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SYSTEM DYNAMICS MODEL FOR DETECTING CRISES SIGNALS

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ABSTRACT

Crisis, catastrophe, and unexpected event are currently representing a steady part of organizations' lifecycle. Real Estate development organisations in particular are vulnerable to crises' events due to complexity of: external environment, internal structure, and operation systems. The ability of managing crises could be considered as a real core competence for the organization. This research provides developers by a model to detect crises' signals by monitoring all the organization's processes and operations. By combining balanced scorecard principles with system dynamics techniques, this model is introduced. The model presents acceptable forecasting for the crisis event time as well as its negative impact. Identifying crises' triggers in a reasonable time will facilitate the entire measures required to stop the crisis event from occurring or at least being well prepared for it.

KEYWORDS: Crisis management, signal detection, system dynamics, balanced scorecard, real estate development.

1. INTRODUCTION

The definition of Crisis is a unique, unexpected, and uncommon event that raises a high level of ambiguity, improbability, and uncertainty that threatens an organization in terms of its existence and objective as well as its reputation [1]. In general, according to Institute for Crisis Management, number of crises in the news in 2017 reached 801,620 with an increase of 25% over 2016, in which, mismanagement led the way by 26.73% [2]. Further, according to Global Bankruptcy Report 2017, numbers of companies facing bankruptcy in highly developed countries keep on increasing; in UK by 19.8%, in U S by 2.6 %, and in Russia by 2% in the first half of the year only [3].

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Regarding real estate development, it is defined as the process of undertaking real estate projects by means of operating on the land, design, planning, construction, capital, space, and asset market, with the expectation of gain that upon thorough analysis has a high degree of security [4]. Clearly, the above reports are revealing that effective managing for real estate development crises is crucial and vital whether to the organization itself or the country economy. About organizational crisis management, it is defined as the provision of an organization's preplanned, rapid response capability supported by a leadership, information management and communications capacity to enable fast decision making at a strategic level and thereby allowing for effective recovery and protecting an organization's survival or reputation [5]. Indeed, there are different crisis management models such as the ones introduced by Fink, Smith, and Coombs, in which they developed specific management processes according to different perspectives [6-8]. These models provide specific management processes which are effective in dealing with different crises situations. However, the adopted one in this research is Mitroff’s model which consists of five main phases; signal detection, prepare / prevent, containment and damage control, business recovery, and learning [9].

The reason for selecting this model, besides its practical nature, lays in the fact that it is the only one that gives much concern for crises' signal detecting which represents the fundamental objective of this research. In this model, it is asserted that it is most important to recognize that prior to its occurrence; nearly every crisis is thought to leave a trail of early warning signals [10]. Consequently, if organizations could learn to read these warning signals, then there is much they could do to prevent many crises from occurring [10]. On the contrary, earlier mentioned models do not show the same attention, some classify it as just a part in a major phase and some put it in the general context of the management process without any special attention.

2. LITERATURE REVIEW

In this section, a review of the relevant literature regarding Mitroff's model, system dynamics, balanced scorecard, and signal detection is performed.

- Mitroff's model deployment

Previous studies which discussed the deployment of Mitroff's model in crisis management were found to be mainly focusing on comparing between adopted management activities and Mitroff's phases. For example, in a study of the relation between crisis management capabilities of property developers and their size, a comparison process was performed and the similarity was obviously noticed [11].

- System dynamics

It is a method to describe, model, simulate and analyze dynamically complex systems in terms of processes, information, boundaries, and strategies [12]. The fundamental elements of system dynamics models are stocks, flows (rates), auxiliaries, constants, and causal links with (or without) delay [12]. A stock could be seen as a bathtub or reservoir, which can only be changed by flows; ingoing flows could be seen as taps and outgoing flows as drains [12]. Further, stocks characterize the state of the system and generate the information upon which decisions and actions are based [13]. About flows, they regulate the states of their stocks, hence they are the ones which be targeted by strategies to improve the problematic state [12]. For auxiliary (intermediate) variables, they help to keep flow equations simple and understandable because they are closely corresponding to real world system elements [12]. Regarding time delays, a delay is a process in which output lags behind input [13].

Concerning adopting system dynamics in real estate development, it was asserted that system dynamics can provide intuitive models that should be able to improve pedagogy for educating potential real estate entrepreneurs [14]. Within same context, exploring previous work which combines crisis management with system dynamics, it was noticed that most of which were revolving around understanding issues rather than providing answers. For instance, system dynamics methodology was used to examine the major causes of the US housing market crisis [15]. Moreover, a system dynamics model was developed to investigate the Bhopal crisis in India [16].

- Balanced scorecard

It is a concept for measuring organizational performance which provides a balanced picture of the operating performance [17]. It has four perspectives; learning

and growth (measures staff's performance), processes (measures operations' performance), customer (measures ability to satisfy customer), and financial (measures ability to make profit) [18]. Notably, balanced scorecard registered in top ten of the most strategic management techniques in 2014 [19]. Although the balanced scorecard approach has many advantages, but also suffers some significant limitations. These limitations are: it focuses on unidirectional causality, unable to distinguish delays between actions and their impact, has a dearth of validation capabilities, integrates insufficiently strategy with operational measures, and suffers from internal biases [20-22].

System dynamics approach provides solutions for these shortcomings such as: feedback loops rather than unidirectional causality, explicit separation of cause and effect in time, mechanisms for rigorous validation, linking strategy with operations, and broadening focus by challenging system boundaries [20]. For example, system dynamics was combined with balanced scorecard to form a dynamic balanced scorecard in order to evaluate the organization's performance [21]. Moreover, it was emphasized that the combined use of the two systems has the potential to be developed into a comprehensive management flight simulator [22].

- Signal detection

The purpose of this research is to provide a tool to detect real estate development crises' signals. The significance of detecting crises' signals has been highlighted in many scholars' work, for example, it was asserted that a dynamic performance indicator system should give warning signals when certain performance limits are reached [23]. In general, there are specific modeling techniques which have been used in detecting crises' signals such as neural network and case-based reasoning [24, 25]. However, the problem with these models lays in the fact that they were focusing on financial indicators only and neglecting other types of signals. While in real estate development in particular, some modeling techniques which include database management system were used for developing alternative variants of crisis management solutions [26]. Still, there was no special attention toward crises' signal detecting.

In this regard, there were few researches that utilized system dynamics in signal detection systems for real estate development. For instance, a system was introduced to monitor and provide early warning signals to decision makers in Shenzhen property market [27]. In addition, a system dynamics model was established for monitoring and forewarning of real estate development industry in China by utilizing housing price factors as model variables [28]. Finally, it could be concluded that utilizing this coupling technique in detecting crises' signals is a topic that has not been explored deeply. Therefore, this research is representing an attempt to participate with small contribution in this field.

3. METHODOLOGY

The research construction process will start first by collecting all necessary information about research topic from scholars' previous work. Second, a collection for crises' scenarios will be gathered from the literature to recognize their attributes and related signals. Third, the signals inherent in the model will be defined from the related previous researches. Fourth, the model will be formulated and its parameters will be identified using unstructured interviews with ten real estate development experts working in large organizations with thirteen to twenty years of experience. Moreover, this phase will be finished by the validation tests performed in order to ensure model's robustness. Finally, a deployment process for some of the scenarios will be conducted to monitor model's behavior.

4. CRISES' SCENARIOS

The scenario is defined as a coherent, internally consistent and plausible description of a possible future state of the analyzed system [29]. The main function of crises' scenarios is to identify and register all crises events that could happen, which in turn will facilitate taking the required measures to prevent or at least be well prepared for it. In this regard, it was concluded that building hypothetical crisis scenarios is an opportunity to test an organization's ability to confront these events [30].

4.1 Real Estate Development Crises' Scenarios

Crises scenarios for real estate development are various and differ in its nature; this is referring mainly to many external and internal factors. This research considers twenty crises' scenarios which were extracted from scholars' previous studies [10, 31-35].

1. Wrong Feasibility Study.
2. Unjustified Bank Loan.
3. Wrong Design.
4. Inefficient Management Board.
5. Sales Operation Failure in New Development Areas.
6. National Economic Problem.
7. Construction Problems.
8. Fatal Events.
9. Building Materials and Fuel Prices Rising.
10. Too Much Supply.
11. Aggressive Competition.
12. Bad Customer Management.
13. No Loyalty among Employees.
14. Losing Organization Founders.
15. No Development or Innovation.
16. Wrong Marketing Strategy.
17. Laws Tighten Footprint Area and Height Limits.
18. Deteriorating Assets.
19. No Risk Management or Crisis Management.
20. Wrong Stakeholder Management.

5. MODEL DEVELOPMENT

The development process starts by identifying the indicators for the four branches (financial, customer, process, and learning and growth). Subsequently, the mathematical equations for the variables and their relationships will be defined. The

model in Fig. 1 represents the integration process between system dynamics and balanced scorecard to provide a signal detection mechanism for crises. It consists of the four fundamental branches that belong to the balanced scorecard; each branch is containing its relevant signals which are closely attached to its main components. The signals within each branch are transformed into stocks, flows, and auxiliaries which are the basic building blocks of system dynamics. These blocks are linked together by arrows (causal links) which represent the type of correlation between them. Eventually, the four branches are connected together by means of specific arrows which represent the basic relationships between them in order to make the model fully integrated and to operate as one system.

However, the model is not only containing the signals but it encompasses all factors related to the development process. The basic idea is to monitor all daily operations of the organization in order to track any shift of normality. In fact, these operations are the outcome of transforming the organization's strategies into activities. Therefore, the input data entered will represent these strategies in terms of numbers. For the indicators, they were collected from scholars' previous work [21, 23, 36-40].

5.1 Financial Subsystem Signals

The major stock is net income, which is represented by a rectangle; it is the accumulation of inflows minus outflows over time, starting from a predefined initial value. This specific stock is fed by revenue (inflow), which is represented by a pipe, and drained by expenditures (outflow). Basically, the formula in Eq. (1) represents the general form of function for a stock [13].

$$Stock=INTEGRAL\ (Inflow - Outflow, Stock_{to}) \quad (1)$$

The function represents the concept that *Stock* accumulates (integrates) its *outflows* subtracted from its *inflows*, beginning with an initial value of $Stock_{to}$. Equation (2) represents the *Stock* for net income (*NET_INC*).

$$NET\_INC\ (\$) = INTEG\ (Rev - Exp, PE + BL) \quad (2)$$

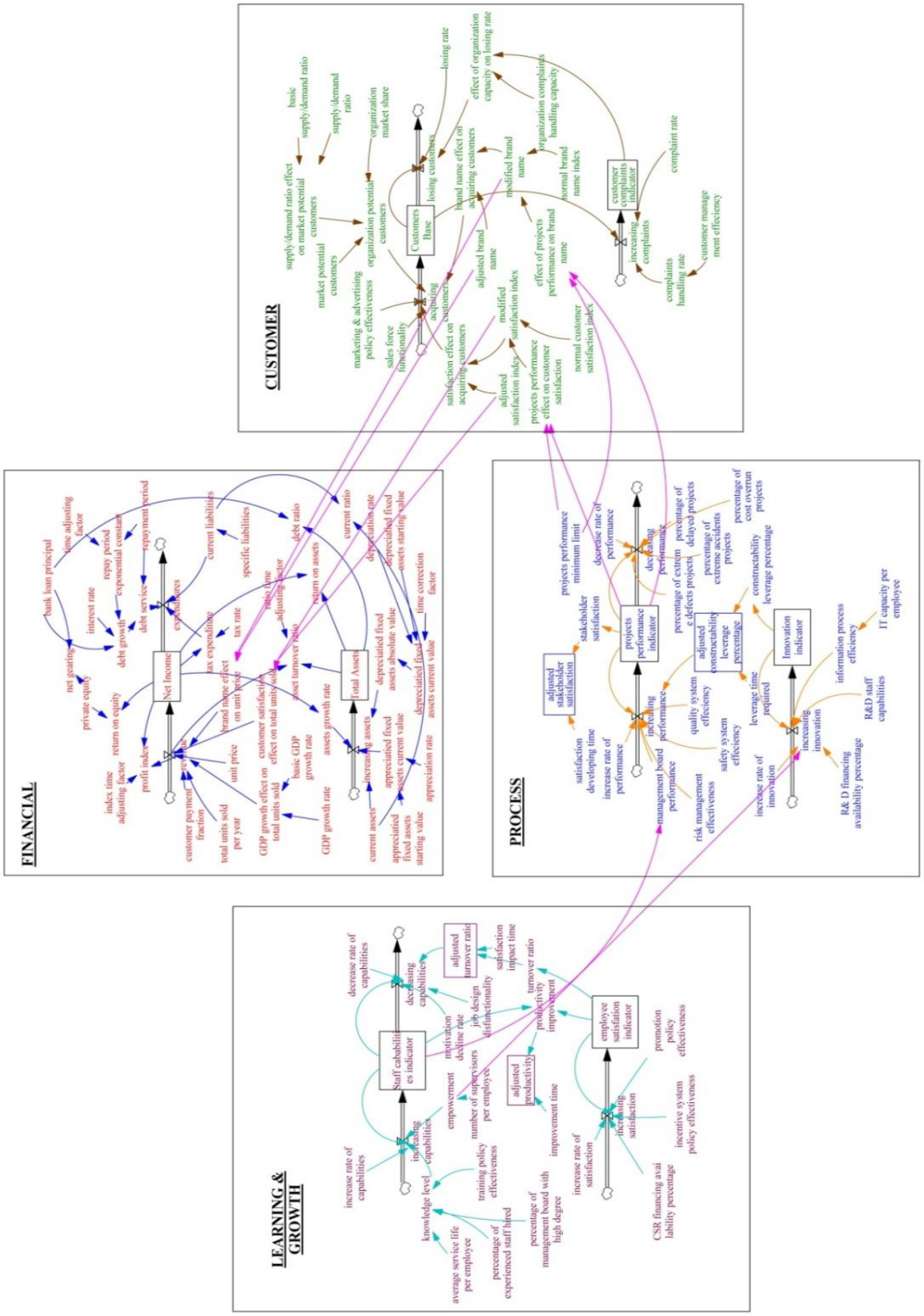

Fig. 1. Signal detection mechanism stock and flow diagram.

Where *INTEG* means integration, *Rev* is revenue, *Exp* is expenditure, *PE* is private equity, and *BL* is bank loan principal. Regarding revenue; it is governed by unit price, total units sold, and payment fraction. In addition to other factors which are connecting to revenue with a positive correlation such as brand name index and GDP growth rate. Equation (3) represents the *flow* for revenue (*Rev*).

$$Rev\ (\$/year) = UP^{*}\ bra\_\ eff\_up\ ^{*}US^{*}sat\_\ eff\_us\ ^{*}CP^{*}gdp\_eff\_us \quad (3)$$

Where *UP* is unit price, *bra_ eff_up* is brand name effect on unit price, US is total units sold per year, *sat_ eff_us* is customer satisfaction effect on total units sold, *CP* is customer payment fraction, and *gdp_eff_us* is GDP growth effect on total units sold. On the other hand, the expenditure part contains all expenses, for example, tax expenditures and debt service. These expenses are influenced by their accompanied factors, for instance, tax rate and interest rate. Concerning the other stock in the subsystem, it is representing assets and it is controlled by a flow named increasing assets. This flow is driven by three rates; growth, appreciation, and depreciation. Finally, all accounting ratios are connected to their variables according to predefined mathematical equations.

5.2 Customer Subsystem Signals

The basic stock is customers' base that acts as an accumulator (reservoir), which all acquired customers are aggregated within it. This stock absorbs the difference between inflow (tap) and outflow (drain). The inflow in this case is a variable representing the rate of acquiring customers, which is connected to five auxiliaries. These auxiliaries are Sales force functionality, marketing policy effectiveness, potential customers, brand name index, and customer satisfaction index. Equation (4) represents the *Stock* for customers' base (*CUS_BAS*).

$$CUS\_BAS\ (customer) = INTEG\ (Acq\_Cus - Los\_Cus, 10) \quad (4)$$

Where *Acq_Cus* is acquiring customers, and *Los_Cus* is losing customers. Equation (5) represents the *flow* for acquiring customers (*Acq_Cus*).

$$Acq\_Cus\ (customer/year) = PC\ ^{*}SF\ ^{*}\ MAE\ ^{*}\ bra\_eff\_acq^{*}\ sat\_eff\_acq \quad (5)$$

Where *PC* is organization potential customers, *SF* is sales force functionality, *MAE* is marketing & advertising policy effectiveness, *bra_eff_acq* is brand name effect on acquiring customers and *sat_eff_acq* is satisfaction effect on acquiring customers. Conversely, the outflow is representing the rate of losing customers, which is linked to two auxiliaries; one is the annual losing rate and the other is the organization handling capacity regarding complaints. Customers' complaints indicator is a stock for the number of the complaints; it is enforced by one flow that represents its rate of increasing. This flow is under the control of two rates; the annual one and the handling capacity.

5.3 Process Subsystem Signals

Projects performance indicator is the fundamental stock for this subsystem, and it is amplifying by a flow (rate) represents performance increasing. This rate is growing according to five auxiliaries, which are: management board performance, risk management effectiveness, safety system efficiency, quality system efficiency, and constructability. Equation (6) represents the *Stock* for projects performance indicator (*PRO_IND*).

$$PRO\_IND\ (point) = INTEG\ (Inc\_Per - Dec\_Per, 10000) \quad (6)$$

Where *Inc_Per* is increasing performance, and *Dec_Per* is decreasing performance. Equation (7) represents the *flow* for increasing performance (*Inc_Per*).

$$Inc\_Per\ (point/year) = RP*MP*\ QE*RE*SE*CL*PRO\_IND \quad (7)$$

Where *RP* is increase rate of performance, *MP* is management board performance, *QE* is quality system efficiency, *RE* is risk management effectiveness, *SE* is safety system efficiency, and *CL* is adjusted constructability leverage percentage. On the contrary, the stock is consumed by decreasing performance flow; it is a rate depending on four auxiliaries. These four are the percentages of projects with: delay, extreme accidents, extreme defects, and cost overrun. The innovation indicator is another stock which is led by one flow named increased innovation. This flow is

accelerated by three auxiliaries; research and development financing, research and development staff capabilities, and information process efficiency.

5.4 Learning and Growth Subsystem Signals

The main stock in this branch is staff capabilities indicator which is reinforced by increasing capabilities flow. This flow is controlled by knowledge level and empowerment. Knowledge level is attached to four auxiliaries and they are: average service life, percentage of experienced staff, percentage of management board with high degree, and training policy effectiveness. Equation (8) represents the *Stock* for staff capabilities indicator (*STA_IND*).

$$STA\_IND\ (point) = INTEG\ (Inc\_Cap - Dec\_Cap, 10000) \quad (8)$$

Where *Inc_Cap* is increasing capabilities, and *Dec_Cap* is decreasing capabilities. Equation (9) represents the *flow* for increasing capabilities (*Inc_Cap*).

$$Inc\_Cap\ (point/year) = RC*KL\ *E*STA\_IND \quad (9)$$

Where *RC* is increase rate of capabilities, *KL* is knowledge level, and *E* is empowerment. On the other hand, the decreasing capabilities flow is driven by motivation decline, job design dysfunctionality, and staff turnover ratio. Employee satisfaction indicator is another stock which is charged by only one flow named increasing satisfaction. This flow is governed by corporate social responsibility, incentive system effectiveness, and promotion policy effectiveness.

5.5 Integrated Signal Detection Mechanism

Linking the four subsystems together will introduce the signal detection model in its final structure. From the learning and growth subsystem there are two links; one is between empowerment and innovation in form of a conditional equation and the other is between staff capabilities and management board performance. The process subsystem is attached to the customer subsystem by a link between projects performance indicator and both brand name index and customer satisfaction index. The final connections are between both brand name index and customer satisfaction

index within the customer subsystems and both unit price and total units sold within the financial subsystem.

5.6 Model Assumptions

All the parameters within the model had been identified accurately by means of interviews with real estate development experts and practitioners. The variables values were checked and reviewed by experts in the domain to ensure full accuracy. Finally, the equations are constructed according to the instructions and requirements of the governing rules of the adopted software (VENSIM). This software is a visual modeling tool that allows conceptualizing, document, simulating, and analyzing models of dynamic systems. It provides a simple and flexible way of building simulation models. By connecting words with arrows, relationships among system variables are entered and recorded as causal connections. This information is used by the equation editor to help forming a complete simulation model. After building a model that can be simulated; its behavior can be explored [41].

5.7 Model Validation

The definition of model validation is as follows: A process of establishing confidence in the soundness and usefulness of a model [42]. Accordingly, several validation tests were performed to ensure model robustness. These tests are based on the model validation process established by system dynamics scientists [13, 42]. Moreover, in order to gain more confidence in the model's results, interviews with four real estate practitioners were conducted. The main purpose of these interviews is only to ensure that the model is truly representing real life system.

5.7.1 Structure validation

Structure validation set of tests encompass the following:

- Structure verification test: Each real-life acting factor in the development lifecycle has a representative element in the model and all of them represent the real estate industry as identified by several authors in their books [4, 43-45]. Moreover, the

subsystems' structures where adopted from different scholars' previous work [17, 18, 21, 46, 47] in which they were representing parts of their models. Finally, the model subsystems structures were checked by experts in the domain and some modifications had been performed accordingly.

- Boundary adequacy test: The main boundaries are the four branches of the balanced scorecard and for every branch there is also an adequacy in its boundaries. This adequacy is clearly appearing in the chosen elements for each subsystem, because there is no elimination to any significant one. Lastly, the model boundary adequacy was reviewed by experts and they truly provided some useful remarks.
- Extreme conditions test: This specific validation process is achieved by a special function within the software (VENSIM) named reality check. Reality Check equations create behavioral conditions and then check to see if the structure of the model causes the appropriate behavioral response and there is no violation to the constraints that reality imposes. The test was conducted to different variable in the four subsystems and there was no violation recorded.
- Dimensional consistency test: This test is done automatically by the software program (VENSIM) after finishing the model building process and the software gave a confirmation message that all units are consistent.
- Parameters' verification test: The model parameters were obtained from interviews with experts and practitioners in real estate development industry, thus it is truly representing their real-life ones.

5.7.2 Behavior validation

Behavior validation process contains the following tests:

- Behavior sensitivity test: The behavior sensitivity test focuses on sensitivity of model behavior to changes in parameter values. The test conducted by changing the parameters values by ± 25% and there were no observed changes in model behavior which led to increase confidence in the model's results.

- Behavior anomaly test: The model shows no anomalies in its results, they were reasonable, logic, and consistent with the basics and principals that rules each subsystem.
- Family member test: Even though the model has been developed for a large or medium size real estate organization, it could be applied to other types as well. This could be achieved with appropriate modifications in the parameters' values, which are separate from the equations. Finally, this was the opinion of the experts who checked and reviewed the model.

5.7.3 Integration error

This test checks the mathematical integration technique used in the model equations to confirm its consistency. The test was conducted by reducing the time step to half its value and then rechecking the model's results and there were no actual changes in it.

6. SCENARIOS' DEPLOYMENT

Two scenarios will be deployed in the model by means of manipulating the corresponding related variables. This manipulation process will also perform the function of the sensitivity analysis to provide insightful conclusion about the significance of these variables. For each scenario's deployment, there will be first a base run which represents the normal case then the crisis scenario will be manifested by three changes in the variables' values. By monitoring the curve of the base run and compare it with the three other curves, the difference in the trend will be observed.

6.1 Wrong Feasibility Study

In this Scenario, the assumptions assert that the sales were overestimated while expenditures were undervalued. Hence, the variables chosen to be manipulated are total units sold and current liabilities; the first decreases by 15 to 40 % while the second increases by the same magnitude. Accordingly, transforming the scenario's assumptions will be achieved by changing the input data regarding these variables from their normal values to be entered into the model by different ones. The indicator

selected to be analyzed is profit index; it is a financial measure which is calculated by dividing net income (profit) by revenue. The diagram in Fig. 2 represents the output data after running the model; the profit index is on the vertical axis, while the time period for the simulation is on the horizontal axis. The diagram encompasses four curves; one represents base run (normal case). While the other three curves represent the changes happened to the profit index value through time due to the manipulation process of the variables' magnitudes. Clearly, by monitoring the organization's profit index; the negative effect due to this crisis's scenario is observed in curves' paths.

In general, it starts by a high value, because in the beginning the expenditures' values are small while the revenue is fed by loan principal and private equity. Overtime, expenditures escalate due to cost of land, design, construction, advertising, and administrative. Eventually, when these costs diminish; it is by this time revenue starts to balance expenditures. Later, with more successful sales operations, revenue overrides expenditures. Regarding the other three curves, they have higher starting values for profit index because revenue values are smaller due to less sales operations. Accordingly, the profit index will increase because the revenue is the denominator in this formula. Notably, the minor change in the rates is below the normal case but still in the positive zone while the medium and major changes are both in the negative zone.

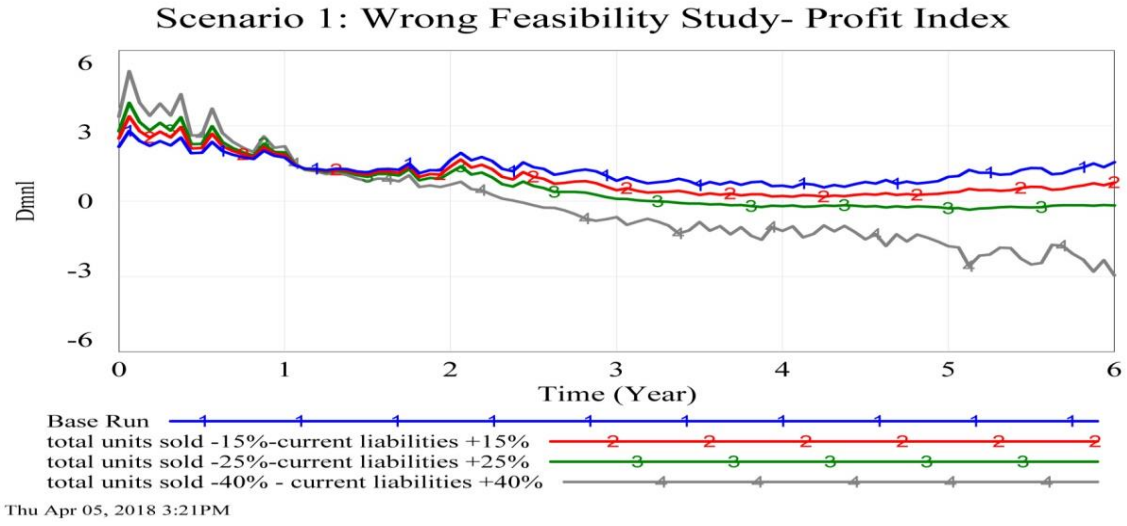

Fig. 2. Wrong feasibility study.

6.2 Deteriorating Assets

For this Scenario, the chosen factors to be changed are asset growth rate and depreciation rate. Asset growth rate decreases by 5 to 30% while depreciation rate increases by the same rate. The variable chosen as an indicator is increasing assets, which represents the annual rate of increase for assets in terms of money as shown in Fig. 3. In base run case, the curve starts with the initial value of the assets (current and fixed) then it drops by a specific amount at the end of each year. These drops in the curve are governed by the annual depreciation rate of the physical assets. However, between the third year and the fourth, there is an extremely huge drop in the curve which is caused mainly due to the other governing factor which is asset growth rate. Notably, during this specific period, the net income was in its minimum level, thus the organization could not afford to add more assets.

Subsequently, when net income returned to normal, the curve returned as well to its normal path. Regarding the three changes in the two factors, they represent the case when the organization reduces budget for replacement and rehabilitation of assets which will directly lead to degrade its condition. Clearly, the difference between the base run and the other three curves is obviously recognized, the value of assets increasing rate keeps on shrinking as more increasing in depreciation rate and more decreasing in growth rate.

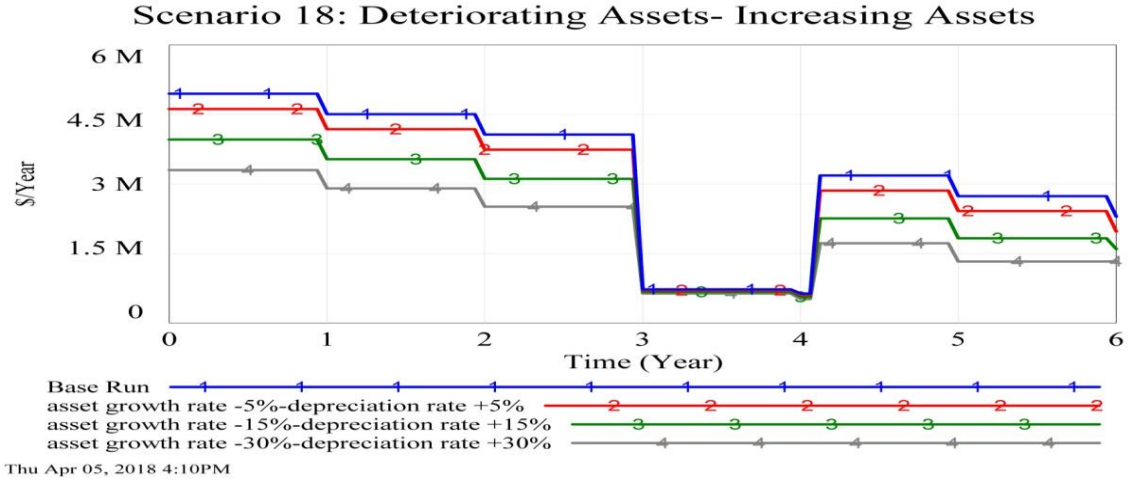

Fig. 3. Deteriorating assets.

7. SCENARIOS' COMBINATIONS

Combining some scenarios together in one set is a functional activity and the analysis process for these sets will reveal which scenario has more negative influence than the other, thus it acts as a sensitivity analysis. The criteria for scenarios' combinations selection are as follows: hold a strong logical relationship, accelerate each other, share same symptoms and negative influence, could happen simultaneously, and together they could lead to a catastrophic event. However, not every combination must contain all criteria, but it definitely must contain some. The deployment procedure begins by entering the base run data then the worst-case data for each scenario in the combination. According to the previous criteria, two combinations are provided for analysis.

7.1 Combination 1

The combination includes the following scenarios: Wrong Design, No Development or Innovation, Wrong Feasibility Study, and Laws Tighten Footprint Area and Height Limits. These scenarios possess different criterions that combine them together, such as: share same symptoms and characteristics, escalate each other, share same negative influence, and could be happened simultaneously. Clearly, by comparing the base run curve with the other scenarios' curves, it is obviously how it keeps on lowering as more scenarios are added as observed in Fig. 4.

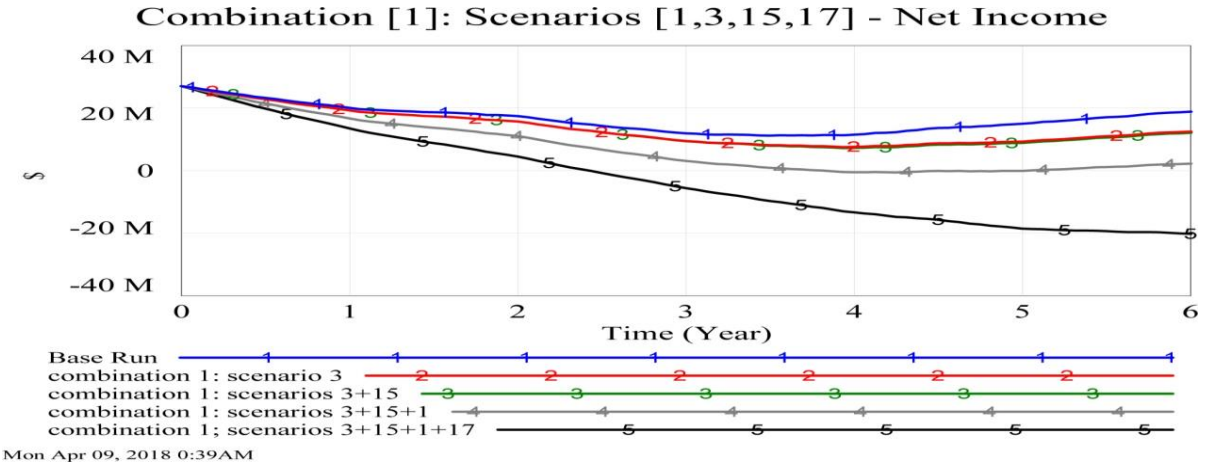

Fig. 4. Combination 1.

However, the figure shows that No Development or Innovation Scenario has almost no effect on net income. In fact, it has an effect but it is neither direct nor imminent.

7.2 Combination 2

This combination contains the following scenarios: Unjustified Bank Loan, Deteriorating Assets, Building Materials and Fuel Prices Rising, and National Economic Problems. For this combination, there are multi criterions that gather these different scenarios, which are: strong logical relationships, amplifying each other, share same characteristics, share same negative influence, and together they could lead to a catastrophic event. The analysis process is adopting the debt ratio, which is calculated by dividing the debt by total assets, as a reference for comparison. The results in Fig. 5 show the negative effect on debt ratio value; it increases as long as more scenarios being added. Notably, the curves start with a period of overlapping then each curve has its own path. The main reason behind that is the conditional relationship between net income and asset growth rate. Whenever the net income reaches a specific limit; which is too low to afford adding more assets, the asset growth rate becomes nil.

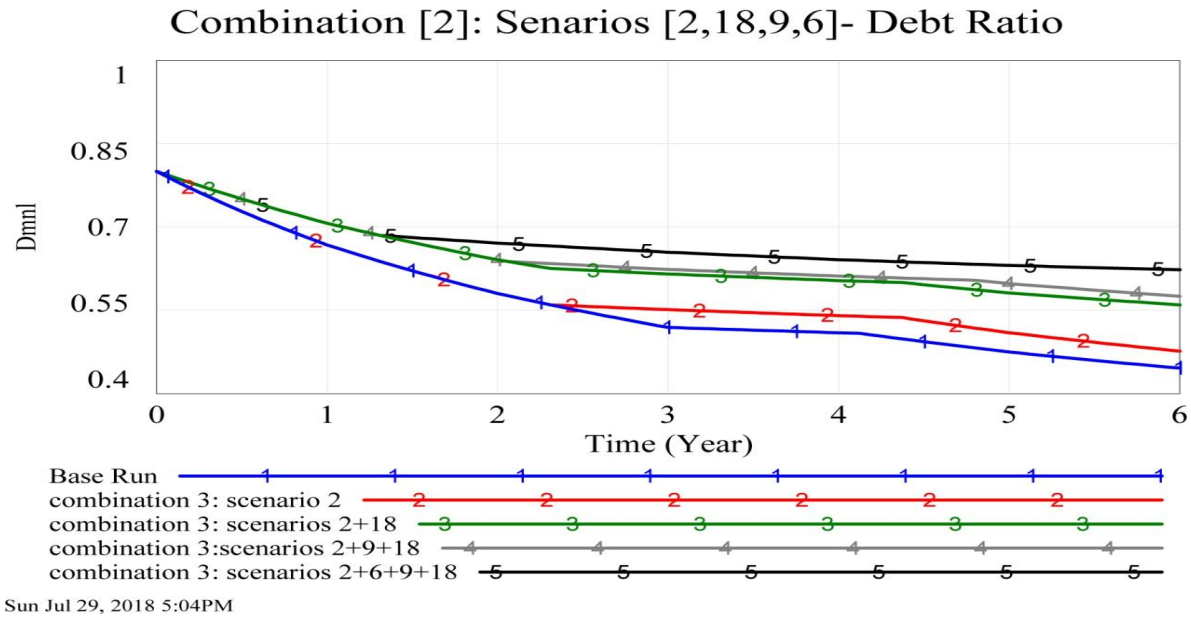

Fig. 5. Combination 2.

8. CONCLUSIONS

This research paper main purpose was to provide decision makers in real estate development organizations with a mechanism to detect crises. This early detecting of crises events will lead to that most of -if not all- crises events can be averted before they happen. Surely, almost all internal crises events could be averted, but external ones could only be well prepared for it. Moreover, the organization can predict any consequences for any adopted policy, which in turn will enable decision maker to decide whether to go on with it or not. This was clearly observed in the deployment process of the selected scenarios in the model. The deployment process revealed the exact time of the crisis event as well as the precise magnitude of its negative impact. Subsequently, the deployment process stretched to contain more than one scenario combined together in order to reach the worst case possible. While the model's ultimate target is to detect crises' signals in real estate development organizations, it could be utilized in other types of profitable organizations. Further, it could be expanded to other areas such as the containment policies adopted for crises scenarios. Finally, it will be mostly beneficial to the literature if researchers could explore the possibility of adopting system dynamics methodology in the remaining phases of Mitroff's model.

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إستكشاف مؤشرات الأزمات بإستخدام تقنية ديناميكية النظم

يقدم البحث نموذج لكشف مؤشرات الازمات عن طريق مراقبه كل العمليات التنفيذيه لشركات التطوير العقارى، وتم تصميمه بواسطه بدمج تقنيه ديناميكيه النظم مع مبادئ الاداء المتوازن، كما تم تحديد السيناريوهات المحتمله للأزمات وتغذيه النموذج بالبيانات الخاصه بتلك السيناريوهات فى شكل مدخلات ومراقبة المخرجات وتحليلها والاستفاده منها، وتقدم نتائج النموذج توقع دقيق لموعد بدايه الازمه ولتاثيرها السلبى، حيث أن كشف هذه المؤشرات فى موعد مبكر يتيح للشركات اتخاذ كل الاجراءات اللازمه من اجل منع هذه الازمات او على الاقل الاستعداد لها مما يعزز جدارتها التنافسيه.