Conceptual Model from a Financial Contagion Case to Build an Agent-Based Model

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Abstract. The first step to create an Agent-based model is to develop a conceptual model that represents the actors, their behavior, and the interactions among them and with the environment. This study presents the results of a content analysis of newspaper articles to exemplify the use of this qualitative research tool to map the main elements of a financial contagion case in Brazil. The results can be used as a primary source of data to develop a conceptual model in this area and, later, an Agent-based simulation model.

Keywords: Agent-based Modeling, Contagion, Conceptual Model, Financial Environment.

1 Introduction

This study aims to contribute to the understanding of the financial systemic risk and contagion, whose effects can significantly change the liquidity conditions of the financial environment and the market volatility. It is of crucial importance for central banks and monetary authorities the prevention of such risks and their spread to mitigate the impacts on the institutions that operate in the economic and financial environment and on the economy as a whole [9]. The functioning of the financial system has been tested by a series of negative events and the effects of these impacts have demonstrated the high level of complexity and connectivity of these environments.

However, despite the high number of publications and researches in this area [1, 3, 4], most of these studies have been focused on financial institutions relationship, i.e., the degree of contagion that depends on the relationships among financial institutions in certain risk scenarios. This kind of contagion as a direct contagion, since it occurs by direct exposures between institutions. The contagion, however, may be indirect, when it occurs by informational effects (Information-based contagion) [2]. In this case, the propagation of the shock is the perception that the institutions were also affected by the initial shock. Then, new failures may occur due to the mistrust in the payment capacity of the banks, followed by the withdrawal of money from these banks [18].

We believe that the Information-based contagion can be analyzed by computer modeling and simulation. Among the various approaches in this area, Agent-based modeling (ABM) has been used successfully to simulate complex environments in varied

fields of science. This success is explained by the gradual increase of the system complexity to be analyzed and modeled, such as the financial markets, and, on the other hand, because of the computational power available for this purpose (processors, systems data management) [15].
Thus, this article examines how the contagion impacts the economic and financial environment using content analysis of a newspaper articles. It explores the BTG Pactual Brazilian bank case in the context of an investigation being carried out by the Federal Police of Brazil, known as Lava-Jato operation ("operation Carwash"). The main executive of the bank was arrested and it caused several impacts in the financial environment. According to the Brazilian justice, it is the biggest case of corruption and money laundering among public and private institutions, politicians and big companies. We believe that the content analysis results can provide the main elements to develop a conceptual model in this area and, later, an Agent-based simulation model.

2 Conceptual Model and Agent-based Modeling (ABM)

Conceptual models are used to guide the data analysis process and to assist the process of drafting an ABM. It is a way to describe and build a model, which can be implemented in simulation software [13].
On the other hand, ABM is a way to model systems with autonomous agents that interact with each other and with an environment. Agents are elements of society that use sensors to realize, usually in a limited way, the environment where they are inserted and thus, through actuators, can act and affect this environment directly or in cooperation with other agents [14, 17]. And, as reported by [11], ABM is not limited just to the execution of agents and the understanding of their attitudes, but has become a very useful tool to get more realistic results to both the environment as well as to the behaviors and real relations of human beings. Therefore, the computerized ABM model is the conceptual model implemented as a computational model [5].

3 Methodology

We used the content analysis research from newspaper article to identify the actors who influenced and were influenced by the contagion in the financial environment and to recognize behavior patterns to the design of the conceptual model. In order to reach this goal, the research strategy was developed in four phases.

3.1 Main Actor Chosen for the Analysis

BTG Pactual bank was chosen as the main actor to be analyzed because it is in the center of the contagion problem. The BTG CEO arrest was the main cause of the contagion and, despite the good financial condition of the bank it suffered a herd behavior effect.

3.2 Data Source

The Folha de São Paulo, one of the most important newspapers in Brazil, was chosen as a data source of the study, more specifically its printed version.

3.3 Period of the Study

The period of analysis was chosen from the BTG Pactual group equities behavior (Br Pharma, Br Properties, BTG Pactual, Oi).

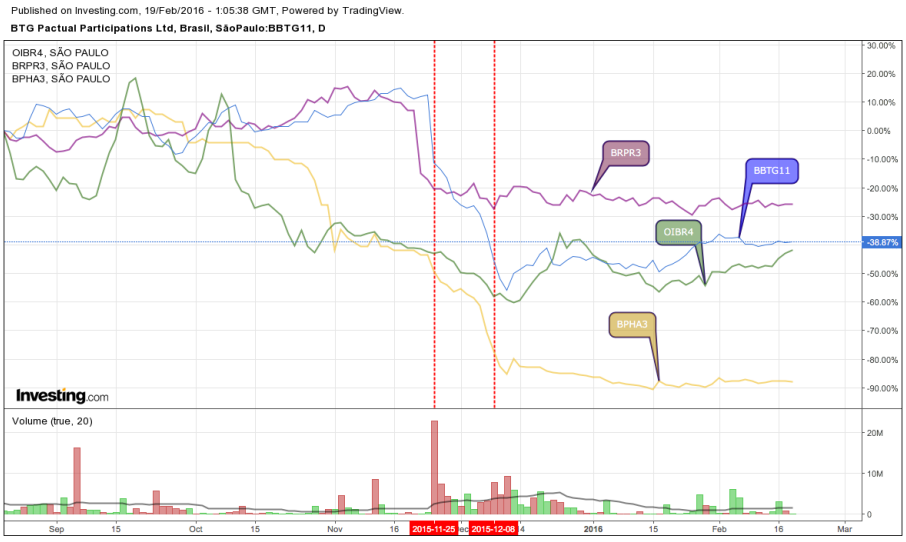

Fig. 1. Graphic of the equities: Oi, BR Properties, BR Pharma and BTG Pactual. (Source: Published on Investing.com, Feb. 2016).

It is possible to see in Figure 1, that the value of the BTG companies' equities had suffered a significant reduction in the period from November 25 until December 08, 2015. Also, it was possible to verify in the news that this period corresponds to the main facts of the BTG bank case. For this reason, this period was selected for the study.

3.4 Content Analysis Process

Content analysis is a research technique to do valid interpretation from texts using a set of procedures (Weber, 1990). In this study, it was used to obtain a better interpretation of the semantics of the case. The procedures are listed below:

- We searched all news that showed the string "BTG Pactual" and belonged to the chosen period of the study. It 78 newspaper articles were selected and saved.

- The relevant text segments of the articles were identified. We found 131 text segments that were organized in three different categories: (i) actors; (ii) the behaviors of the actors; and (iii) facts.
- Using the platform NVivo, which is software that supports qualitative data analysis, the actors were counted. Then, the actors with low and high frequency were grouped in accordance of their common characteristics. They were discarded when they were not relevant for the study.
- After grouped actors with common behaviors and identified the main facts and consequences related to these groups it was created one simple structure of analysis (duality Condition-Action): antecedent part (IF part) and consequent part (THEN part) which it resulted in a structure: IF < fact > THEN <behavior of the actors that have relation with the fact >. The structure to be followed removed of the diagram of figure 3 is had as example:
  IF < Operação Lava-Jato (November, 25, 2015 – December, 08, 2015) > THEN < Justice apprehends evidence and order that investigated be imprisoned >
  IF < Justice apprehends evidence and order that investigated be imprisoned > THEN < Investigated and Bank Executive is imprisoned >.
  IF < Investigated and Bank Executive is imprisoned > THEN <Bank Executive is imprisoned> THEN <Investigated deny accusations>.
- From the structures of you analyze IF-THEN was developed the conceptual model represented by a sequence of diagrams divided in levels. The first level has as origin main node: Operação Lava-Jato (November, 25, 2015 – December, 08, 2015) that it resulted in 3 new node which compose the second level: Bank Executive is imprisoned; Bank Executive have your prison prolonged by Justice; Private Bank reinforces finances to contain financial crises. The node "Investigated deny accusations" is not part of second level because it did not generate a new important fact for the study.

4 Results and the Relation with ABM

Each specific actor was grouped in a class that represents a similar kind of behavior. The Figure 2 shows the actors' frequency distribution.

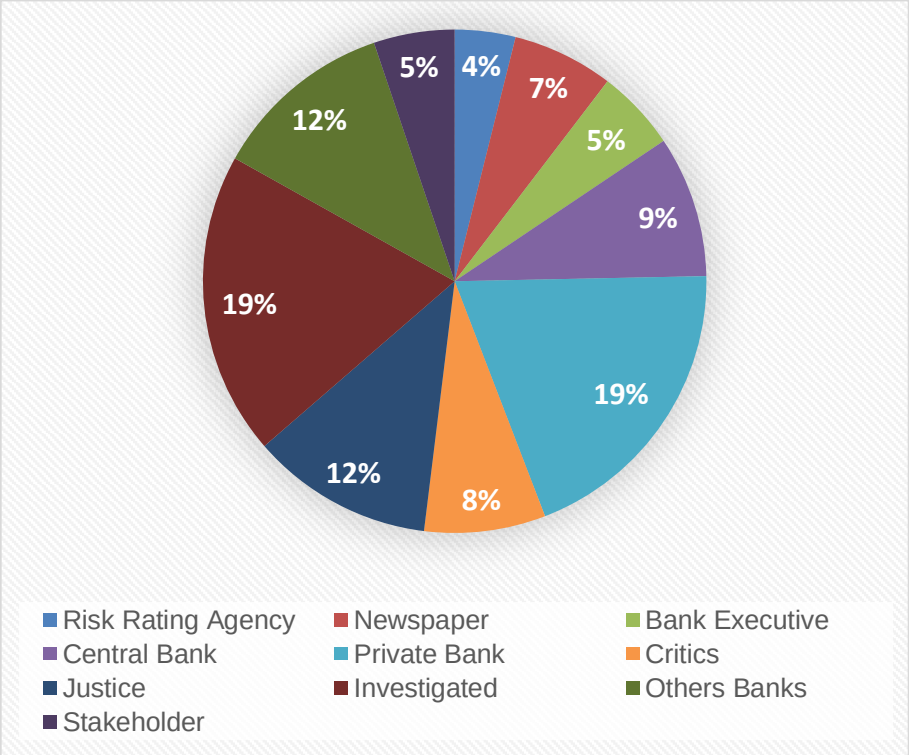

Fig. 2. Agents compared by number of references. Total of actors: 113. (Source: Prepared by the authors)

In accordance with [11], the ABM is a set of topologies used to represent the interactions and relationships among the agents. Moreover, for modeling, it is important to follow some questions: (i) “Who is, or could be?" for example, Critics; (ii) "Is it connected to whom?” Critics are connected with Private Bank and Stakeholders, as depicted better in Figure 7. Also, these questions may indicate properly the rules of behavior and decisions. In our model, it is possible to observe it in the diagrams below. They represent the contagion spreading across the financial environment. The following figures show the structure of the IF-THEN rules regarding the observed behaviors.

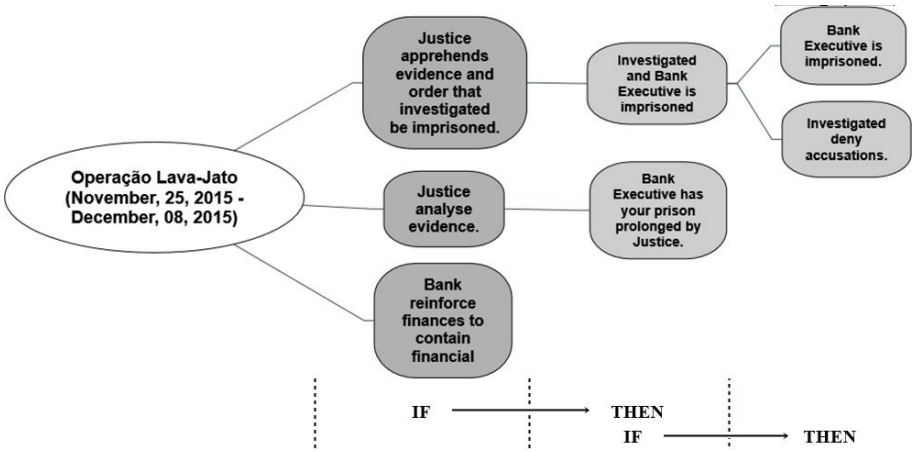

Fig 3. Behavior diagram of the first level nodes, formed by interactions between agency classes and environment. (Source: Prepared by the authors)

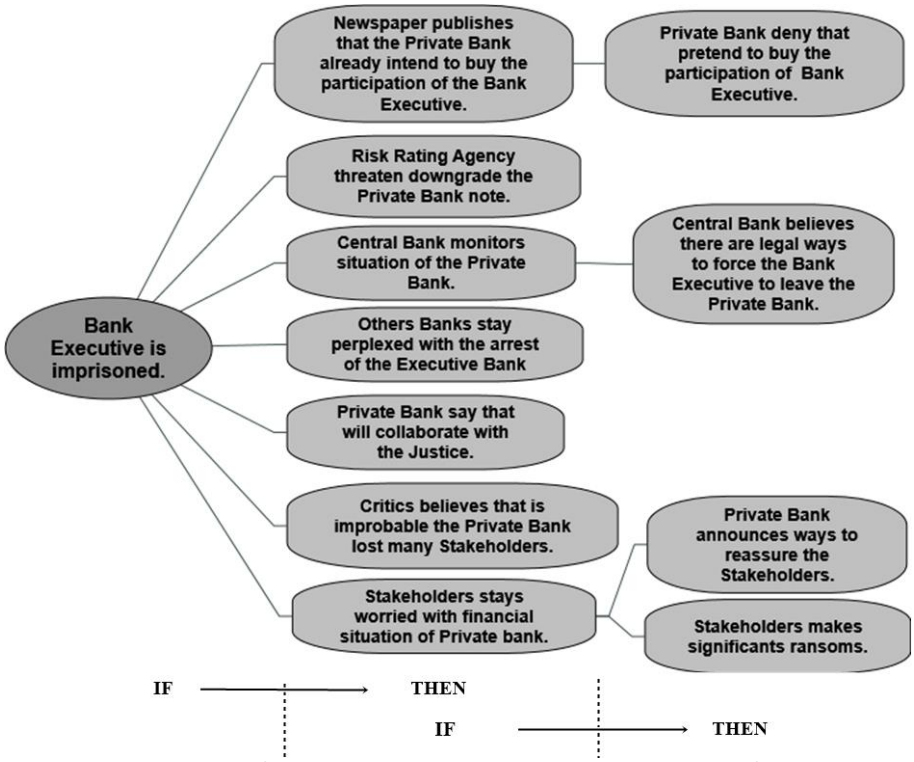

Fig 4. Behavior diagram of the second level nodes – Deepest representation of the behaviors of the node "Bank Executive is imprisoned". (Source: Prepared by the authors)

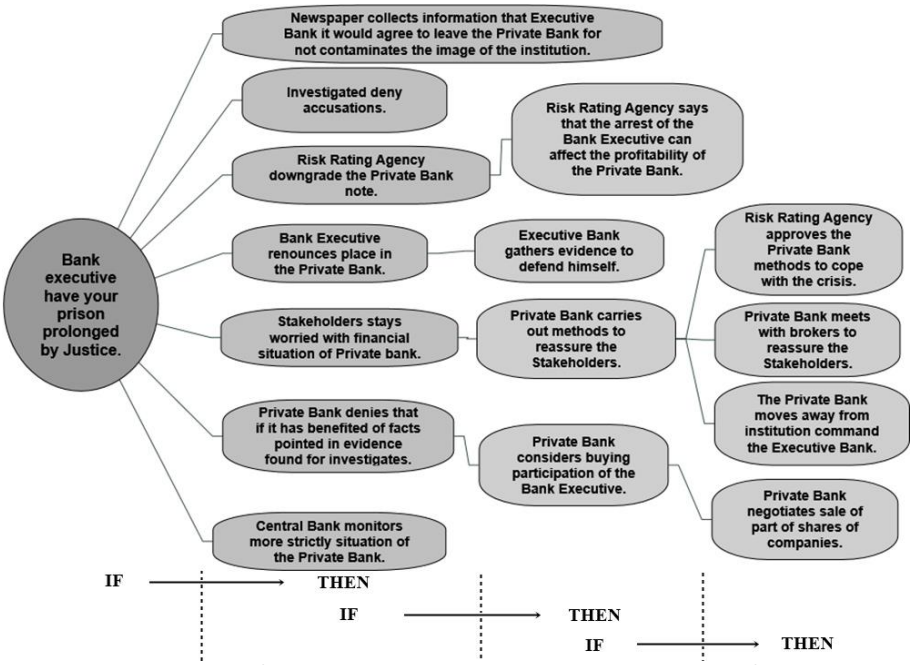

Fig 5. Behavior diagram of the second level nodes – Deepest representation of the behaviors of the node: Bank Executive has your prison prolonged by Justice. (Source: Prepared by the authors)

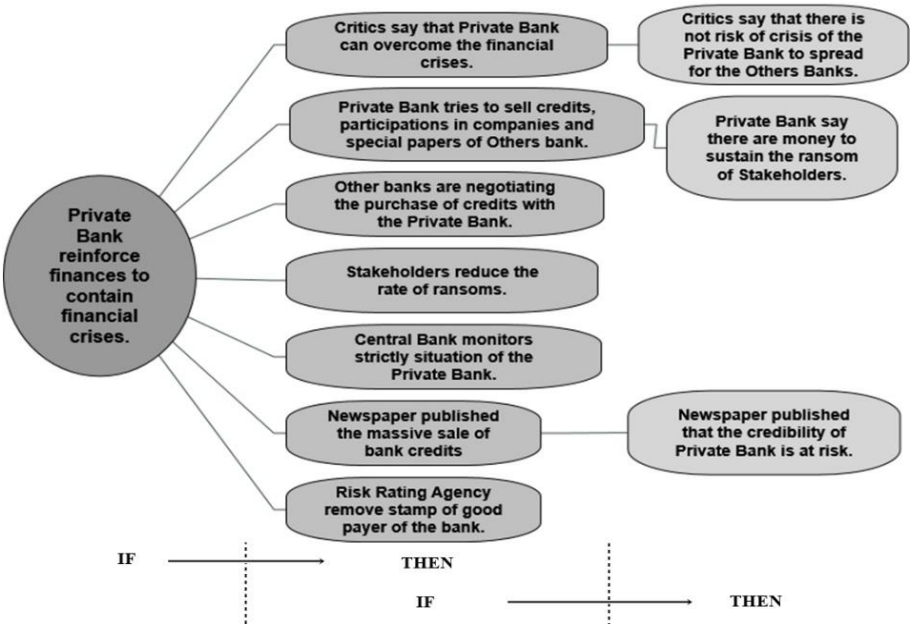

Fig 6. Behavior diagram of the second level nodes – Deepest representation of the behaviors of the node: Private Bank reinforce finances to contain financial crises". (Source: Prepared by the authors)

The following figure shows the relationships between the actors present in the diagrams:

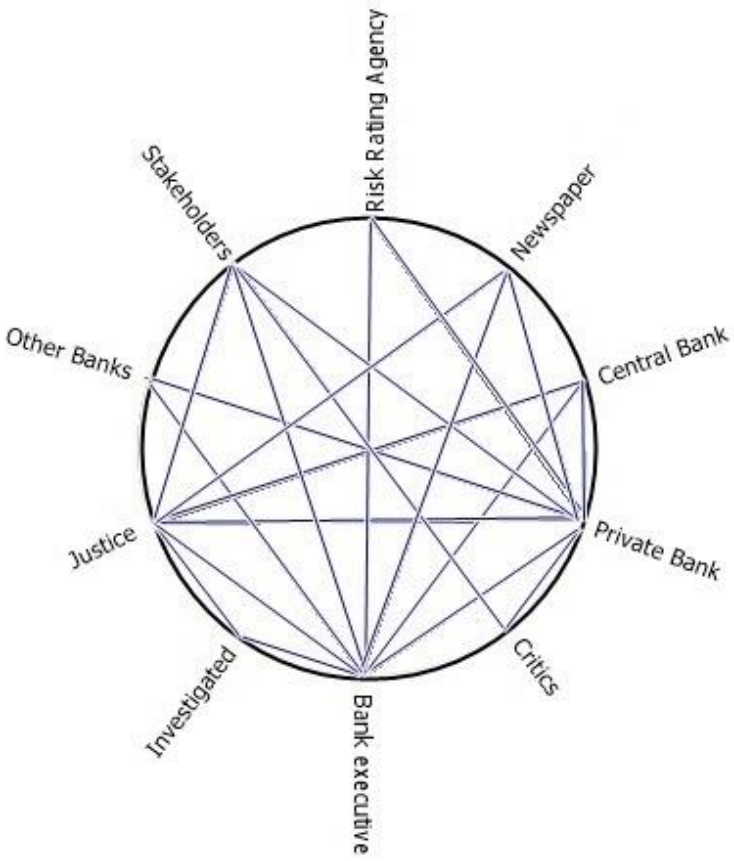

Fig. 7. How the agents are connected in a Two-dimensional network with links to other agents. (Source: Prepared by the authors)

5 Results and final Conclusions

Validity of the conceptual model can be defined by the confirmation that the theories and implicit preconditions to the model are correct [5]. So with this model it is easy to point the agents (actors), your links (relationships) among themselves and the environment that they are part of, and the parameters that change the dynamics of your world (environment), making it valid for an ABM. The representation of the problem when reasonable for the proposed model is also a conceptual model. Therefore, analyzing the diagram above, it is possible to notice how each actor influences and was influ-

enced by the environment around it due to facts that have arisen because of the contagion. The conceptual model developed has sufficient information to do the modeling of an Agent-based model based.

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