

DESIGNING THE PRODUCTION RULES FOR AN EXPERT SYSTEM TOWARDS VALUATION LIQUIDITY AND SOLVENCY RISK

*Ștefan Cristian Gherghina*¹

ABSTRACT

Liquidity ratios analyze the company's capacity to pay off its short-term debt obligations, whereas solvency ratios examine the company's ability to meet its long-term liabilities. However, banks are particularly concerned about the liquidity and solvency of a corporation rather than just the collateral securitizing the loan. One of the artificial intelligent tools which have been most widely employed for applications out of various industrial sectors is expert systems. An expert system provides support towards removing limitations on information that only the experts in the specific field could provide. The knowledge is represented as a set of rules called productions. A suitable set of rules can be used to form the basis of a production system which is one of the main methods of implementing expert systems. Current paper aims at designing the production rules for an expert system in order to assist risk managers towards valuation liquidity and solvency risk. Likewise, several tools for building the suggested expert system are proposed.

Keywords: Expert system, Production Rules, Shell, Liquidity Risk, Solvency Risk

1. INTRODUCTION

The duration and asperity of the liquidity break-up over the recent financial crisis of 2007-2009 has prompted regulators to emphasize the importance of sound liquidity risk management. In 2013, The Basel Committee on Banking Supervision has developed the liquidity coverage ratio to promote the short-term resilience of the liquidity risk profile of banks by ensuring that they have sufficient high quality liquid assets to survive a significant stress scenario lasting 30 calendar days. Liquidity and solvency are dashboard clues as regards the firm financial health. As such, liquidity and capital solvency are completely connected and cannot be evaluated and managed separately. In fact, liquidity measures the ability of a firm to pay its short-term obligations, whilst solvency reveals the capacity to cover debt obligations in the long run. Besides, solvency is vital for remaining in business, but a corporation also needs liquidity to flourish. However, an insolvent firm must enter bankruptcy, as well as a company without liquidity can also be constrained to enter bankruptcy even if it is solvent.

Within computer science, the artificial intelligence (hereinafter 'AI') depicts the area which aims at explaining and simulating by the means of mechanical or computational processes several aspects of human intelligence. As forms of intelligence we emphasize the capacity to interact with the environment through sensory means and the ability to make decisions in unexpected situations without human intervention. However, AI was developed as an attempt to answer the basic questions about human existence trying to understand the nature

¹ Bucharest University of Economic Studies, 6 Romana Square, 1st district, Bucharest, 010374 Romania, E-mail: stefan.gherghina@fin.ase.ro

of intelligence. Subsequently, AI has evolved into a scientific and technological field influencing many aspects of commerce and society. In fact, defining fields of research towards AI covers game playing, the understanding and synthesis of natural language, computer vision, problem solving, learning, as well as robotics. Alan Turing proposed in 1936 the Turing Machine that could be used to perform a finite mathematical operation, being the mathematical tool equivalent to a digital computer. Further, there was suggested the Universal Turing Machine that could be used to perform literally any finite mathematical operation.

Likewise, Hans Moravec introduced the idea of a Universal Robot that could be used to perform any humanly performable task. Accordingly, by 2040 robots will become as smart as people are, moreover replacing humans as the dominant form of life on Earth. There were revealed the following generations: first-generation universal robots: 2010 - 3,000 microprocessor without interlocked pipeline stages (hereinafter 'MIPS') showing a lizard-scale intelligence; second-generation universal robots: 2020 - 100,000 MIPS showing a mouse-scale intelligence; third-generation universal robots: 2030 - 3,000,000 MIPS showing a monkey-scale intelligence; fourth-generation universal robots: 2040 - 100,000,000 MIPS showing a human-scale intelligence. Moreover, Ray Kurzweil, considered by many to be the world's leading expert on AI, said that by 2029 computers will be more intelligent than humankind and will be able to learn from experience, crack jokes, tell stories, and even flirt. Chess programming emphasizes a challenging way to employ the techniques related to AI. For instance, Deep Blue was a chess-playing computer designed by IBM that defeated the world champion Garry Kasparov in 1997.

Besides, expert systems (hereinafter 'ES') are part of computer applications known as AI. An ES is a software system that reproduces the reasoning results of human experts (hereinafter 'HE') in a well defined area, having the purpose to bring counsel towards problems in the field comparable to the advice that a HE would deduce for those same problems (Holsapple et al., 1988). In other words, the expertise is transferred from a human to a computer, thus the knowledge being then stored in the computer and users call upon the computer for specific advice as required. In fact, an ES describes an AI application that uses a knowledge base of human expertise to support towards solving problems. The computer emphasizes the ability to make inferences and give off a particular summary. ES provide powerful and flexible paths towards gathering solutions to a variety of problems that often cannot be dealt with by other more traditional and conventional methods. Consequently, their use is proliferating within several sectors of our social and technological life, where their implementation is proving to be critical in the process of decision support and problem solving.

Furthermore, Feigenbaum and McCorduck (1983) noticed that 'knowledge engineering is an engineering discipline that involves integrating knowledge into computer systems in order to solve complex problems normally requiring a high level of human expertise'. Hillyer (1985) defined an ES as 'a computer program to solve the difficult problems that a human expert solves' and a knowledge-based ES as 'an expert system that has the ability to solve its problems by virtue of explicit, declaratively represented knowledge of the problem domain, not just clever algorithms'. Withal, Hillyer (1985) stated that an expert addresses to the quality of the problem solving, whereas knowledge-based to the means of solution. Therefore, current paper aims at designing the production rules for an ES towards

valuation liquidity and solvency risk. This approach is useful for risk managers regarding their tasks of valuation liquidity and solvency risk.

The paper is organized as follows: the basics of ES are provided in Section 2; a review of the most recent ES in different fields is disclosed within Section 3; the suggested production rules for an *ES towards valuation liquidity and solvency risk* are revealed in Section 4; several tools for implementing the proposed production rules are provided in Section 5; concluding remarks and further research directions are proposed in Section 6.

2. THE BASICS OF EXPERT SYSTEMS

By the means of AI there could be developed computer systems that prove features of intelligent behavior, whereas *ES make it possible for a novice to commit at the level of an expert in very specific situations*. According to Feigenbaum (1982), an ES ‘is an intelligent computer program that uses knowledge and inference procedures to solve problems that are difficult enough to require significant human expertise for their solution’. **DENDRAL is one of the early examples of a successful AI program, developed beginning in 1965 by the AI researcher Edward Feigenbaum and the geneticist Joshua Lederberg, both of Stanford University in California aiming at examining the organic compounds to determine their structure.** Developed in 1968 by Engleman, Martin, and Moses at Massachusetts Institute of Technology and written in Lisp, MACSYMA was a large, interactive mathematics ES towards handling mathematical expressions symbolically. HEARSAY-I project developed in 1971 was the first blackboard system developed with the purpose to recognize human speech. **MYCIN was developed at Stanford University by Shirliffe (1970’s) for treating blood infections.** Subsequently, there were attempts to coordinate multiple ES in the HEARSAY II and HEARSAY III systems. Developed in 1974 at the University of Pittsburgh, INTERNIST-I was a rule-based ES designed to support diagnosis, whose knowledge base contained over 100,000 links between diseases and their symptoms, being used as a basis for successor systems including CADUCEUS, as well as Quick Medical Reference (QMR). **First used in 1978, PROSPECTOR was an ES for mineral exploration developed by the Stanford Research Institute.** LITHIAN was developed to give advice to archaeologists examining stone tools. **Fist used in 1979, PUFF was an ES for interpretation of pulmonary function data.** Developed in the 1980s, ONCOCIN was a rule-based medical ES designed to assist doctors with the treatment of cancer patients receiving chemotherapy.

Figure 1 shows the conventional architecture of an ES, consisting of a knowledge system, an inference engine, and a user interface. The knowledge base comprises the set of facts and rules that set out the expertise. The inference engine carries out the process of inference from the facts and rules in the knowledge base. There are two inference methods, namely forward chaining or data driven reasoning, as well as backward chaining or goal driven reasoning. Being a data-oriented approach, forward chaining searches the solution space from an initial state to a final goal state. On the other hand, being a goal-oriented search technique, backward chaining starts with the desired goal state and works backward to the initial state by applying the inverse operator. The user interface depicts the path whereby the user supplies additional information to the system, either in response to demand or by volunteering it, and the means whereby he gets the output.

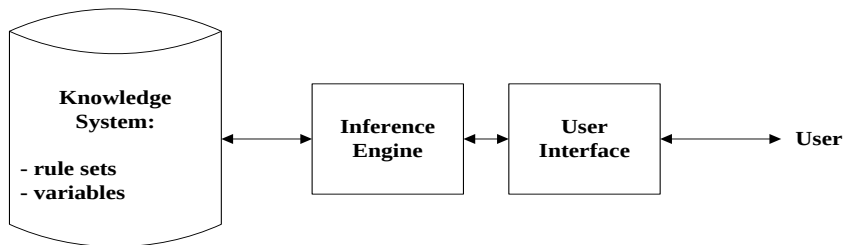


Figure 1. The conventional architecture of an expert system

Source: Holsapple, C. W., Tam, K. Y. and Whinston, A. B. 1988. Adapting expert system technology to financial management. *Financial Management*, 17(3): 12-22.

The development of an ES proceeds through the following typical stages: (1) system concept, (2) feasibility study, (3) outline specification, (4) preliminary knowledge acquisition, (5) knowledge representation, (6) tool selection, (7) prototype development, (8) main knowledge acquisition, (9) revised specification, (10) system development, (11) testing and evaluation, and (12) handover. Besides, the process is iterative with looping back between some of these stages. Prototyping includes the creation of the prototype, the writing of the documentation, the induction of the user, alongside the use and evaluation by the user.

As regards the advantages, an ES is permanent (HE is perishable), an ES is consistent (HE is unpredictable), and ES ensures quick replication (HE provides slow reproduction), an ES is affordable (HE is expensive), an ES is fast processing (HE is slow processing). Otherwise, as regards disadvantages, an ES lacks inspiration (HE is creative), an ES needs instruction (HE is adaptive), an ES shows a narrow focus (HE proves a broad focus), and an ES is machine knowledge (HE have common sense).

3. REVIEW OF EXPERT SYSTEMS IN THE SCIENCES

ES in agriculture. Jeanneret et al. (2014) presented an ES to estimate and compare the impact of farming systems on biodiversity using a set of indicator-species groups. Lambert et al. (2014) described an efficient orchard production management model based on an ES that uses fuzzy logic to imitate the knowledge and expertise of the agricultural field dynamics for fruit production in its three basic stages (flowering, fruit set, fruit growth).

ES in commerce. García-Crespo et al. (2011) developed a semantic hotel recommendation ES (Sem-Fit), based on the consumer's experience about recommendation supplied by the system. Navarro-Barrientos et al. (2014) developed an ES for predicting purchasing behavior in the semiconductor market.

ES in education. Dias and Diniz (2013) introduced a fuzzy logic-based model entitled FuzzyQoI showing the ability to consider the professors' and students' interactions, as expressed through the learning management systems usage within a blended-learning environment. Jaques et al. (2013) presented an ES module of an Algebra Intelligent Tutoring System, entitled PAT2Math, liable for correcting student steps and modeling student knowledge components over equations problem solving.

ES in finance. Grahovac and Devedzic (2010) developed a cost management ES (COMEX). Yunusoglu and Selim (2013) developed a fuzzy rule based ES to assist portfolio managers in their middle term investment decisions.

ES in manufacturing. İpek (2013) built an ES in order to solve the wrong selection of materials which caused huge prices and product breakdown. Urrea et al. (2015) discussed the development of an ES for the selection of materials to be used in the construction of the main structure of a crane-like device for transporting persons with physical disabilities.

4. THE PRODUCTION RULES FOR AN EXPERT SYSTEM TOWARDS VALUATION LIQUIDITY AND SOLVENCY RISK

There are considered the following liquidity ratios: current ratio, quick ratio, and cash ratio, as well as the following solvency ratios: general solvency ratio, and patrimonial solvency ratio. Current ratio shows the firm's ability to meet its short-term obligations with its current assets, covering cash, accounts receivable, and inventories. Quick ratio points out a corporation's capacity to pay off its short-term liabilities with its most liquid assets, and therefore inventories are precluded from its current assets. Cash ratio denotes the extent to which readily available funds can pay off current obligations. General solvency emphasizes the company's ability to use its debt for financing its assets. Patrimonial solvency ratio determines the proportion of the total assets that are financed by stockholders and not creditors.

The computation formula for each selected ratios is provided below:

- Current ratio = Current Assets/Current Liabilities;
- Quick ratio = (Current Assets - Inventory)/Current Liabilities;
- Cash ratio = Cash and Cash Equivalents/Current Liabilities;
- General solvency ratio = Total Assets/Shareholders' Equity;
- Patrimonial solvency ratio = Shareholders' Equity/Total Assets.

The conventional format for a production rule is the IF-THEN statement: IF < condition > THEN < action >, where <condition> describes a logical statement that, if true, leads to the <action> being undertaken. The production rules have a Left-Hand Side (LHS) known as the antecedent, premise, condition, or situation, as well as a Right-Hand Side (RHS) known as the consequent, conclusion, action, or response. Moreover, the proposition on the LHS may be a compound one with a number of propositions ANDed together. A production system has three main features: the rule base, a working memory, and the inference engine. The rule base covers the set of rules that incorporate the expertise of the system. The working memory is provided with the input data or facts on the problem to which the rules are to be employed. The inference engine controls the operation of the rules to infer a summary from these data. A suitable set of rules, or productions, can be used to form the basis of a production system. Besides, production systems are one of the main methods of implementing ES.

The production rules for an ES towards valuation liquidity and solvency risk are provided below as logical blocks (hereinafter 'LB').

- LB 1

IF:

Do you want to analyze the liquidity risk based on the current ratio? NO

THEN:

You have not selected the analysis of the liquidity risk based on the current ratio!: Confidence = 70

IF:

Do you want to analyze the liquidity risk based on the current ratio?

YES

AND: $[\text{Current_Assets}] / [\text{Current_Liabilities}] > 2$

THEN:

The company shows a good short-term financial strength: Confidence = 70

IF:

Do you want to analyze the liquidity risk based on the current ratio?

YES

AND: $[\text{Current_Assets}] / [\text{Current_Liabilities}] < 1$

THEN:

The company has difficulty meeting current obligations: Confidence = 70

- LB 2

IF:

Do you want to analyze the liquidity risk based on the quick ratio? NO

THEN:

You have not selected the analysis of the liquidity risk based on the quick ratio!: Confidence = 70

IF:

Do you want to analyze the liquidity risk based on the quick ratio? YES

AND: $[\text{Current_Assets} - \text{Inventory}] / [\text{Current_Liabilities}] > 1$

THEN:

The company can meet its current financial obligations with the available quick funds on hand: Confidence = 70

IF:

Do you want to analyze the liquidity risk based on the quick ratio? YES

AND: $[\text{Current_Assets} - \text{Inventory}] / [\text{Current_Liabilities}] < 1$

THEN:

The company cannot currently fully pay back its current liabilities: Confidence = 70

- LB 3

IF:

Do you want to analyze the liquidity risk based on the cash ratio? NO

THEN:

You have not selected the analysis of the liquidity risk based on the cash ratio!: Confidence = 70

IF:

Do you want to analyze the liquidity risk based on the cash ratio ratio?

YES

AND: $[\text{Cash_and_Cash_Equivalents}] / [\text{Current_Liabilities}] > 0.5$

THEN:

The company shows the ability to pay off its current liabilities with only cash and cash equivalents: Confidence = 70

IF:

Do you want to analyze the liquidity risk based on the cash ratio ratio?

YES

AND: $[\text{Cash_and_Cash_Equivalents}] / [\text{Current_Liabilities}] < 0.5$

THEN:

The company does not show the ability to pay off its current liabilities with only cash and cash equivalents: Confidence = 70

- LB 4

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IF:
  Do you want to analyze the corporate solvency based on the general
  solvency ratio? NO
THEN:
  You have not selected the analysis of the corporate solvency based on
  the general
  solvency ratio!: Confidence = 70
IF:
  Do you want to analyze the corporate solvency based on the general
  solvency ratio? YES
AND: [Total_Assets]/[Shareholders_Equity]>1.5
THEN:
  The company shows the ability to return the loans: Confidence = 70
IF:
  Do you want to analyze the corporate solvency based on the general
  solvency ratio? YES
AND: [Total_Assets]/[Shareholders_Equity]<1.5
THEN:
  The company records solvency risk: Confidence = 70
    • LB 5
IF:
  Do you want to analyze the corporate solvency based on the patrimonial
  solvency ratio? NO
THEN:
  You have not selected the analysis of the corporate solvency based on
  the patrimonial solvency ratio!: Confidence = 70
IF:
  Do you want to analyze the corporate solvency based on the patrimonial
  solvency ratio?
    YES
AND: [Shareholders_Equity]/[Total_Assets]>0.3
THEN:
  The company records an increased self-financing ability: Confidence = 70
IF:
  Do you want to analyze the corporate solvency based on the patrimonial
  solvency ratio?
    YES
AND: [Shareholders_Equity]/[Total_Assets]<0.3
THEN:
  The company does not record self-financing ability: Confidence = 70

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5. TOOLS FOR BUILDING EXPERT SYSTEMS

There was noticed that ES building tools (shells) are not so flexible, but they are easier to use as compared to high-level languages. Most ES are developed by means of specialized software tools entitled shells which come equipped with an inference mechanism (backward chaining, forward chaining, or both), and require knowledge to be entered according to a specified format. An early ES shell was 'Empty Mycin' or 'Essential Mycin' (E-Mycin) taken from the medical diagnostic ES Mycin. Further, we provide several tools for implementing the proposed production rules. Exsys Corvid development software provides non-programmers a new way to easily build interactive Web applications that capture the logic and processes used to solve problems and deliver it online, in stand-alone applications and embedded in other technologies. ILOG, part of IBM, is a leader in business rule management systems. The Java Embedded Object Production System (JEOPS) it's a

project intended to give Java the power of production systems. Java Expert System Shell (Jess) is a rule engine and scripting environment written entirely in Oracle's Java language by Ernest Friedman-Hill at Sandia National Laboratories in Livermore, CA. Java Theorem Prover (JTP) is an object-oriented modular reasoning system developed by Gleb Frank in Knowledge Systems Laboratory of Computer Science Department in Stanford University. Production Systems Technologies (PST) is a company in Pittsburgh, PA that supplies high-performance rule-based systems.

6. CONCLUDING REMARKS AND FURTHER RESEARCH DIRECTIONS

Financial distress is well-known as a driving force towards several corporate decisions. Liquidity and solvency risks are tight related to cash-flow incertitude since short-term shocks to cash flows, alongside with the availability of cash reserves, influence corporate liquidity. Moreover, there are occurring solvency concerns due to the uncertainty as regards average future profitability, as well as financial leverage. In fact, a corporation can become illiquid after a negative short-term cash-flow or it can become insolvent if the expected rate of cash-flows falls duly (Gryglewicz, 2011). An ES depicts a computer program that simulates the judgment and behavior of a HE, being used for counseling novice whenever the HE is unavailable. The most acknowledged approach related to knowledge representation is to use production rules, namely IF-THEN rules. Thereby, several production rules were designed for an ES with the purpose to assist risk managers towards valuation liquidity and solvency risk. As future research avenues, our aim is to implement the rules by using any of the tools for building ES revealed in current paper.

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