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Web-Based Decision Support for E-Business Strategies: A Balanced Scorecard Approach

Fen Wang*

Information Technology & Administrative Management
Central Washington University
Ellensburg, WA 98926-7488, USA
wangfen@cwu.edu

Manuel Mora

Department of Information Systems
Autonomous University of Aguascalientes (UAA)
Aguascalientes, AGS 20100, México
mmora@securenym.net

Mahesh S. Raisinghani

School of Management
Texas Woman's University
CFO 405, Denton, TX 76204, USA
mraisinghani@twu.edu

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This paper describes the design and proof of concept of a web-based e-business decision-making support system (EBDMSS), to deliver a balanced scorecard (BSC)-based modeling and analysis in support of e-business strategic management. EBDMSS is designed, built and validated through a conceptual design research method. Its design is theoretically underpinned in three DMSS design schemes: an e-business BSC (EBBSC) framework for decision-making process (DMP), a DMSS architecture, and a DMSS design-evaluation framework. The EBBSC scheme aims to support e-business managers during the business strategy making process in a comprehensive, integrated, and continuous manner. The DMSS architecture and the DMSS design-evaluation frameworks help to deliver the expected design capabilities of an integrated DMSS. The paper reports related literature review, conceptual design methodology and principles, EBDMSS design and prototype implementation, and illustrates how practitioners can use this system to deliver a valuable range of embodied e-business strategy expertise in support of real-time decision making. The paper concludes with limitations of design, implementation and validation, recommendations for further research, and conclusions.

Keywords: Decision-making support system; e-business strategic management; balanced scorecard; e-business balanced scorecard framework; DMSS.

*Corresponding author.

1. Introduction

Huber and McDaniel[1] foresaw modern business organizational environment characterized by turbulence (more unpredictability by fast organizational changes), hostility (more organizational aggressive or offensive actions by market competition), and complexity (more differenced business entities and more interrelationships between them) attributes. Under such a new business environment, traditional static organizational designs for decision making are not useful and there is an imperative necessity to improve new and dynamic business decision-making process.[1,2] Huber and McDaniel[1] proposed that in stable, non-aggressive and uncomplicated business environments, any intuitive decision (e.g. not well elaborated through a formal or semi-formal decision-making process but rapidly chosen) will provide satisfactory outcomes. In contrast, modern dynamic business environments, such as e-business, demand a more elaborated decision-making process (DMP). As Raisinghani and Schkade[3] pointed out: "*perhaps, one of the best ways to succeed in the world of e-business is to start off with a dynamic and new e-business strategy*".

Diverse models for decision-making processes have been proposed in the core literature.[4–9] A main and widely accepted stream is based on the seminal model posed by the Nobel prize awarded scientist Herbert A. Simon.[10,11] The original model of Simon's consists of three phases: (i) "intelligence phase"[11] where the decision maker identifies a decision-making situation, its general objectives and collects pertinent quantitative and qualitative data; (ii) "design phase" where is elaborated a formal or semi-formal decision-making model (with alternatives, criteria, and risk preferences); and (iii) "choice phase" where the decision maker (usually supported by a computer-based tool) rates alternatives and select best set of them (it can be also only one action). Thus, a DMP can be defined as the process of selecting the course of action that best meets the decision criteria, subject to the constraints inherent in the decision-making situation (DMS).[9] A broader definition of DMP suggested by Huber and McDaniel[1] (1986) is as follows: "*...the sensing, exploration and definition of problems and opportunities as well as the generation, evaluation and selection of solutions*". In the last two decades,[12,13] Simon's seminal DMP has been extended to include two more phases: "implementation phase" (where decision or set of decisions are realized and controlled) and "learning phase" phase where metrics for the decision process and outcomes are collected, and learned lessons are expected to be included in a knowledge management system, for further utilization as an organizational memory.[14,15]

Consequently, specialized tools designed to support some or all phases of the DMP have been developed[16]: decision-making support systems (DMSS). Standard DMSS include decision support systems (DSS), executive information systems (EIS), and expert or knowledge-based systems (ES/KBS). Integrated DMSS are systems with these three components. Intelligent DMSS (i-DMSS) are enhanced systems with artificial intelligence (AI)-based mechanisms.[17]

In the context of e-business management, which can be characterized as highly dynamic, turbulent and hostile, the demand for a better DMP emerges as a relevant research and relevant issue. In this research, we are interested in supporting the strategy planning process in particular for e-business. DMSS literature reports successful traditional and intelligent DSS for supporting strategic planning process.[18–23] Similarly, for e-business arena, extensive research and solutions have been reported for decision support in general.[24–26] However, for strategic planning process from a modern perspective in particular, few of the previous studies offer an integrated decision support architecture (e.g. including DSS, EIS and ES) to facilitate e-business strategies in real applications.

Since modern strategic planning is strongly based on the balanced scorecard (BSC) model,[26] this scheme is used and adapted in this research. According to Kaplan and Norton,[26] a BSC model is a map which identifies and measures "sources of corporate value creation at each of four levels, or "perspectives" — financial, customer, process, and learning and growth". A BSC model helps visualize value generation from organizational resources to applications (e.g. as cause–effect relationships). Based on the original BSC model, an e-business BSC (EBBSC) framework has been proposed recently for e-business strategy.[27,28] Figure 1 illustrates the EBSSC framework. The EBBSC consists of four perspectives: (i) a business core, (ii) an analytic e-CRM, (iii) a process structure, and (iv) an e-knowledge network. According to Wang and Forgionne,[28] this model can provide design guidelines to translate e-business strategies into conceptual blueprints for strategic management control and performance evaluation. Additionally, it can provide a stable point of reference for businesses to understand and explore e-business initiatives such as decisional courses of action effectively.

Similarly to the standard view of BSC,[29] the four views reported in Fig. 1 assume a causal–effect linkage. It implies that: (i) an e-knowledge network based on knowledge innovations leads to a better process structure layer — based on more intelligent and integrated process for e-business — and to enable an analytic e-CRM layer; (ii) both process structure and analytic e-CRM layers, in turn, lead to a better financial business core layer. It is interesting to identify that such complex and dynamic systems can be modeled in the opposite mode (e.g. there are also feedback

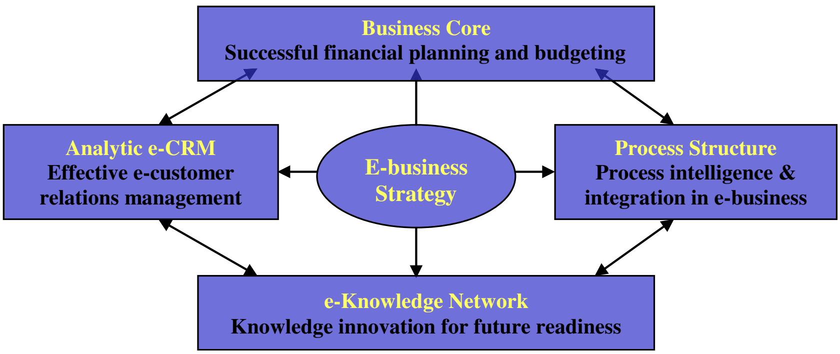

Fig. 1. The comprehensive EBBSC framework.

cause–effect relationships). From this perspective, a better financial business core layer administration in the organization will lead to better analytic e-CRM and process structure layers as well as a better e-knowledge network layer.

Hence, in this paper, we describe how this EBBSC framework, together with the other two DMSS design schemes, can be used to design an integrated DMSS — referred to as EBDMSS hereafter. Although we only report its design and proof of concept at this stage, we claim that EBDMSS provides sufficient functional capabilities to assist e-business managers, with analytical and technical skills not available in-house, via the specialized modeling and analysis components.[30–32]

The remainder of the paper continues as follows: in Sec. 2, we report the conceptual design research methodology; in Sec. 3, a review of related work on intelligent support for decision making in e-business arena is presented; in Sec. 4, the design, implementation (proof of concept) and a three-step validation of EBDMSS is reported; in Sec. 5, limitations, recommendations for further research, and conclusions are reported.

2. Research Methodology

To design and evaluate EBDMSS, a conceptual design (CD) research method is used.[33–36] According to March and Smith,[33] research can be divided into two main streams: behavioral (reality is non-modified) and design (reality is modified by the building and evaluation a new artifact). In general, building activity responds to the inquiry: "is it feasible to build an artifact X by using a design approach Y?", and evaluation activity responds to the inquiry: "does the artifact X fulfill the design range of a set M of expected metrics?".[33] Main usual design M metrics are usefulness and value of the artifact, but the metrics of the design process also can be incorporated. According to Glass *et al.*,[34] research approaches can be divided into descriptive, formulative, and evaluative ones. The approach of this research can be considered formulative and evaluative. In Hevner *et al.*'s framework,[35] there are seven design principles and four possible outputs (a construct, a framework-model, a methodology, or a system instance). This research generates a system instance (the EBDMSS prototype). Table 1 below reports the seven design principles and explains how this research is in compliance with these design principles.

CD research methodology consists of five activities: (CD.1) knowledge gap identification; (CD.2) methodological knowledge selection; (CD.3) CD; (CD.4) design data collecting; and (CD.5) solution analysis and synthesis. Table 2 provides more details about how these five activities were conducted in this research.

Thus, following such a CD research approach, we formulate the main research inquiry as follows: "*is it feasible to design and build a* [*X: EBDMSS*] *to achieve the following set of design objectives* [*O*] = {*o*1: *it is theoretically valid*, *o*2: *it is implementable with standard technology*; *o*3: *it provides the expected capabilities*; *o*4: *it is perceived with adequate levels of usefulness, ease of use, and Forgionne's DMSS process and outcomes metrics*} *and the following set of restrictions* [*R*] = {*r*1: *it is*

Table 1. Compliance to Hevner *et al.*'s design research guidelines.

Id	Guideline	Compliance to the guideline
1	*Design as an artifact: Design-science research must produce a viable artifact in the form of a construct, a model, a method, or an instantiation.*	A new web-based DSS (called EBDMSS) is designed, built and proved (e.g. a proof of concept in a realistic scenario).
2	*Problem relevance: The objective of design-science research is to develop technology-based solutions to important and relevant business problems.*	The strong need of having an affordable tool to support strategic decisions in highly dynamic and challenging e-business environment has been reported in the current e-business literature.
3	*Design evaluation: The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods.*	Among the six evaluation methods reported, this research uses analytical and descriptive techniques. The artifact is validated via analytical techniques because (i) it fits DSS general design criteria evaluated by a panel of DSS experts, and (ii) it fits the architectural functionality expected in the design goals. The artifact is validated also via descriptive technique as its utility is proved with a realistic scenario.
4	*Research contributions: Effective design-science research must provide clear and verifiable contributions in the areas of the design artifact, design foundations, and/or design methodologies.*	Research design contributions include the (i) designed artifact itself, (ii) the foundations for designing web-based DSS focused on strategic decisions using a BSC model, and partially (iii) providing an example of more design-science oriented design methods in the arena of DSS.
5	*Research rigor: Design-science research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact.*	Methodological rigor is satisfied through the utilization of the conceptual design research method based on Mora *et al.*,[36] March and Smith,[33] and Glass *et al.*[34] It also satisfies Hevner *et al.*'s.[35] criterion for a problem to be considered for design research versus routine design: "*Design-science research in IS addresses what are considered to be wicked problems . . . That is, those problems characterized by . . . complex interactions among subcomponents of the problem and its solution*".
6	*Design as a search process: The search for an effective artifact requires utilizing available process means to reach desired ends while satisfying laws in the problem environment.*	Design as a process — in Artificial Intelligence discipline — can be defined as the time–space-economical feasible localization/generation of a feasible node in the solution space under the satisfaction of the goal and related constraint set. For complex problems, this is an iterative process guided by axioms — if available — or heuristics. This research, given the complexity of the conceptual construct, requires such a heuristic design process based on DSS literature, BSC literature and design literature.
7	*Communication of research: Design-science research must be presented effectively to technology-oriented as well as management-oriented audiences.*	Design research is presented effectively to both web-based DSS designers (design issues) and DSS business users (functionality issues).

Table 2. Research activities of CD research.

Research activity	Inputs	Process	Outputs
CD.1 Knowledge gap identification	* Initial research goals * Conceptual units of study	1.1 Selection of studies by (i) recognition of authors; and (ii) comprehensibility of studies 1.2 Identification of contributions and limitations in studies regarding the research goals. 1.3 Relevance validity assessment of the knowledge gaps	* The confirmed and refined research goals * The relevant knowledge gaps
CD. 2 Methodological knowledge selection	* Confirmed and refined research goals * Relevant knowledge gaps * Conceptual units of study	2.1 Definition of the research purpose (conceptual exploratory or full design) 2.2 Assignation of unit of studies between researchers 2.3 Selection of the design approach (heuristic or axiomatic)	* The research purpose * The work plan
CD. 3 CD	* Conceptual units of study	3.1 Designing of the construct, framework/model/theory, method, or system/component (not instanced in a real object) by applying the selected design approach	* The conceptually designed artifact
CD. 4 Design data collecting	* Conceptual designed artifact	4.1 Identification of conceptual units for testing 4.2 Application of conceptual units for testing 4.3 Face validity from a panel of experts (not involved in the design team)	* The conceptually designed and tested artifact (initially used with internal test data) * The face validity assessment
CD. 5 Analysis and synthesis	* Conceptual designed artifact tested (initially used with test data) * Face validity assessment	5.1 Analysis (direct insights) and synthesis (emergent insights) of findings derivable from the designed conceptual artifact	* The contributions from the conceptually designed artifact

economically affordable (*labor and TI costs*); *r*2: *it can be developed in a suitable timeframe* (*1 year*)}, *by using a design approach* [*DA*] = {*design philosophy* [*DP*] = {*dp*1:*rational design*}, *design theories* [*DT*] = {*dt*1:*EBBSC framework*; *dt*2: *Forgionne's DMSS Framework*; *dt*3:*DMSS Design and Evaluation Framework*}, *design methods* [*DM*] = {*dm*1:*DMSS generic engineering method*}, *and design parameters/components* [*DP*] = {*dp*1: *DSS module*, *dp*2: *EIS module*; *dp*3: *ES module*)?". This paper reports the accomplishment of the design objectives o1, o2 and o3.

3. Literature Review and Synthesis on DMSS for Supporting Strategic Planning in E-business

DMSS have evolved over time and across disciplines.[30,37,38] DMSS has progressed from simple data access and reporting to complex analytical, creative, and intelligent support. With the rapid development of Internet technology, web-based decision support has become part of the evolution. Whether web-based or local, an intelligent DMSS is an interactive and dynamic management system that supports non-routine decision-making and evaluation.[39] Attention has focused on decision technology in support of various e-business activities, but there has been a paucity of research on DMSS for e-business strategy making. Some research on the state of art or the trends and potentials of decision technology mediated e-business,[40–48] found that rapid advancements in data warehousing, OLAP, data mining, intelligent agents, and the Internet technology add new and powerful capabilities to DMSS.

Other studies offer conceptual decision support models in support of general e-business applications.[24–26] A number of these studies focus on web-based decision support from the online customer's perspective[49–54] and most of these studies focused on conceptual models without establishing practical decision support prototypes. Figure 2 illustrates this evolution by highlighting the dominant decision support techniques during each decade.

A third group of studies present DMSS prototypes to facilitate particular e-business activities. Examples include a worldwide real-time decision support system that delivers operations research (OR) tools to facilitate e-commerce applications,[55] web-based decision support applications using statistical analysis software (SAS) for data management, statistical analysis and forecasting,[56] and a web-based physician profiling system (PPS) to manage customer relationships through e-business decision support applications.[57]

Others present intelligent product recommendation systems for e-commerce,[58] a business to business (B2B) approach that deals with e-business people interactions and negotiation to settle strategic differences,[59] and agent-based merchandise management support systems for B2B e-commerce.[60] Still others offer a web-based consumer-oriented intelligent DSS for personalized e-services.[61]. Al-Qaed and Sutcliffe[62] designed an adaptive DSS (ADSS) for e-commerce that matches the appropriate tool support and decision strategy advice to the user's preferences and motivations. Their focus was on providing proper system advice during operation

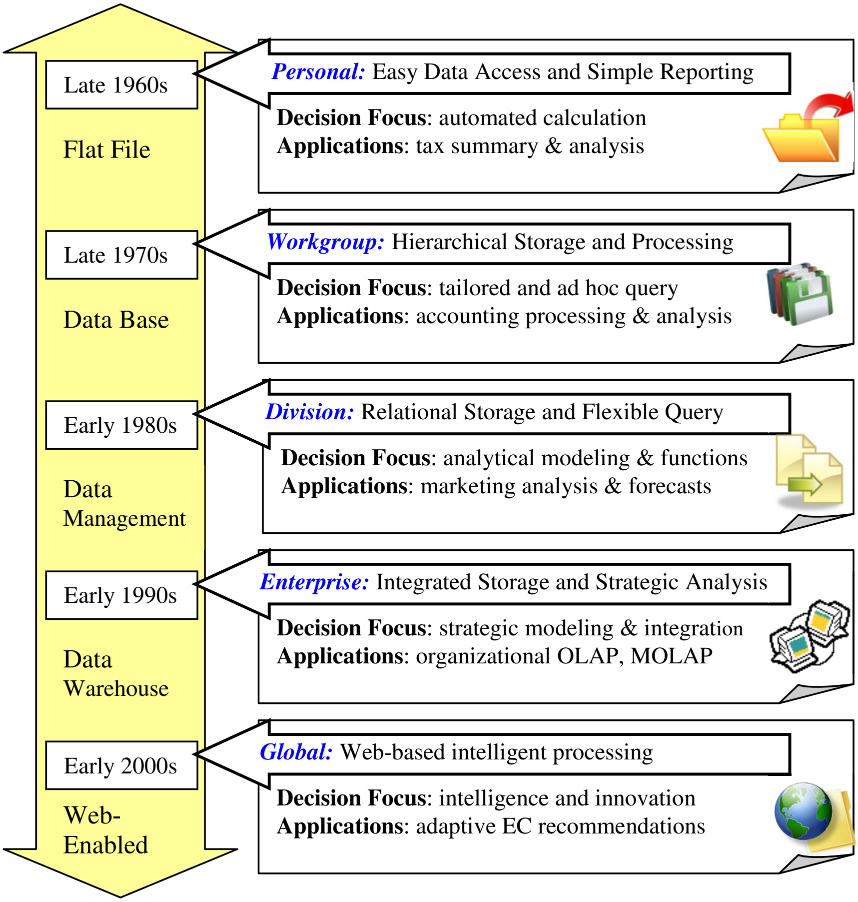

Fig. 2. Evolution of decision support techniques.

rather than providing an integrated decision support framework to guide strategies. In addition, McGregor *et al.*[63] presented a shareable, Internet-based intelligent decision support system for on-demand business process management. More recently, Denguir-Rekik *et al.*[64] developed a multi-criteria DMSS to aid the marketing team of an e-commerce organization in its activities. In Chongwatpol and Sharda,[65] a spreadsheet-oriented DSS was implemented to help making telecommunications pricing decisions for state networks.

Hence, despite of the relevant activities supported for decision-making in the e-business context, none of the previous studies offer integrated decision support architectures to specifically facilitate the e-business strategies in real applications. The reported DMSS — called EBDMSS — aims to close this research gap by linking business strategies to a broad range of measures, examining important business issues facing e-business managers, and providing a complete and integrated view of e-business strategic management.

4. EBDMSS Design, Implementation and Validation

4.1. *EBDMSS design*

Three DMSS design theories were used for designing the EBDMSS: (i) EBBSC framework, (ii) Forgionne's DMSS[30] design framework,[28] and (iii) intelligent DMSS design and evaluation framework.[9] DMSS designed using the EBBSC framework (see Fig. 1) helped to identify four functional capabilities (e.g. the objective design o3): (1) precisely forecasting the e-market demand/supply quantity and total profit, (2) accurately making long-term and short-term e-business strategy plans, (3) explaining, justifying, and reporting the outcome forecasts and recommendations, and (4) performing effective simulation experiments with proposed policy changes (pricing, advertising, etc.) and marketing conditions (competition, coordination, and so forth).

The Forgionne's DMSS[30] design framework,[28] helped to identify that the EBDMSS have to provide an input-processing-output layer design architecture. It must contain a DSS, an EIS, and an ES module for processing layer. The input layer must comprise database/s (decision data), knowledge base/s (problem knowledge), and model base/s (business model solution methods). Finally, the output layer must comprise reports, forecasts, actions plans, explanations and advices in the specific domain of application.

Finally, the Mora *et al.*'s[13] DMSeS design and evaluation framework helped to identify that the EBDMSS must provide adequate (but not necessarily advanced) processing, data-information-knowledge, and user interface capabilities. By using this framework, a system can deliver the scaled computational capabilities: five levels for processing and data-information-knowledge layers and three levels for user interface layers.

The five processing levels are (i) simple and standardized SQL processing, (ii) optimization calculations, (iii) fuzzy processing, (iv) semi-structured problem solving methods, and (v) ill-structured problem solving methods (e.g. advanced artificial intelligence-based hybrid techniques). The five data-information-knowledge layers are (i) minimal DBMS and (ii) multi-dimensional DBMS representations, (iii) numerical models, (iv) knowledge bases, and (v) distributed knowledge bases (can be ontologies). The three levels for user interface are: (i) normal text and graphics (GUI), (ii) multimedia, and (iii) virtual worlds and natural language processing. According to Mora *et al.*,[13] most DMSS reported in the literature (academic demos and real cases) have only deployed the normal and standard layers, due to the complexity, cost and effort involved in elaborating higher level layers (in academic settings mainly).Capabilities target levels expected by the EBDMSS are reported in Table 3 (the symbol • means addressed while the symbol — means not addressed).

By applying iteratively the steps: CD.3 CD, CD.4 design data collecting and CD.5 solution analysis and synthesis, a final EBDMSS architecture is established. Figure 3 below illustrates the EBDMSS architecture.

Table 3. DMSS design and evaluation framework.

Decision phase	Decision step	Processing layer					DIK layer					UI layer		
		(1) SQL-based	(2) Optimization PS	(3) Fuzzy PS	(4) Semi-structured PS	(5) ILL-structured PS	(1) DBMS	(2) M-DBMS	(3) Numerical models	(4) Knowledge bases	(5) Distributed KB	(1) Text and graphics	(2) Multimedia	(3) Virtual and NLP
Intelligence	Data gathering	•	•	—	•	—	•	•	•	•	—	•	—	—
	Problem recognition	•	•	—	•	—	•	•	•	•	—	•	—	—
Design	Model formulation	•	•	—	•	—	•	•	•	•	—	•	—	—
	Model analysis	•	•	—	•	—	•	•	•	•	—	•	—	—
Choice	Evaluation	•	•	—	•	—	•	•	•	•	—	•	—	—
	Selection	•	•	—	•	—	•	•	•	•	—	•	—	—
Implementation	Result presentation	•	•	—	•	—	•	•	•	•	—	•	—	—
	Task planning	•	•	—	•	—	•	•	•	•	—	•	—	—
	Task tracking	•	•	—	•	—	•	•	•	•	—	•	—	—
Learning	Outcome-process analysis	—	—	—	—	—	—	—	—	—	—	—	—	—
	Outcome-process synthesis	—	—	—	—	—	—	—	—	—	—	—	—	—

The theoretical links between Figs. 1 and 3 are illustrated as follows: (i) the analytic e-CRM layer is represented by the marketing mix, e-service quality, and customer satisfaction components, all of which are pertinent to making newcomer acquisition and customer retention strategies; (ii) the process structure layer is specified as the process intelligence and process integration components that eventually lead to reduced overhead, shorter cycle time and shortened sales cycle; (iii) the e-knowledge network layer is manifested in the staff proficiency component and the corresponding decision factors such as staff training and qualification and knowledge network efficacy; (iv) all of the aforementioned components and decision factors eventually lead to a better financial business core layer, which can be measured with the revenue increase and cost reduction components.

While in the software engineering domain, the service-based design approach is emerging as the top design method, it has been much less explored in the DMSS arena. Consequently, a well-established object-oriented (OO) conceptual modeling approach was used to avoid unnecessary design risks. An OO design is useful to uniformly represent classes and relationships of items, services, consumers, vendors, as well as decision procedures, data, models, and knowledge. To enable intensive, dynamic, and speedy applications of data inquiry, update, and management to support strategic decision making with a low-cost implementation, we select the MS

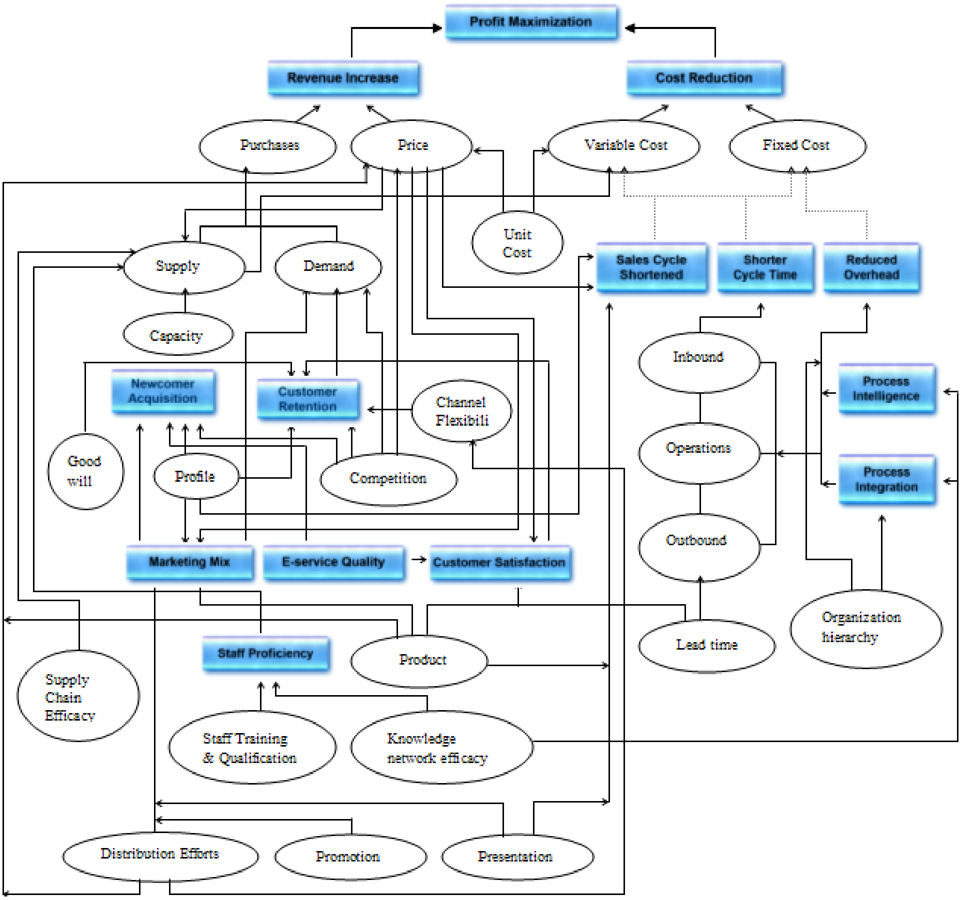

Fig. 3. EBDMSS architecture.

access database technology. It was enhanced with the ADO.Net connection, which provides easy and consistent access to data sources. Important remark is that due to the standardization of SQL language, this design can be translated seamlessly for more powerful IT solutions (e.g. MS-SQL server, Oracle, SAS server).

In brief, the EBDMSS is implemented as a web-based decision support application using affordable (low cost) IT solutions. Figure 4 illustrates the main components of the EBDMSS that a user can access.

Once that the user enters in the system, he/she can perform the e-business strategic management analysis and evaluations by navigating with point and click operations through the display pages illustrated in Fig. 4. These operations can invoke the EIS, DMSS, and ES components of the integrated EBDMSS. As it was aforementioned, they can also be supported with more advanced business intelligence (BI) software such as IBM Cognos or SAS BI.

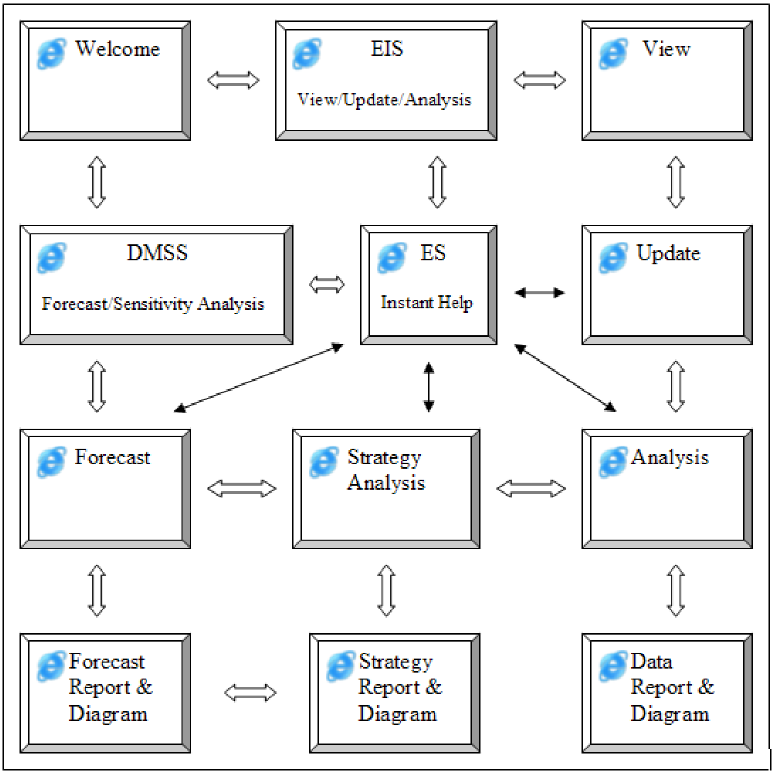

Fig. 4. EBDMSS work flow overview.

As illustrated in Fig. 4, the main functionality of the 12 components is described as follows: (i) the WELCOME component is the entry point to the system that enables the authorized users to access the EBDMSS. Once in the system, the user can interactively select the EIS or go directly to the DMSS; (ii) from the EIS module, the user will be able to interactively select, View, Update, and perform advanced Data Analysis using functions such as "Filter" and the Visual Basic.Net data form classes, which is possible to protect columns and validate data entries, to generate audit trails which record who changed what and when, and to handle user input interactions. Within the EIS module, if desired, all ad hoc query reports, data updates, and graphic data analysis reports can be printed and transformed into other desired formats; (iii) selecting the DMSS element from the WELCOME display will invoke the functions of the DMSS component. Within this module, the user can compute and estimate the e-business revenue and cost, and generate the e-business forecasting and strategy reports; (iv) specifically, In the FORECAST session, the user will be able to specify e-business strategy initiatives and view the corresponding forecasted outcomes. From the FORECAST REPORTS view, the user can obtain detailed explanations to support outcome reports by selecting the "Details" choice. The detail reports offer explanatory computations that justify the summary report; (v) alternatively, if the user selects the STRATEGY ANALYSIS session, s/he can compare and analyze multiple strategy plans and the corresponding outcomes. With the STRATEGY REPORT and plot chart analysis, the user will obtain a clear picture of the projected relationship between a specific input plan and the forecasted outcome. As a result, the user will understand better the effect of the input decisions on the outcomes and plan better accordingly; (vi) throughout the EIS and DMSS sessions, instant and intelligent help readily available in the form of a list of required inputs and explanations for strategy plan inputs, general guidance for selecting decision alternatives and explaining problem relationships, and heuristics for interpreting decision outcomes and making plan changes. Such intelligent assistance is provided through the ES component built upon a cumulative knowledge base of EBDMSS.

In Fig. 5 some sample screenshots of EBDMSS are displayed. In a typical e-business strategy session, the manager will explore new opportunities and problems or conduct a strategy evaluation. If the session involves exploration, management will be facilitated with patterns and suggestions presented for consideration and refinement.

Strategy evaluation can be facilitated by providing a vehicle for the e-business manager to quickly examine potential alternatives, study the consequences, and refine the analyses dynamically as the results unfold. These typical scenarios are fully supported by the EBDMSS web-based prototype.

4.2. *EBDMSS validation*

In this research, with the aforementioned design objectives and restrictions, the validation process was conducted in three steps: (i) a theoretical validation realized by a panel of experts, (ii) a conceptual validation of the EBDMSS capabilities in comparison to an ideal system, and (iii) a proof of concept internal validation to verify that the proposed functional capabilities were appropriately implemented.

The theoretical validation of this model is already reported in Wang and Forgionne,[28] It was realized by a panel of experts who after several rounds and corrections approved the theoretical model. Although it can be assumed that at least one valid theoretical design can be realized for stable domains (e.g., the solution space design is not empty), it cannot be taken for granted that it can be realized within some constraints (cost, time, and/or fit to some predefined theories). Actually, for some engineering problems, the complexity of the solution space precludes such a premise (e.g., it is always possible to find a theoretically valid design). However, the opposite is true: it has been proved that solutions (algorithms) for some kind of problems (see Halt's problem from Theoretical Computer Science) do not exist.

Table 4 illustrates the DMSS Evaluation framework.[9] It consists of thee decisional service layers (analysis, synthesis, and hybrid) versus the decisional phases and steps. Decisional analysis services are useful for pre-classified solutions. Decisional synthesis services are useful during building the process solutions phase (e.g. they need to be

Fig. 5. EBDMSS sample screenshots.

assembled from smaller pieces). Hybrid decisional services are a mix of the analysis and synthesis types and in general considered to be more difficult services than either type. Decisional target service levels achieved by EBDMSS are reported in Table 4 (by symbols • and — means not addressed). According to Mora *et al.*[13] most i-DMSS reported in the literature during the 1990–2003 period fulfill approximately less than 50% of the expected and ideal capabilities. Thus, we believe that this EBDMSS design fulfills expected DMSS capabilities for academic research contexts.

The third evaluation — a proof of concept internal validation — was performed in the context of an operating e-business entity at eBay featuring a typical e-store

Table 4. DMSS design and evaluation framework.

Decision phase	Decision step	Analysis services				Synthesis services				Hybrid services				
		Classify	Monitor	Interpret	Predict	Configure	Schedule	Formulatate	Plan	Explain	Recommend	Modify	Control	Learn
Intelligence	Problem detection	—	•	—	—	—	—	—	—	—	—	—	—	—
	Data gathering	—	•	—	—	—	—	—	—	—	—	—	—	—
	Problem formulation	—	•	—	—	—	—	—	—	—	—	—	—	—
Design	Model classification	—	—	—	—	—	—	•	—	—	—	—	—	—
	Model building	—	—	—	—	—	—	•	—	—	—	—	—	—
	Model validation	—	—	—	—	—	—	•	—	—	—	—	—	—
Choice	Evaluation	—	—	—	•	—	—	—	—	—	—	—	—	—
	Sensitivity analysis	—	—	—	•	—	—	—	—	—	—	—	—	—
	Selection	—	—	—	•	—	—	—	—	—	—	—	—	—
Implementation.	Result presentation	—	—	—	—	—	—	—	—	—	•	—	—	—
	Task planning	—	—	—	—	—	—	—	—	—	•	—	—	—
	Task monitoring	—	—	—	—	—	—	—	—	—	•	—	—	—
Learning	Outcome-process analysis	—	—	—	—	—	—	—	—	—	—	—	—	—
	Outcome-process synthesis	—	—	—	—	—	—	—	—	—	—	—	—	—

using simulated testing scenarios of each function module within the EBDMSS (please refer to Fig. 5 EBDMSS sample screenshots for sample system display and views). Table 5 summarizes the expected functional capabilities and how these were delivered by the EBDMSS system during the simulated testing scenarios.

Without a decision support system, the manager's business management operations are normally time-consuming and manually handled. His/her decisions are

Table 5. EBDMSS proof of concept evaluation.

Functional capability	Evidence of implementations in EBDMSS
(1) Timely gathering and analyzing data about business status and trends	Verified by simulated testing results of the ANALYSIS session within the EIS module.
(2) Precisely forecasting the e-market demand/supply quantity and total profit	Verified by simulated testing results of the FORECAST session within the DMSS module.
(3) Accurately making long-term and short-term e-business strategy plans	Verified by simulated testing results of the STRATEGY ANALYSIS session within the DMSS module.
(4) Explaining, justifying, and reporting the outcome forecasts and recommendations	Verified by simulated testing results of the STRATEGY ANALYSIS and corresponding STRATEGY REPORT sessions within the DMSS module together with the help of the ES component.
(5) Performing effective simulation experiments with proposed policy changes (pricing, advertising, etc.) and marketing conditions (competition, coordination, etc.)	Verified by simulated testing results of the STRATEGY ANALYSIS and corresponding STRATEGY REPORT sessions within the DMSS module together with the help of the ES component.

generally made based on his/her experience and the available raw data provided by the eBay system. It is difficult to find the patterns underlying the business operations and therefore hard for the manager to employ effective strategies in his/her e-business management.

In the simulated scenarios, the testing user opens the EBDMSS page and views the saved records through the EIS component where he/she is able to view the previous business data by specifying the period or factor where if he/she is curious about what type of product has the highest sales in the past week, he can view the last seven days records by specifying the data range by time period and then sort the data by quantity demanded. If the subject is concerned about the quantity he has supplied during the past month, he can analyze the last seven days records by comparing the factor of quantity supplied with histograms generated by the EBDMSS. This organized and formatted data will provide a better understanding of the underlying business processes and possible uncover problems within the processes. The investigation should help the user form ideas about which and how many products he will put on sale for a particular selling period.

The testing user can also use the DMSS component of the EBDMSS to make decisions on the price, quantity for sale, and other critical factors. For example, he decides to sell an N scale British Columbia railway 50′ boxcar today but is not sure about how much he should ask for it or how many he would offer for sale during one selling period. In addition, he would like to know the effect of his decisions on the potential profit such as which channel to sell it, and so on. So the user enters the "Forecasting" page via the DMSS page. From there, he enters the required set of inputs and then clicks the "Enter" button to view the projected outcome. According to the simulated testing results generated by the DMSS component, the system recommends selling this product at a particular starting bid price, given the specified selling channel to be an auction. The projection also shows that the expected profit is for this specified testing strategy setting.

In another testing scenario, the user is uncertain about whether to sell a HO scale engine and a set of adhesive weights for HO scale engines together or to sell them separately. Then the user inputs two possible strategy plans, one of which treats the engine and the adhesive weights set as one product package while the other implements them as two separate product sets. By comparing the different projected outcomes (the total profit for the product package and the sum of two product profits), the user decides to sell them as a package as this option generates higher projected profit. Furthermore, the user can enter multiple strategy plans and view the strategy outcomes comparison in charts and diagrams at once by selecting the "Analyze" session from the DMSS page. The strategy analysis report offers the user a specific and clear picture of the projected relationship between the supply and the total cost and thereby enables the user to plan more effectively on the quantity to be supplied during a particular selling period.

In summary, the three-step system validation strategy, including a theoretical validation, a conceptual framework evaluation, and a proof of concept testing,

Table 6. Design validation summary.

Category	Item		Compliance
Design guidelines[35]	Seven design guidelines		Table 1 reports all issues related with the compliance to the seven design guidelines.
Design goals	{o1: it is theoretically valid }		A panel of three DSS experts considered the EBDMSS architecture theoretically valid.[28]
	{o2: it is implementable with standard technology}		EBDMSS was built using very standard TI (MS-Access + VBasic + HTML + Internet Browser).
	{o3: it provides the expected capabilities}	(1) Precisely forecasting the e-market demand/supply quantity and total profit	Verified by simulated testing results of the FORECAST session within the DMSS module.
		(2) Accurately making long-term and short-term e-business strategy plans	Verified by simulated testing results of the STRATEGY ANALYSIS session within the DMSS module.
		(3) Explaining, justifying, and reporting the outcome forecasts and recommendations	Verified by simulated testing results of the STRATEGY ANALYSIS and corresponding STRATEGY REPORT sessions within the DMSS module together with the help of the ES component.
		(4) Performing effective simulation experiments with proposed policy changes (pricing, advertising, etc.) and marketing conditions (competition, coordination, etc.)	Verified by simulated testing results of the STRATEGY ANALYSIS and corresponding STRATEGY REPORT sessions within the DMSS module together with the help of the ES component.
	{o4: it is perceived with adequate levels of usefulness, ease of use, and Forgionne's DMSS process and outcomes metrics}		This experimental validation is pursued in next stage.
Design constraints	{r1: it is economically affordable (labor and TI costs)}		The TI used for building EBDMSS is highly affordable. Its TI costs are approximately 3,000 USD.
Proof of concept	{r2: it can be developed in a suitable timeframe (1 year)}		EBDMSS despite its complexity functionality was designed and built over 1.25 years.

verifies that the EBDMSS satisfies the aforementioned design guidelines, requirements, and goals for EBDMSS implementation. Table 6 presents an integrative summary of the three-step validation strategy as well as the outcomes and compliance evidences.

4.3. *Implications of EBDMSS implementation and outcome evaluation strategies*

In designing a system, information system specialists often consult with end users, identify current and potential requirements, and then design the system to meet the identified requirements with prototyping and other rapid application development (RAD) tools,[30,66–68] the focus has been put on efficiency, cost effectiveness, and user acceptance. In the context of the present study, three basic requirements for such an EBDMSS were identified at the beginning: (1) the practitioners should be provided a friendly and adaptive interface[62,70]; (2) the users should be able to manage data in a transparent and visual way[71]; (3) the managers should get timely, integrated, and intelligent support throughout the decision making process.[30,63]

Set against this current field setting, the EBDMSS has been designed, developed, and implemented with an adaptive design strategy that relied on rapid prototyping and interfacing, and other forms of RAD tools. Besides the heavy use of prototyping, several new strategies were utilized and evaluated in the process. These strategies, which involved but were not limited to adaptive development and three-step system validation methodologies, offer important lessons for successful design, development, and implementation of future decision making support systems.

Generally, the adaptive development strategy relied heavily on computer aided software engineering (CASE) and object-oriented analysis (OOA), using Microsoft's Visual Studio.Net System. As with previous studies, these approaches have led to a greater clarity of usage, more ease of development, and reusability for future enhancements.[72] The Visual Studio.Net system based e-business planning reports or graphs can be viewed in corresponding HTML format for rapid distribution via the web and can also be saved to the local computer for future reference. The current Visual Studio.Net version provides new web-enabled data visualization capabilities which enable us to embed interactive graphics in a web page.[72] The design and development experiences suggest that decision making support systems can be effectively implemented through such an adaptive design strategy to satisfy the first two basic requirements for EBDMSS implementation (i.e. to provide a friendly and interactive interface and allow users to manage data in a transparent and visual way). While the Visual Studio.Net system offers one such suite, there are others available, such as the SAS system for Information delivery. Studies that utilize such alternative integration tools can broaden the application base, and confirm or refute the findings from this study.

The three-step system validation strategy helps verify the satisfaction of the third requirement for EBDMSS implementation (i.e. to provide timely, integrated, and intelligent support throughout the decision making process). A theoretical validation of EBDMSS was firstly performed to assess the soundness of the underlying EBBSC framework and the DMSS design framework,[28] which provides the conceptual foundation for building the system. Secondly, the Mora, Forgionne, Cervantes *et al.*[9] DMSS evaluation framework was utilized to verify that the EBDMSS provides adequate and ideal DMSS capabilities on three decisional service layers (analysis, synthesis, and hybrid). Finally, a proof of concept internal validation was performed by the authors using simulated testing scenarios of each function module within the EBDMSS. Such integrated three-step system validation strategy can be easily adapted and utilized to assess other similar DMSS development and implementations in an efficient and effective manner. It also provides a practical and cost-effective approach for internal system testing before the final release to the target market or external users.

In the follow-up stage, empirical studies are needed to evaluate the theoretical gains reported and verified at this current stage. In the context of e-business management, the outcome evaluation criteria are mainly concerned with the business core and customer relationship perspectives, which can be manifested by the strategic measures and factors under each perspective in the EBDMSS framework. Such measures can be objectively recorded in a field setting or a simulated experiment. Staff proficiency measures the learning and maturation of the e-business decision maker. In addition to a periodical staff qualification assessment, users' feedback can be assessed through a directed self-evaluation survey on their experiences or acquired knowledge and skills with the use of the decision aid.[73]

Process improvements may be assessed using two major measures: process effectiveness and efficiency. Process effectiveness is concerned with decision outputs, such as the quality of e-services with the decision aid and the number of products offered for sale or shipped out during a certain period, while process efficiency is concerned with how resources are used to achieve the objectives, such as the time for a sales cycle, the lead time (order-to-delivery time), and the general cycle time. Such process effectiveness and efficiency assessments can be objectively recorded in a field setting or a simulated experimental setting.

Using the multiple criteria EBDMSS architecture (as shown in Fig. 3), the e-business manager can establish an empirical evaluation model for strategic e-business decision support. Figure 6 shows such a strategy evaluation model utilizing the strategic measures specified in the EBDMSS framework. Based on the analytic hierarchy process (AHP) methodology,[74,75] this strategy evaluation model associates a hierarchy of evaluation measures (for both decision making process and outcome assessment) relevant to the context of e-business strategy in an integrated fashion.

Using the hierarchy in Fig. 6, the e-business manager can make pair-wise comparisons of alternative support systems, including the EBDMSS, across the multiple decision criteria. The AHP methodology then will convert the multiple measures into an overall scorecard value for each considered system. This AHP-based EBDMSS

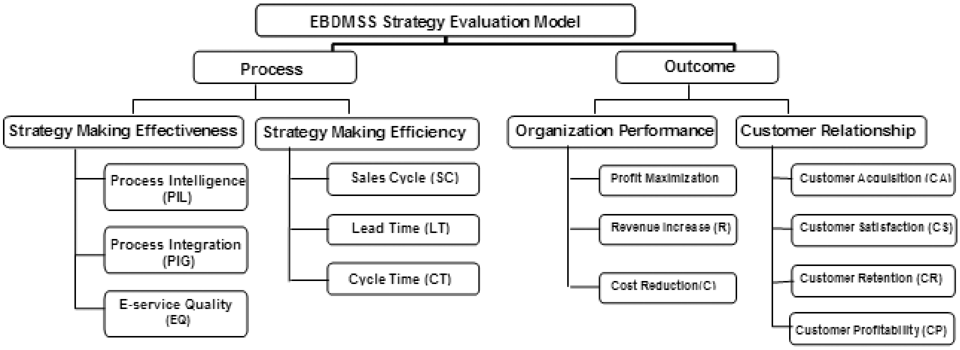

Fig. 6. Conceptual EBDMSS strategy evaluation model.

evaluation model, then, will identify, in rank order, the best performing e-business strategy making support systems.

Further research could implement the proposed EBDMSS architecture within a corporate e-business setting and/or a non-market-oriented industry, such as e-government and evaluate its effectiveness and efficiency. Multiple test users can experiment with the system and their behavior and personal productivity can be tracked and recorded. A longitudinal study, since strategic studies are essentially about the long-term, with triangulation of data collected from multiple perspectives/interpretations from multiple business units, and the selection of the appropriate level of aggregation is important. Then using the AHP-based EBDMSS evaluation model illustrated above, empirical testing results can be generated to verify the significant improvement, or lack thereof, in both the e-business decision making process and the outcome with the use of the EBDMSS framework.

5. Conclusion

In the context of strategic business e-management, the provision of dynamic and intelligent support for decisions made by e-business managers has been an imperative.[8,38,39,69] Traditionally, decision-making support systems — in general and in particular in its diverse modes — have provided decisional support for managers. While that such decisional support has been reported as successful, such support has been realized in a business organizational environment more stable than unstable, more predictable than unpredictable and more non-turbulent than turbulent.

In this research, it was identified that an enhanced decision-making support system that focused on satisfying user's design requirements including: (1) a friendly and adaptive interface[62,70]; (2) to manage data in a transparent and visual way,[71,76] and (3) to get timely (e.g. real-time support), integrated, and intelligent support throughout the decision making process,[30,63] is demanded for dynamic, turbulent and non-predictable business environments lived by e-managers.

A particular DMSS — called EBDMSS — for the aforementioned business environment was designed, built and validated through a conceptual design research method. Its design was theoretically underpinned in three DMSS design schemes: an EBBSC framework for DMP, a DMSS architecture, and a DMSS design-evaluation framework.

EBDMSS design delivers a BSC-based modeling and a wide range of embodied e-business strategy expertise in support of real-time decision making for e-business management. The EBDMSS delivers, through web-based computing technology, econometric and heuristic programming models, statistical methodologies, data conversion formulas, production rules, and data warehousing techniques. Such decisional support helps assist e-business management in specifying a variety of decision factors, establishing profitable e-business plans, and forecasting for future development.

EBDMSS was developed using an adaptive design strategy that relied on rapid prototyping and interfacing, and other forms of RAD tools. While that EBDMSS might have been implemented with advanced computational tools, this research has also proved that such valuable support can be also implemented using affordable computational tools (MS Access, Visual Studio.Net, and HTML). After depicting the theoretical framework and the design and implementation of the system, this current study has assessed the value of EBDMSS through a three-step system validation strategy. According to the three-step system validation outcome, EBDMSS provides timely, integrated, and intelligent support throughout the decision making process.

Hence, this research contributes to the decision-making support systems design research stream in the following aspects: (i) it has realized — via a proof of concept — a satisfactory integration of three theoretical schemes for designing a web-based DMSS for strategic e-business domains; (ii) it has provided evidences on the usefulness of using DMSS design frameworks, architectures and development methodologies for releasing an adequate DMSS; (iii) it has reinforced the general underlying premise on the usefulness of DMSS for improving a DMP; (iv) it has provided diverse key design insights for web-based DMSS in the domain of e-business; and (v) it has showed that the design of DMSS cannot be taken for granted as totally known especially in new domains like e-business settings in this case.

Practically, this research contributes to the practice of using DMSS in the following ways: (i) it has proved that a valuable DMSS for e-business managers can be developed using affordable computational tools; (ii) when analytical and technical skill is not available in-house, the company could take advantage of the specialized modeling and analysis expertise delivered through an i-DMSS; and (iii) it has demonstrated a valid prototype (EBDMSS) for supporting e-business strategy making and management.

In conclusion, by supporting all phases of decision making in a complete and integrated manner, systems like EBDMSS can help the e-business manager more efficiently recognize strategic opportunities and problems, better identify important strategy alternatives and events, more systematically and scientifically evaluate strategic alternatives, and generate more pertinent justification to facilitate strategy implementation than current largely unguided approaches. Such process improvements can be expected to yield more competitive e-business plans that result in lower costs, higher revenues, and increased profits and value proposition when compared to current non-dynamic DMSS efforts.

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