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Graph Models for Capital Markets

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Abstract. The sub-prime mortgage crisis of 2008 has heightened the need for more effective and transparent tools in the modelling of uncertainty of returns from expected cash flow streams within the capital markets. One of the key development needs is that of effective assurance methods. Graph Transformation Systems (GTS) are natural verification and validation tools given that dynamic graphs are able to provide mechanisms for explaining complex situations intuitively, and rule based systems are able to mathematically capture the dynamics of otherwise relatively difficult problems. In this paper we present a preliminary secondary market GTS model for validation purposes. We use port graphs to represent system states, and port graph rewriting rules to specify the dynamics of the system. The model is implemented within PORGY, a visual, interactive port-graph rewriting tool.

Introduction

The sub-prime mortgage crisis of 2008 has heightened the need for more effective and transparent tools in the modelling of uncertainty of returns from expected cash flow streams within the capital markets. Improper evaluation of new mortgage derivative products is believed to be the key driver behind the bubble. Given the failure of traditional top-down macro equilibrium models to predict the crisis, economists are gradually turning away from them in favour of more autonomous agent-based models (ABM), that, as a result of examining behaviour at a micro-level, are able to provide more realistic views [2].

'Rational negligence' has been noted as the behavioural pattern among agents in the Asset-Backed Securitization (ABS) space that has led to weakening in the market. Instead of performing a proper risk assessment, agents relied on ratings from agencies that were sometimes found to be inaccurate, especially in terms of underestimated default probabilities [1], details the DSGE (Dynamic Stochastic General Equilibrium) models were unable to capture or anticipate.

In this paper, we seek to formalise theories that have developed in the study of this area as a series of graph transformations rules, governed by suitable strategies. The resulting derivation tree describes the operational execution of the graph transformation system. It represents the whole process, right from origination to placement of securitized assets within a secondary market. By employing a graph transformational paradigm, inbuilt mechanisms that favour

accurate verification and validation, or assurance, can be more easily utilized. In addition, graph transformation systems provide a visual trace of the evolution of a dynamic system.

Contributions

We have built a hierarchical model of secondary capital markets, where the ‘rational negligence’ model sits at the top level of the hierarchy. Non-deterministic in nature, it highlights the strategy the market has adopted with regards to independent analysis. The model can handle different approaches to due diligence, operational costs, asset value and liquidity perceptions, among other variables. Below this system, able also to be executed to handle asset pricing and valuation issues, lie several more deterministic subsystems that model origination, structuring, SPV transfers and profitability of the sale, and therefore aid in enforcing internal checks as a result of complete system integration. Calculations are executed at rule level, such as in deciding whether or not propagation of an independent risk assessment of the asset separated from the influence of sentiment and market perception should occur. In addition to the graph transformation rules, the model includes strategies that not only control execution but also perform analytics.

All functionality is housed within the PORGY system, a graph transformation tool based on port graph rewriting, which provides a visual, interactive interface and an expressive strategy language [3]. Strategic port graph rewriting is a powerful mechanism to model dynamic behaviour. It has been used to model social networks, biochemical systems, interaction nets, etc.

Conclusion

We have used strategic port graph rewriting as a tool to model secondary capital markets. The derivation tree, which gives a visual account of the possible behaviours of the system, can be used as a debugging tool, or to experiment with different strategies and fine tune the rules. In future, we plan to develop predicate abstractions and state-based abstractions, as a technique to verify properties of the system.

References

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