter ' [6,12].

This calls for automation of 'informational work' carried out by the soft components of the enterprise wherein 'data' is seen as raw material, 'data processing or transformation or conversion' as the system function and 'data product' or 'information' as processed data used to trigger information use (decision making stage included) so as to deliver 'information decision ' in the form of information to add value to the product [4,6].

This is an application of flexible automation accounting for product innovation, customer needs (product requirements) and constraints of costs and capabilities - a structural variant from inflexible automation. Specifically, the flexible automation is becoming possible due to (a) availability of on-line computers, (b) computers providing capability for moment by moment optimization of processes and decision-making, and (c) availability of system integration capability so as to yield a computer integrated system for attaining business objectives.

What makes it possible now to 'put it all together ' in a total production, delivery and service system is technological reality of digital data as medium of information flow across the enterprise. Further, most importantly, such systems can be applied to both hard components of production like processes, machinery and equipment, and soft components like information flow and data bases --- the informational work systems [10,6].

It is within the above framework of interrelationship between informational and physical work systems and with reference to IFM as already mentioned, that it then becomes possible to reinforce often articulated proposition that whatever else a business does, it processes information [5]. For the purpose of the research investigation at hand, this business process IS view indeed is a very helpful observation. It suggests that system engineering techniques used in understanding the dynamics and responses of physical systems could, therefore, be used for understanding and predicting the operation and performance of more subjective and probabilistic description of business processes controlled by the requirements of flexible information decisions for control implementation [Figure (1)].

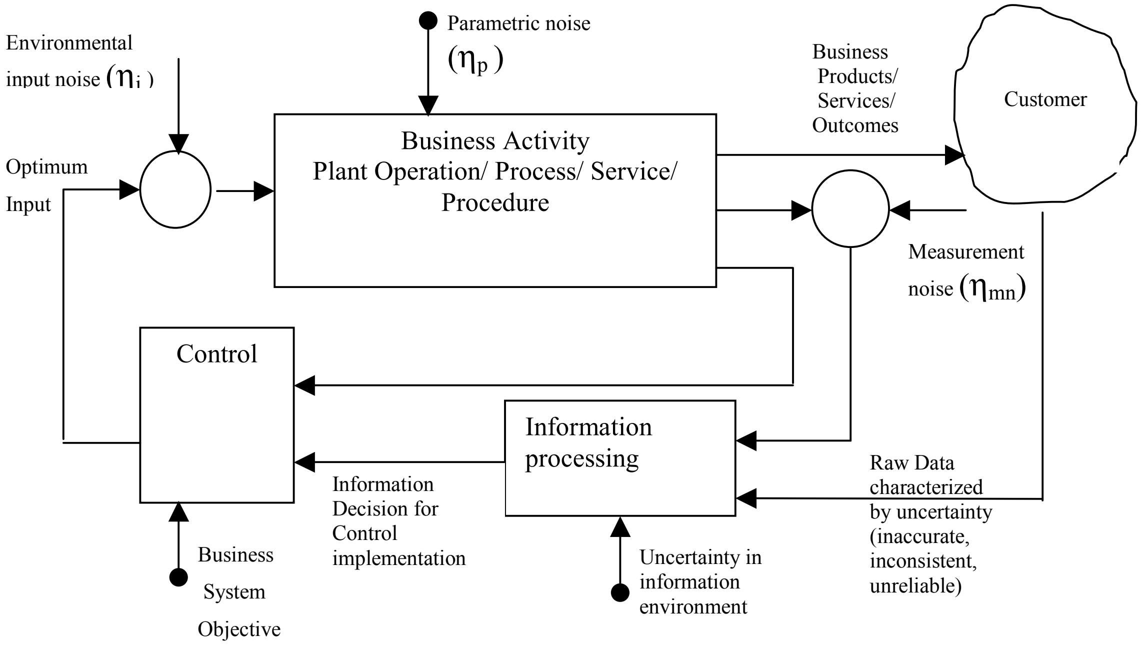


Figure (1): A Business Process IS View - A systems representation of a generic business process as integral to a closed loop information and control system.

In what follows, this paper addresses this research issue in the context of a generic business process. It may be mentioned that as the model emphasizes information, it is applicable to manufacturing, production, or service activity. As a result, choice of any specific activity to represent the business process is only illustrative; the conclusions drawn being applicable to all types of business activities. Further, for understanding the integrity implications, the business process IS view can be arranged as per the levels of controls applied. Figure (2) gives this information and control system based model of the business process IS view for an environment characterized by uncertainty along with its I*I implications.

2. Uncertainty in Business Process IS view and its Integrity Implications

Due to the system environmental factors of 5 Cs [Change (C1), Complexity (C2), Communication (C3), Conversion (C4), and Corruption (C5)], this information and control system constituting business process IS view is characterized by uncertainty at various levels as described here [4,8]. Traditional systems, emphasizing individual production machines, exhibit the existence of uncertainty at plant operations level and first control level. At plant operation level, the uncertainty is in the input (η_i), operations (η_p), and output ($\eta_{C1,2,4}$). At first level of control, the uncertainties are due to measurement or observation noise (η_{ob}). Measurement error factors and uncertainty at the plant/ process operations ($\eta_{C1,2,4}$) may render information observed at plant output to be inaccurate and incomplete, i. e., affected by measurement or observation noise.

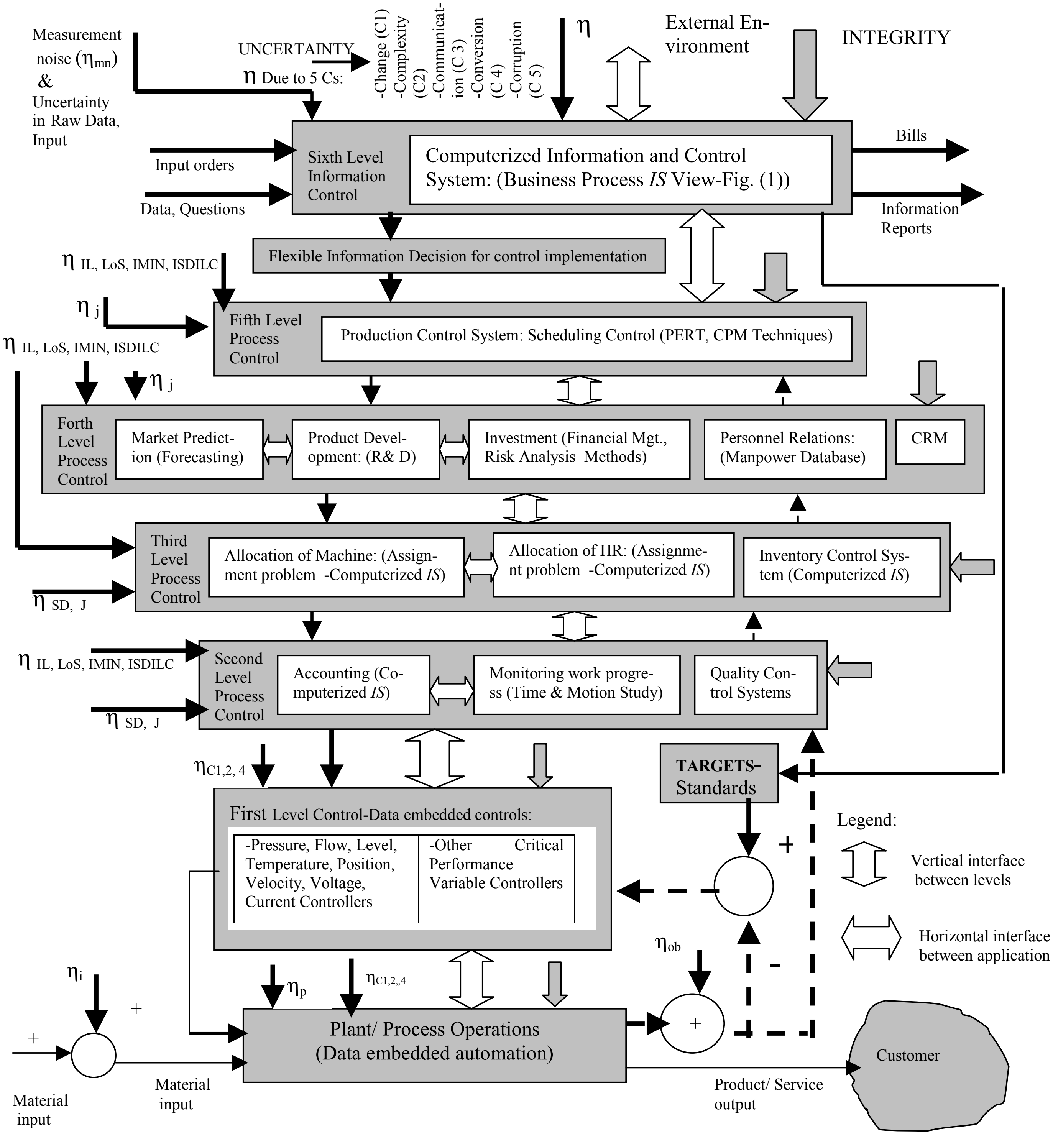


Figure (2): Business Process IS View Model describing a generic business process as integral to an information & control system for a business environment characterized by uncertainty and its Information Integrity Implications.

2.1. Uncertainty types newly emerged due to 'application' emphasis with system non-integration

With the advent of computer technology, further impetus for automation initiatives came in the form of higher-level process controls [Figure 2]. Specifically, these were 'applications' of computerized information systems justified (a) initially on the cost reduction aspects of processing structured and periodic information, the business work clerical in nature being the obvious choice, and (b) later as management tools for planning, direction and control [6,7]. Figure (2) shows different process control levels - higher than the first level control, with the feedback information from lower level control to the higher level, and the reference, i.e. feed-forward information, from higher level to lower level. For the reasons mentioned, businesses developed more and more of these 'applications', each with its own terminology, procedures and data sources giving rise to new uncertainties. Further at these higher levels, the human-machine interface is also prevalent. Within this framework, following uncertainties are identified.

i) *Uncertainty types present at all process control levels* ($\eta_{\mathrm{IL, LoS, IMIN, ISDILC}}$)*:*

  a) Uncertainty due to information overload (η_{IL}),
  b) Uncertainty due to lack of standardization(η_{LoS}),
  c) Uncertainty due to lack of relationship between the data in several applications (problems arising from emphasis on integration minimization) (η_{IMIN}),
  d) Uncertainty due to errors in hardware, software, data entry, or accidental or intentional failures (including human failures, etc.), i.e., uncertainty due to errors in information system development and implementation life cycle (η_{ISDILC}).

ii) *Uncertainty types at process control levels 2 & 3*: The process control levels 2 & 3 deal with managerial decisions at middle level [Figure (2)]. In addition to types of uncertainties identified above, these levels are also characterized by uncertainty due to incomplete knowledge of system dynamics (η_{SD}) and due to judgmental errors at human-IS interface (η_j) [Section (1)]. These levels are characterized in much more rudimentary and uncertain way by the deterministic and stochastic models of linear and non-linear programming decisions as against the plant/process and first-level controls that can be fully described by deterministic model.

iii) *Uncertainty types at process control levels 4 & 5:* The process control levels 4 & 5 deal with higher management level decisions [Figure (2)]. Understandably these levels are characterized by human-machine systems in which humans start playing dominant part in decision making. Particularly, the process controls at level 4 are often described by decision theory models, while process control level 5 which may comprise production and scheduling controls (planning control included) differs from conventional control in that it includes humans as part of the process to be controlled. All this adds to uncertainty at process control levels 4 and 5 (η_j).

iv) *Uncertainty type at information control level 6*: While automating (optimizing) production process with the help of five control levels as above put in operation in isolation, what has not been possible is to optimize design continually, i.e. in *on-line* fashion. This continuity is the basis for production line delivering mass-customized products for continually changing business environment (product innovation included) with emphasis on integration maximization across the supply chain.

The technological reality of the sixth level information control makes this possible. Specifically, the sixth level control is a business process *IS* view, and it comprises human - machine systems. Thus, very little is understood about the physical structures governing the sub-systems and components of the sixth level control system. As a result this level is normally described by an inductive model which is developed based on observations made on the real-world business operations, and, as the problem is, these observations are invariably noisy. In other words, one is faced with the problem of implementing the sixth level information control, when the data available to develop the control model is characterized by uncertainty (η_{mn} and uncertainty in raw customer data) [Figure (1)].

2.2. Uncertainty types due to increased complexity

And even as there is an increased emphasis on 'applications' for competitive business advantage, microprocessors and data driven technology keyed to the flow of information across the enterprise have led to total shift toward system integration. Resulting reduction in information processing costs and the competitive advantage of the systems developed have further accelerated this shift [7]. Thus, on the one hand, one sees a dramatic increase in the use of computers in the form of 'embedded systems' over a widest range of systems [11]. On the other hand, the business enterprise has its goal shifted from that of 'cost minimization' to that of 'financial optimization'. At every level all this has, understandably, led to use of components and systems complex in nature, thereby further adding to the uncertainty due to system integration as follows ($\eta_{C1,2,3,4,5}$) :

i) *Uncertainty in plant operations*: Process failures may occur due to complex error mechanisms coming from design, manufacturing, commissioning and maintenance phases and acting with delay ($\eta_{C1,2,4}$).

ii) *Uncertainty in plant and first and higher level control operations due to failure of 'embedded systems'*: Traditionally, hardware has been considered to be reliable. However, with embedded systems all this has changed. This failure can emerge due to inadequate tests undertaken; due to incompatibility between electrical components and maintenance errors. It is these failures of 'embedded systems' that then result in uncertainty in plant and first (and higher) level control operations (η_{C2}).

iii) *Uncertainty due to presence of system interfaces* ($\eta_{C1,2,3,4,5}$): The system integration impacts all the six levels of controls as also the plant /process operation by introducing system interfaces [Figure (2)]. These interfaces call for the specification of each IS module to include details of its interaction with other modules. This interaction may be formalized in an interface design specification (IDS), which sets out the data or messages sent between modules, and any protocols used. As the levels of information and control system in Figure (2) interact laterally and vertically (not shown in full), it follows that modules that are internal will also have interfaces with modules at the boundary and, therefore, with external system and vice versa. In the wake of emphasis on system integration maximization, more often than not the resulting interactions will be complex, thereby introducing further uncertainty at all levels (plant operation inclusive).

2.3. Information Integrity Implications

The presence of uncertainties as above at all levels of information and control system leads to errors in business process IS view (that are made but not corrected in spite of application controls [5, 4]). This results in loss of integrity at the data processing stages, thereby, rendering data and information processed inaccurate, incomplete, not up to date, and unreliable. Figure (2) indicates at critical points the noise inputs discussed above, and acknowledges the presence of systems interfaces. For the purpose of presentational simplicity, the vertical interfaces between levels are shown in complete, while the lateral interfaces between applications at a level are shown nominally.

3. Improved Business Process IS View, consequent Uncertainties and Information Integrity Implications thereof for a Complex and Changing Environment

In the study of a business process operating in an environment characterized by uncertainty, the identification of an information and control model as in Figure (1) has made it possible to consider applying system engineering techniques to research the I*I problem at hand. As shown in Figure (2), what one is dealing with is a multi-level control problem. Though a large system problem, on the face of it, the problem looks tractable. At the lowest level, one is concerned with plant operation and processes, which primarily comprise individual production machines, and microprocessor based data embedded systems that are describable by deterministic mathematical models. Similar is the case with first level control models. These models are deductive and are arrived at by having complete understanding of physical structure of the system and either by analytical consideration or by experiment. Such models are susceptible to being controlled in accordance with the principles of classical theory of automatic control.

As mentioned in Sub-sections [2.1-(ii) and (iii)], the controls at levels 2-5 are amenable to quantitative treatment through various models covered by systems engineering tools and techniques scanning a wide range of interdisciplinary areas. Thus, based on knowledge of system engineering tools and techniques, the Figure (2) problem of information and control system modeling of a business process, looks tractable even as one grapples up to 5th level control, which include product innovation, planning and design stage requirements.

However, methodological inadequacy creeps in as one deals with the information control at level 6. As pointed out in Section (1) and Sub-section [2.1–(iv)], now, it is possible to optimize design continually, i.e. in *on-line* fashion (continuous product innovation), as a basis for production line delivering mass-customized products and services for continually changing business environment. In other words, in order not to be blind-sided in rapidly changing markets, the search and relevant information decision must not be restricted to diagnostic routines and procedures ballistic in nature. Instead, senior management needs a measurement and decision system more like the one used by the national weather service. Ground stations all over the country monitor temperature, barometric pressure, relative humidity, cloud cover, wind direction and velocity, and precipitation. Balloons and satellites provide additional data. These are monitored continuously and fed to central location where they can be used to search for patterns of change. Based on these intelligence data, forecasts of impending conditions can be made or revised (flexible information decision) in the light of changing circumstances [9].

As mentioned in Section (1) and Sob-section [2.1-(iv)], in the form of information control at the 6th level, thus one has inductive modeling exercise at hand based on real world business observations. This exercise (a) involves multiple goals, many factors, and a large number of interdependent information variables, varying with time, and not completely and correctly observable, and (b) its system dynamics is not well understood. This is a complex problem solving exercise, and significantly the complexity is not of the *order*, but of the *organization* [1,2]. In other words, the information control at 6th level involves processing of unstructured (maximal) information as against structured (minimal) information as has been the case up to 5th level control [6, 9]. To that extent the 6th level information control dramatically distinguishes itself from information processed at lower levels by mainly acquiring an open system character. In fact when system integration is complete, all levels acquire open system character, the degree of openness being directly proportional to the order of the level; and in the process the system at its all levels assumes a high degree of complexity.

One of the unique properties of an open system is it has a purpose or goal or direction. As a result, activities of continual operable goal setting and implementing so as to deliver correct action i.e. implementing with integrity - become critical to the satisfactory functioning of the open system in a constantly changing environment. And as it should be these goal setting and implementing activities in themselves work out to be information processing activities characterized by their own brand of uncertainties; thereby making integrity of information processed through various stages an additional necessary requirement (to the integrity implications as already identified under Figure (2)).

System's research suggests that goals can be of various types: general, specific, positive, negative, clear, unclear [2]. Unclear goals are further characterized by implicit goals, which often may come with time delay. A system can have multiple goals, and, depending on type, goals can be multi-criteria or few (single) criterions. In multiple goal situations, goals can be independent or interdependent. Further, goals are characterized by many factors that may lead to large number of information variables which within themselves may be independent or interdependent (linked positively or negatively). It so works out that complex systems are invariably characterized by multiple, interdependent, conflicting and often unclear goals described by multiple criterion and by many factors and large number of interdependent and time varying information variables. Even seemingly simple open systems are complex; e. g., a simple user interface can add substantial uncertainty and hence complexity.

There is yet another aspect. Specifically, as shown through Figures [3(a)] and [3(b)], the information processing for the operable goal setting is characterized by its own uncertainty; thereby ensuring, in the goal set, ambiguity for strategic uncertainty. This indeed is a welcome requirement as it is this ambiguity that provides a basis for constructing an acceptable opportunity space for business for continuous innovation in a changing environment [2,9]. However, this ambiguity may also constitute an entry point for such planning and design processes and procedures (human behavior included) which may not fit the core business values, and, hence, may not be acceptable. In other words, the ambiguity in goal set would bring in strategic uncertainty and, therefore, a risk element. As a result, the methodology for operable goal implementation would also need to develop information systems for constructing acceptable opportunity (innovation) and constraining (process and procedure) spaces in order to increase the benefits of the positive risk (acceptable opportunity) and reduce the implications of the negative risk (unacceptable procedures and processes).

It is based on these goal setting and opportunity and constraining space defining activities that the subsequent stages in goal implementation can be carried out. Specifically, one can develop the structural model for information variables by observing the changes that the information variables (identified from the operable goal setting exercise) undergo over time and/or through study of their co-variances with time delays. This requires collection and integration of information over time, and thus becomes an information processing activity. This would then need to be followed by developing time sequence development trends, i.e., information dynamics model; so as to model the information structure dynamics. As described through Figures (6-7), respectively, their own types of uncertainties characterize both of these information-processing stages.

Given the customer requirements for products and/or services at any time 't', the business process IS view, in the form of 6th level control, would then need to develop (using the model of information structure dynamics obtained as above) the flexible information decision for control implementation within the boundaries of the opportunity and constraining spaces. This then gives the framework for removing the inadequacy in methodology for undertaking the inductive modeling exercise at the 6th level information control.

The task of delivering the flexible information decision as a result of the information processing at the 6th level in Figure (2) cannot be seen merely as that of forecasting (prediction), evaluation of alternatives and selection (as traditionally suggested under system engineering techniques as also in literature [7]). It must be seen as that of dealing with maximal information involving a process of information gathering and processing which leads from the initial recognition of a problem, i.e. operable goal setting followed by subsequent stages as shown in Figures (3-8). This indeed is an important observation as it offers a workable method for an inductive exercise to identify unstructured information so crucial to understand the information processing that is carried out by an open system. It also develops an improved business process IS view model over what has been suggested in Figure (2).

Further, as each of these information processing stages are impacted by uncertainties at respective stages [see Figures (3–8)], all through there is loss of integrity as the maximal information gets processed. This results in inaccurate, inconsistent and unreliable processing of operable goal set and further stages, thereby so rendering the flexible information decision also.

It is within this framework then the improved business IS view incorporating the maximal information processing stages from operable goal setting to flexible information decision and its control implementation for customized product/service delivery need to be researched for uncertainties therein and for their I*I implications. Needless to say, each maximal information processing stage as these, by itself, is also a complex system, thereby increasing the complexity of the business IS view by that order. As a result exhaustive I*I studies for each of these stages offer areas of separate research investigations and are beyond the scope of the present research query. However, to tie the knots together in respect of the components, sub-systems (elements), structure and information variables of the improved business IS view, the Figures (3-8) describes systems representations of these maximal information processing stages along with uncertainties and I*I implications.

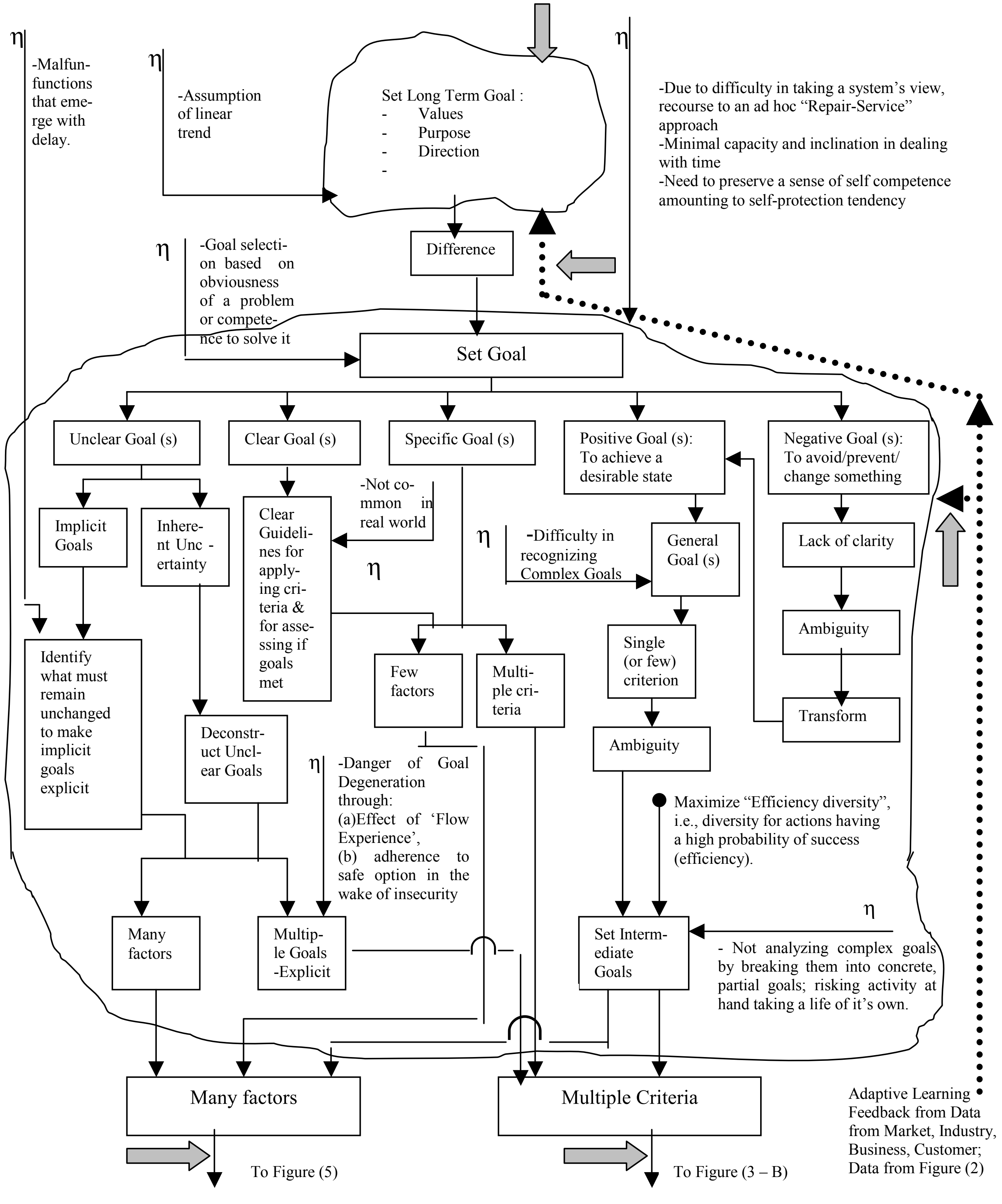


Figure (3 -a) : Systems representation of Information base and its processing for Setting Operable Goal – From 'Set Goal' to obtaining 'Many Factors' & 'Multiple Criteria' characterizing Problem Complexity

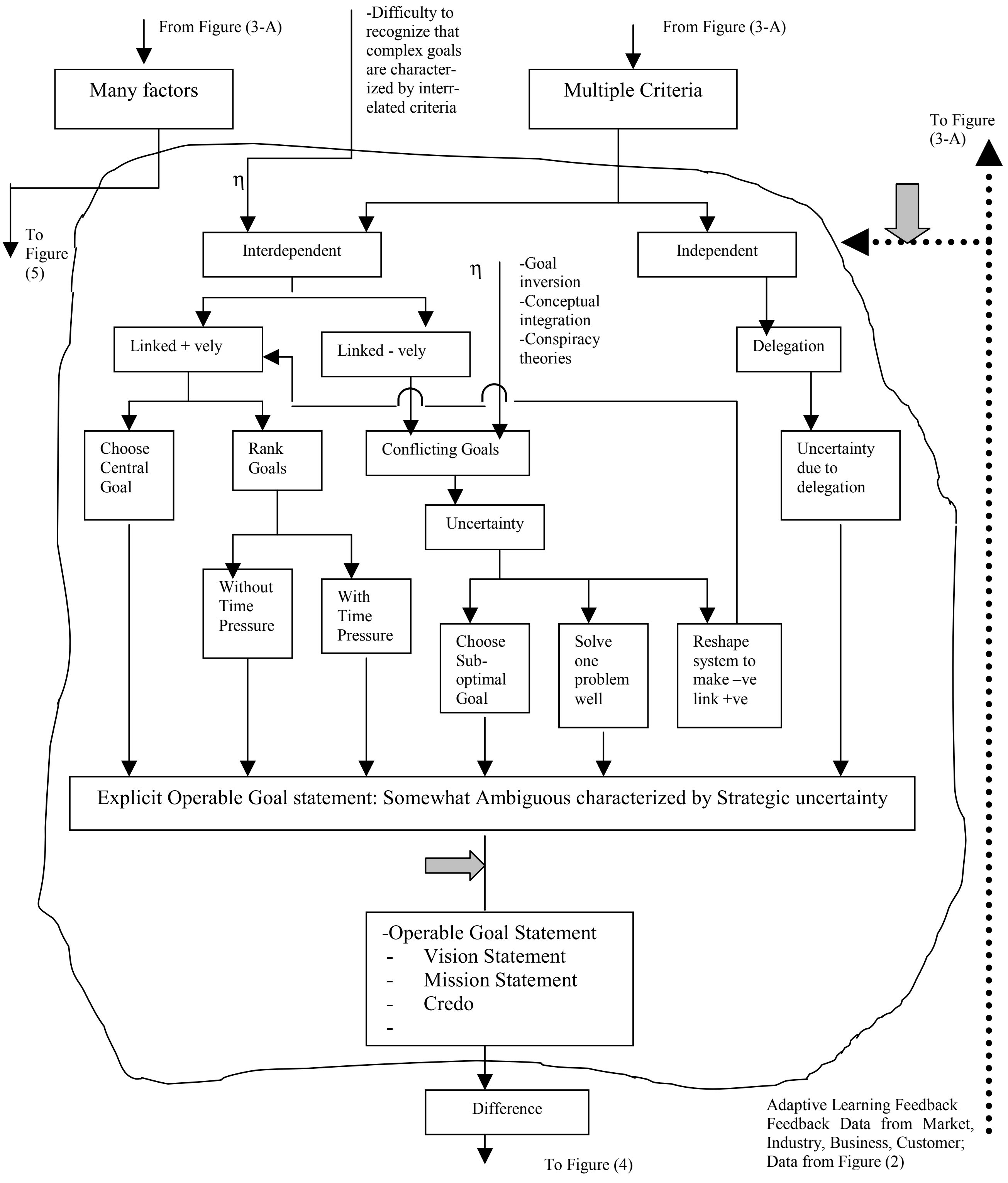


Figure (3 - b): Systems representation of Information base and its processing for Setting Operable Goal – From 'Many Factors' & 'Multiple Criteria' characterizing Problem Complexity to Operable Goal Statement

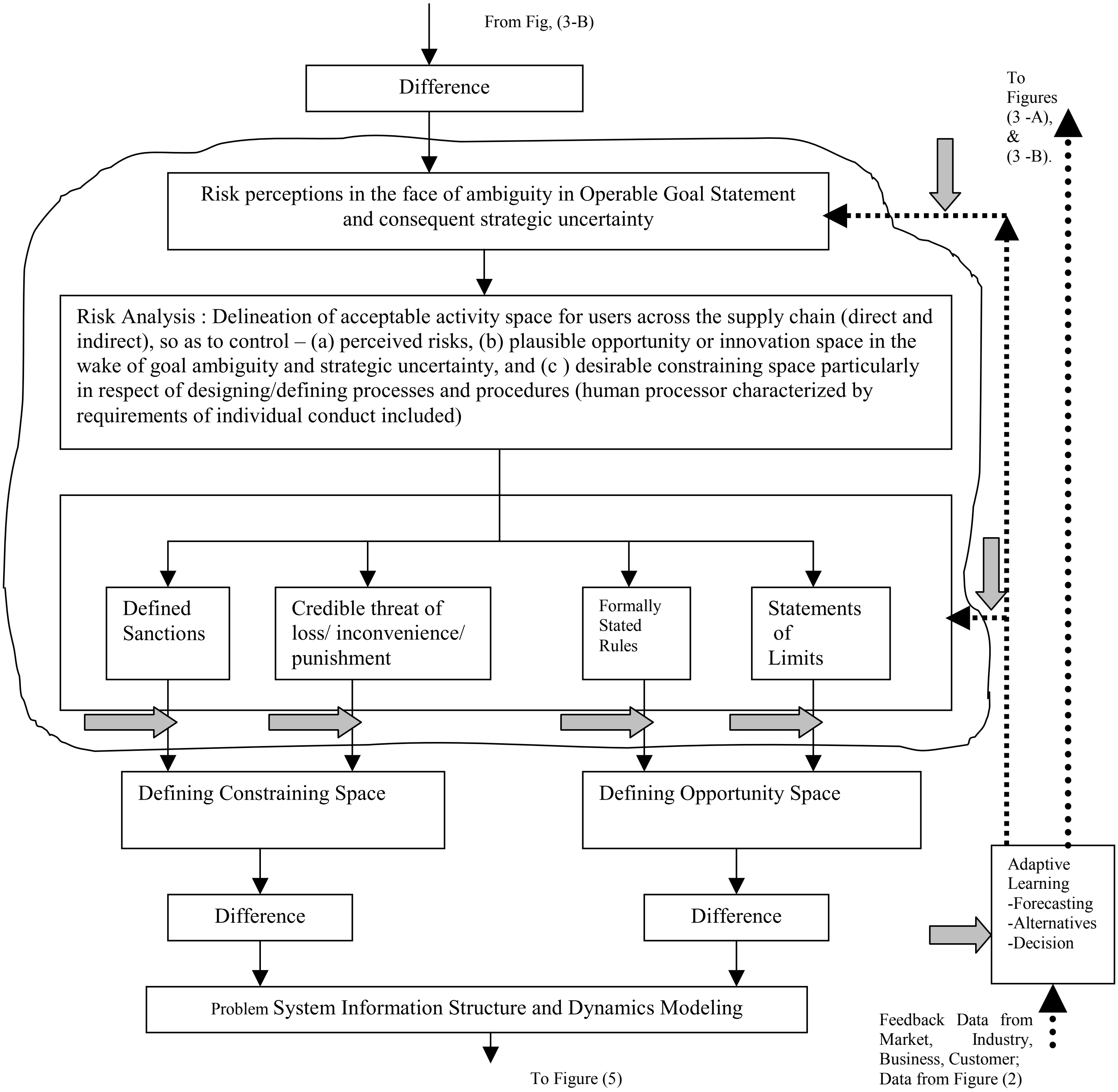


Figure (4): Systems representation of Risk Analysis Information base and its processing – From Operable Goal Statements characterized by Ambiguity and Strategic uncertainty to Defining of Plng. & Design Constraining and Opportunity Spaces

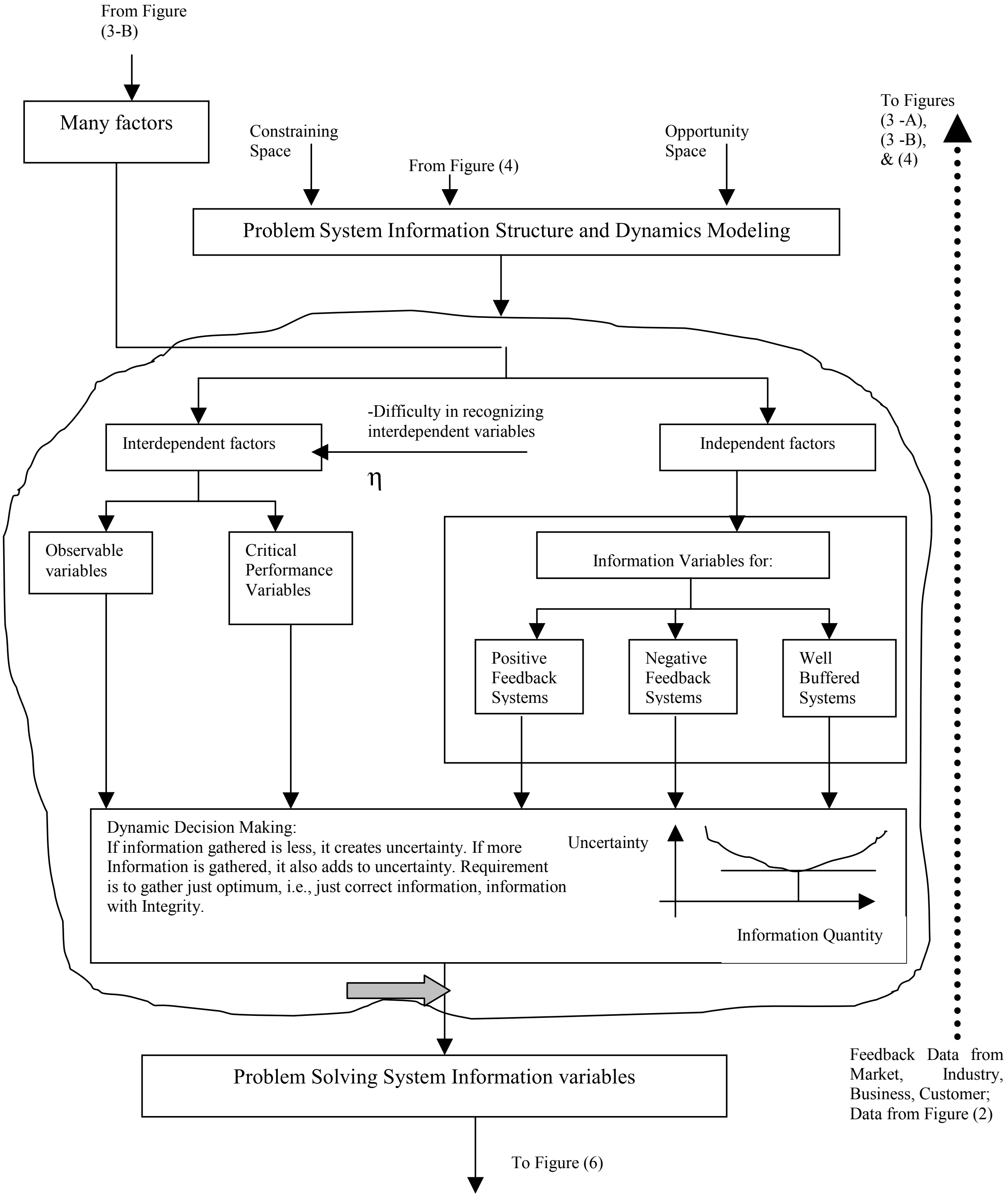
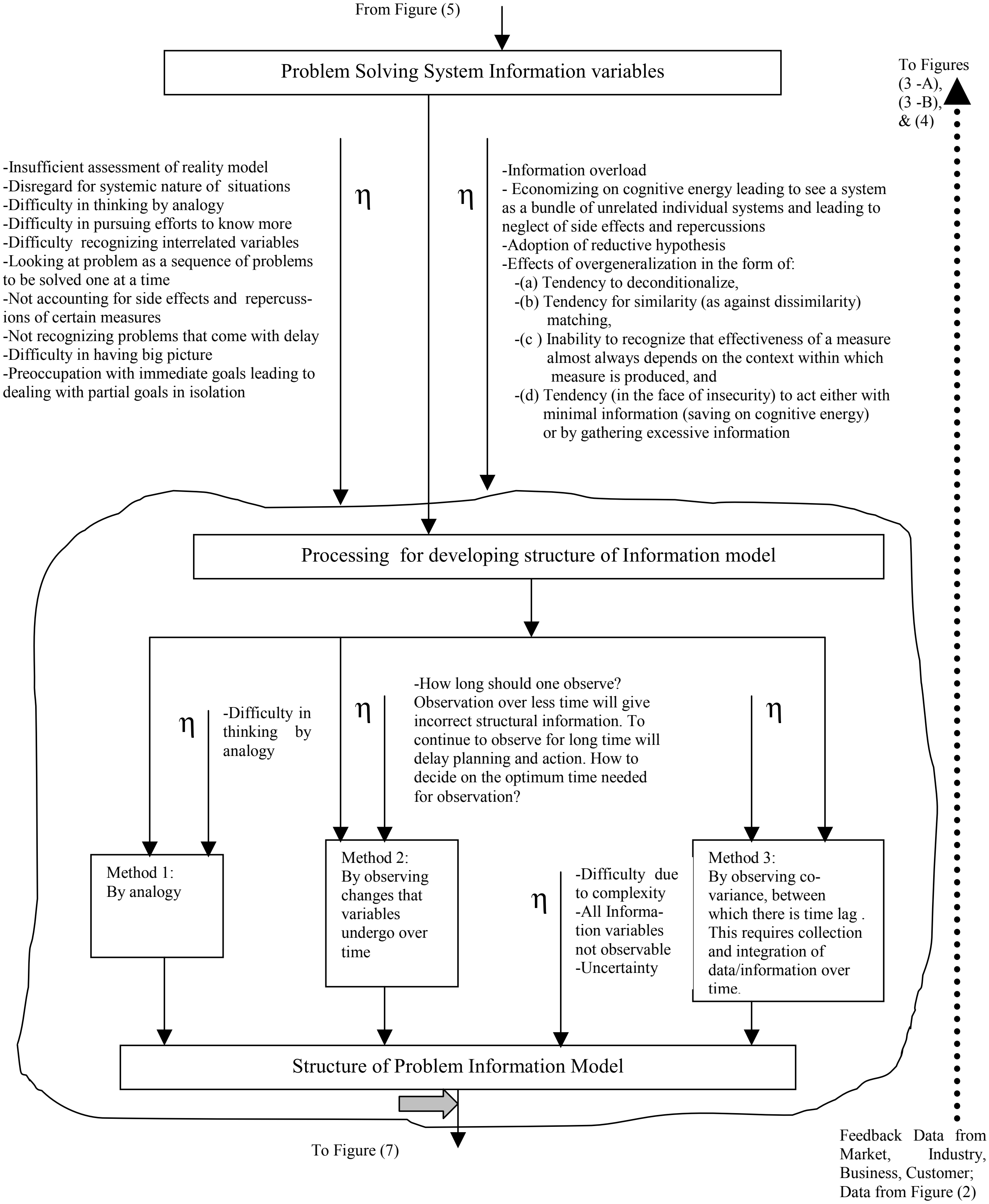


Figure (5): Systems representation of Information base for Problem Information Structure Modeling – From Many Factor Information Variables to Problem Solving System Information Variables



-Insufficient assessment of reality model
-Disregard for systemic nature of situations
-Difficulty in thinking by analogy
-Difficulty in pursuing efforts to know more
-Difficulty recognizing interrelated variables
-Looking at problem as a sequence of problems to be solved one at a time
-Not accounting for side effects and repercussions of certain measures
-Not recognizing problems that come with delay
-Difficulty in having big picture
-Preoccupation with immediate goals leading to dealing with partial goals in isolation

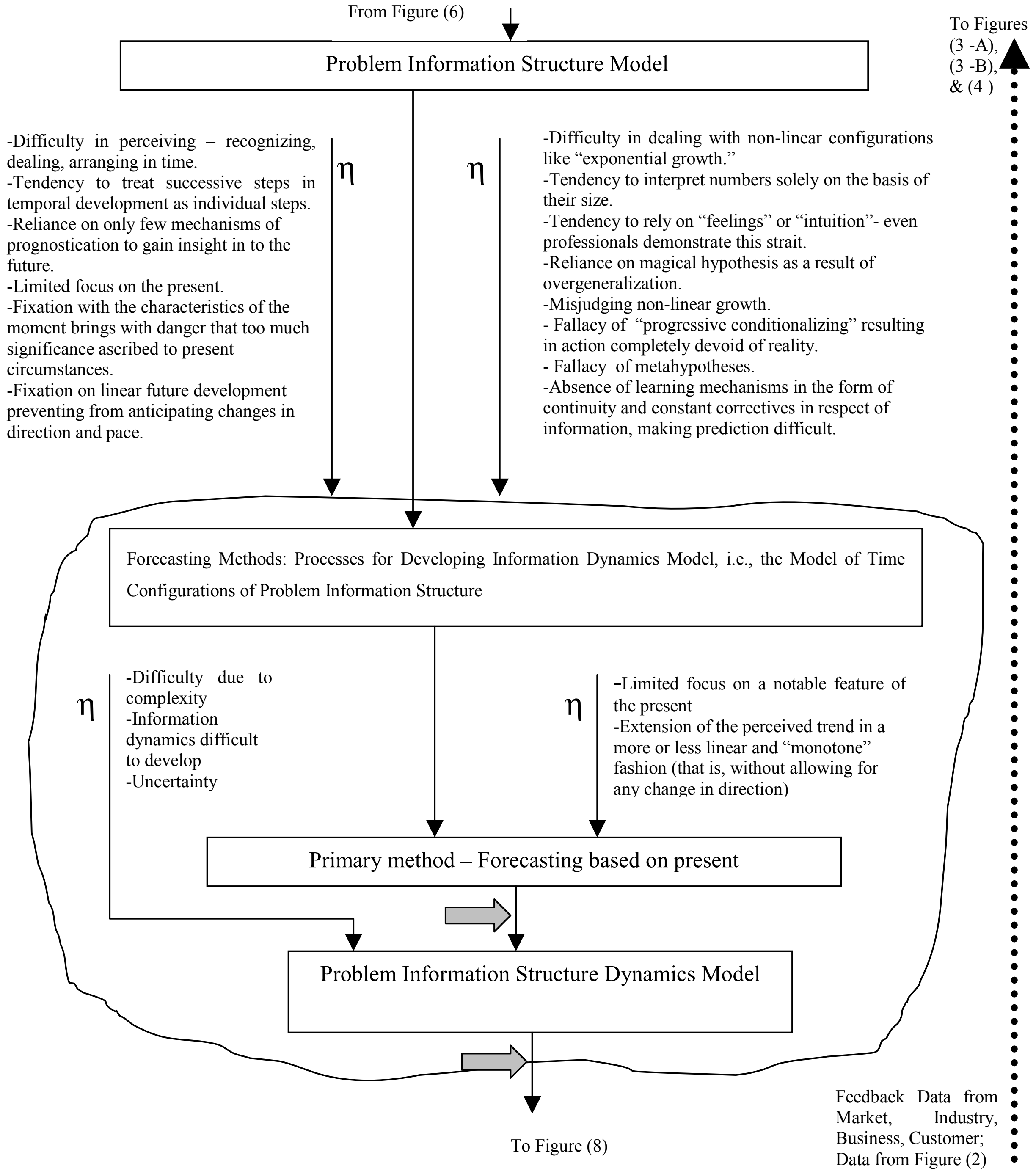
-Information overload
- Economizing on cognitive energy leading to see a system as a bundle of unrelated individual systems and leading to neglect of side effects and repercussions
-Adoption of reductive hypothesis
-Effects of overgeneralization in the form of:
  -(a) Tendency to deconditionalize,
  -(b) Tendency for similarity (as against dissimilarity) matching,
  -(c) Inability to recognize that effectiveness of a measure almost always depends on the context within which measure is produced, and
  -(d) Tendency (in the face of insecurity) to act either with minimal information (saving on cognitive energy) or by gathering excessive information

-Difficulty in thinking by analogy

-How long should one observe? Observation over less time will give incorrect structural information. To continue to observe for long time will delay planning and action. How to decide on the optimum time needed for observation?

-Difficulty due to complexity
-All Information variables not observable
-Uncertainty

Figure (6): Systems representation of Information base for Problem Information Structure Modeling – From Problem Solving System information Variables to Problem Solving Information Structure Model



-Difficulty in perceiving – recognizing, dealing, arranging in time.
-Tendency to treat successive steps in temporal development as individual steps.
-Reliance on only few mechanisms of prognostication to gain insight in to the future.
-Limited focus on the present.
-Fixation with the characteristics of the moment brings with danger that too much significance ascribed to present circumstances.
-Fixation on linear future development preventing from anticipating changes in direction and pace.

-Difficulty in dealing with non-linear configurations like "exponential growth."
-Tendency to interpret numbers solely on the basis of their size.
-Tendency to rely on "feelings" or "intuition"- even professionals demonstrate this strait.
-Reliance on magical hypothesis as a result of overgeneralization.
-Misjudging non-linear growth.
- Fallacy of "progressive conditionalizing" resulting in action completely devoid of reality.
- Fallacy of metahypotheses.
-Absence of learning mechanisms in the form of continuity and constant correctives in respect of information, making prediction difficult.

-Difficulty due to complexity
-Information dynamics difficult to develop
-Uncertainty

-Limited focus on a notable feature of the present
-Extension of the perceived trend in a more or less linear and "monotone" fashion (that is, without allowing for any change in direction)

Figure (7): Systems representation of Information base for Problem Information Structure Dynamics Modeling – From Problem Solving System Information Structure Model to Problem Solving Information Structure Dynamics Model

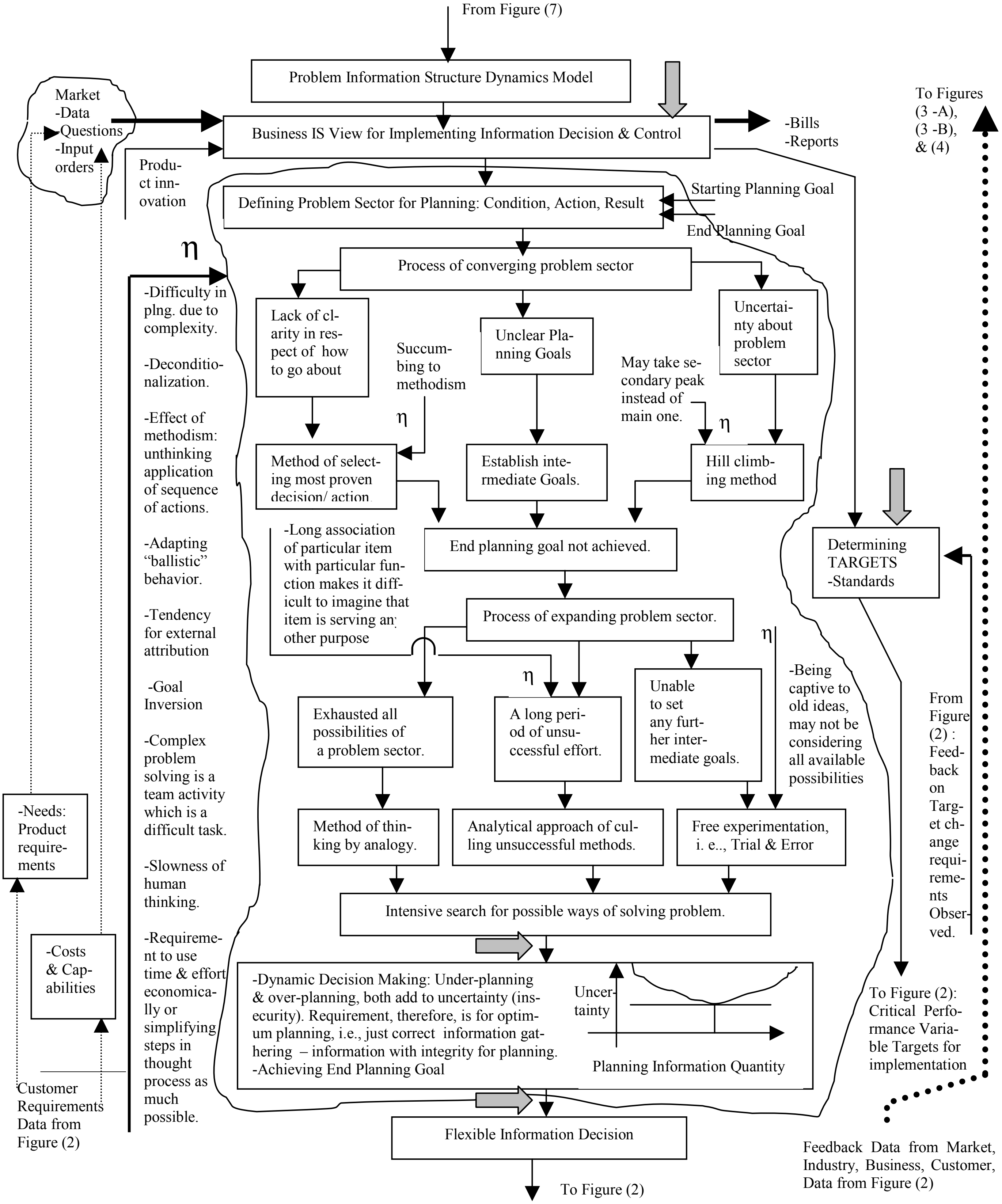


Figure (8): Systems representation of Information base for Flexible Information Decision - From Problem Information Structure Dynamics Model to Flexible Information Decision

4. Defining the Information Envelope

Modeling business process as integral to an information and control system facilitates application of modern control techniques for improved business performance for strategic advantage. Of course this requires means for acquiring process data and information on current basis. The latter requirement can be met with advances in computer integrated systems and with realization of relevant data and information driven technologies. Indeed, it is here that one sees the shift from 'information technology' to 'information' in dealing with the desired objective of strategic business advantage.

Traditionally, with emphasis being on standard products and cost reduction for strategic advantage, business reality model has been viewed as a closed system having structured and repetitive information requirements wherein information content is minimal. Information models were thus developed for meeting the functions of forecasting, evaluation of alternatives, and selection in respect of decision making requirements at various levels of management [1,7].

However, as argued through the paper, this reality model of business process is inadequate. Business process IS view is an open system and, as a result, for strategic advantage emphasis required is not so much on cost reduction in isolation but on maximization of informational value. This requirement in turn goes to suggest a more workable structure for information model comprising information bases as identified through Figures (3-8) in addition to that from Figure (2).

From Figures (2-8), in the form of improved information model, thus, what really one has at hand is a conclave of information bases and the same is termed as 'Information Envelope'. In view of open system character of the business process IS view, it is *for* this Information Envelope that information is required to be continuously gathered and processed. This enables to equip the information and control system model of business to meet the challenges of customization and financial optimization for competitive advantage in a complex and changing environment; in turn making the Information Envelope based informational view of the generic business process the central theme.

Figure (9) gives systems view of an Information Envelope as above characterizing an open, complex system.

5. Emergent All Encompassing View of Information Integrity

And, as shown through Figures (2) and (3-8), it is for this Information Envelope that information gathering and processing for each of its information bases is affected by uncertainties of the type not encountered traditionally, resulting in loss of I*I. This makes I*I, i.e. accuracy, consistency and reliability of Information Envelope, the key factor in determining the strategic business advantage.

Research investigations suggest I*I design basis by incorporating automatic feedback control systems [4,6]. Activity of goal setting is an important requirement in the functioning of open systems. Systems techniques have considered learning mechanism as a workable method to

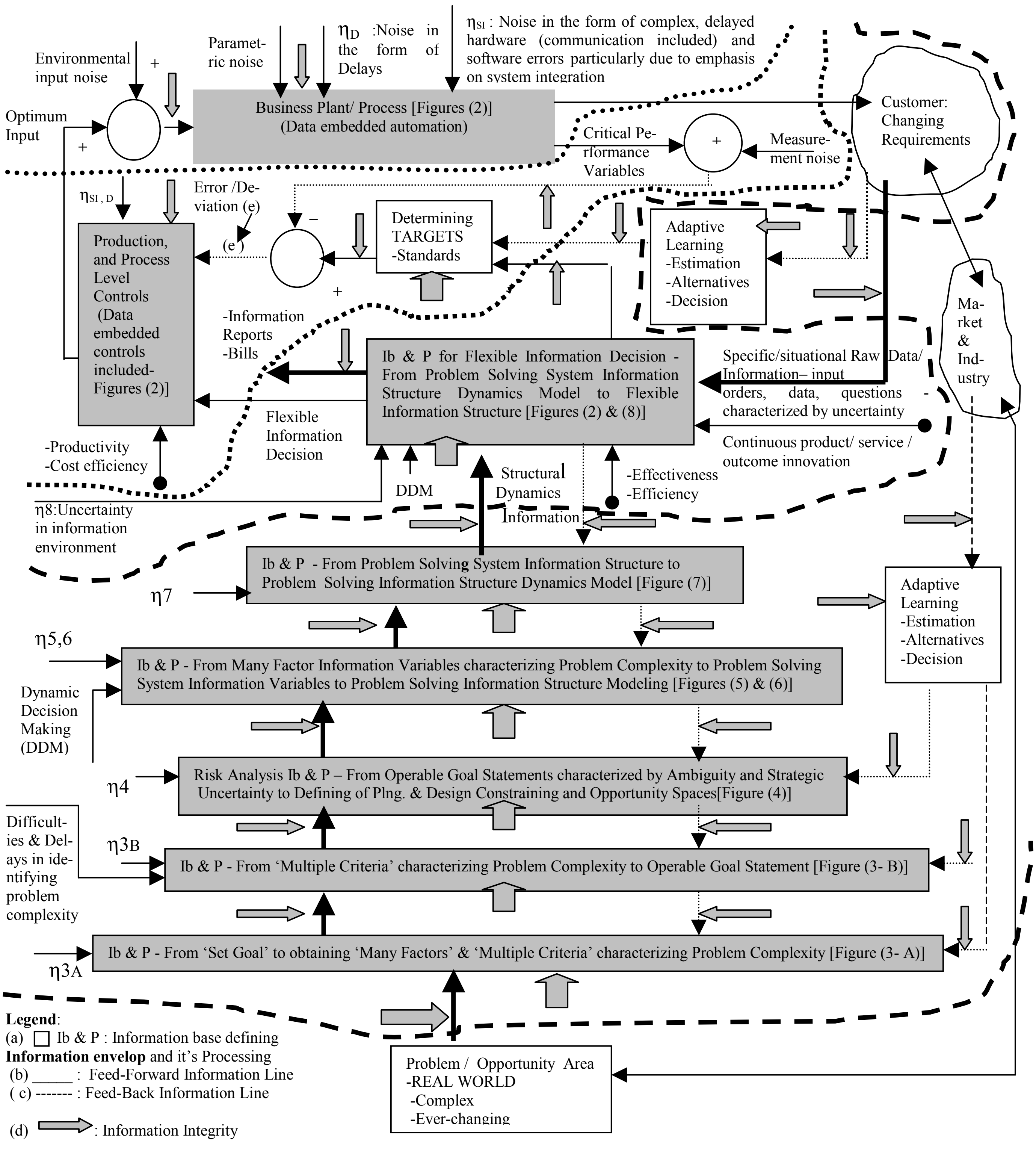


Figure (9): For a complex, changing environment, Systems View of a generic business process as integral part of a closed loop information and control system characterized by Information envelope and its processing in the presence of uncertainty and the emergent all encompassing view of INFORMATION INTEGRITY.

deal with uncertainty in a changing environment [6,13]. Also, as the concept of 'feedback' is implicit in 'learning' mechanism design, literature suggests that the 'automatic feedback control system' conceptualization of I*I Technology can be further extended to develop an adaptive learning based I*I planning framework for complex and changing IS environment characterized by uncertainty [6].

Details of these I*I Technology implementation aspects are outside the scope of the present investigation. However, within their framework and based on the view of the improved business IS model and of uncertainties therein developed in this paper so far, I*I implications can be conceptually indicated for different information bases and their respective processing stages under the Information Envelope [Figures (2-8)]. In the process what emerges is an all encompassing view of I*I as it applies across the information and control system model of the business process operating for competitive advantage in a complex and changing environment, and the same is given in Figure (9).

6. Conclusion

Generic business process covers entire supply chain form concept to delivery. A competitive business strategy calls for a good understanding of business process, which in turn requires choice of a good business model. Depending on research need such models could emphasize different facets as material, flow, equipment, money, information, etc. With advances in computer integrated systems and in data and information driven technologies, it has become possible to obtain process data and information on current basis and to manipulate it 'smarter' for strategic advantage. Specifically, what this leads to is an information and control system based model of which generic business process is an integral part. Therefore, competitive advantage can be achieved in a complex and changing business environment by systematically controlling the information processing under this business process IS view.

This requires a clearer perception of the nature of information processing. Most information processing involves some type of data conversion to information in use and, therefore, is closely related to a decision process with an objective. Even when the information is transmitted without changing form, as in a communication system, the issue is to decide the purpose or objective of the transmission.

Traditionally, within the system-engineering framework, decision process is viewed to comprise of stages of forecasting (prediction), evaluation of alternatives and selection. However, information and control system based model of a business process is an open system. For it more workable model of a decision process spans multiple stages. They are: initial problem recognition (goal setting); identifying information variables for a complex problem system; constructing problem solving opportunity and constraining spaces; developing information structure, and information structure dynamics models; and undertaking customized planning & design for development of alternatives for the evaluation of final choice for delivery of flexible information decision for control implementation.

What is significant is that all of the above stages from goal setting to final choice of flexible information decision for control implementation by themselves are complex information processing stages and, therefore, involve information gathering and processing activities with reference to their respective information bases. And of still greater implication is the reality that at each stage these information gathering and processing activities are affected by uncertainties; resulting in errors in information processed from stage to stage.

The Information Envelope comprising the information bases is thus characterized by loss of I*I at its all levels; thereby making Information Integrity key factor determining the strategic business advantage in a complex and fast changing environment.

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