Improving Systemic Risk Monitoring and Financial Market Transparency: Standardizing the Representation of Financial Instruments

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The financial crisis of 2008 made one fact absolutely clear: neither government financial policy makers and regulators nor firm level executives and risk managers had the data and analytics to understand the risks they were facing. The Dodd-Frank Act (DFA) recognized this deficiency and included specific provisions to correct the situation. These provisions require the Office of Financial Research (OFR) to create two critical reference databases and reporting standards for reporting granular transaction and position data. The first reference database, "a *financial company reference database* "is to encompass unique identifiers and associated information for counterparties to financial obligations. The second reference database, *"a financial instrument reference database*," is to standardize the representation of financial obligations suitable for the analytical use case. Excellent progress is being made on the first reference database under the Financial Stability Board's Global Legal Entity Identifier (LEI) effort. This paper is a progress report on an effort to create what could be, in effect, the second reference database, the standardized representation of financial instruments.

Critical Criteria for Satisfying the Intent of DFA

1) A major criticism of risk analysis in the wake of the crisis of 2008 is that it was backward looking. To use the analogy expressed at the time, it was like driving a car while looking in the rear view mirror. One of the goals of DFA was to make risk analysis forward looking. The analogy used by Senator Dodd, Chairman of the Senate Banking Committee, was to make regulation and risk analysis akin to driving a car while looking through the windshield. Therefore, to meet both the specific requirements of DFA and the intent clearly expressed by the authors, any approach to creating the financial instrument reference database must be an approach that makes possible forward looking financial analysis.

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2) Building a reference database is about representing key reference data needed to support financial analysis. It is not about undertaking analysis. Therefore, the approach to building the financial instrument reference database should produce the inputs needed for financial analysis rather than the analysis itself. State contingent cash flows associated with a financial obligation are the starting point for any financial analysis and they should be derivable from the standardized representation of financial instruments in the reference database if it is to support forward looking financial analysis, such as stress testing. However, items such as fair value at a point in time are analysis elements and should not be included in the reference database.

3) To make any kind of financial analysis feasible for the large variety of financial instruments extant in the market, a way must be found to standardize and efficiently extract the common elements of such instruments that are important for financial analysis. Aspects of such instruments that are not critical for this purpose can be put aside.

An Approach to Building an Instrument Reference Database Suitable for the Analytical Use Case

The most basic data used in financial analysis fall into two categories: (A) the obligations of counterparties to exchange specific cash flows as expressed in a legally binding contract, and (B) the risks factors that determine what cash flows are actually exchanged under the terms of the contract. That is, the contractual obligations are the hard facts of the financial world that embody the specific payment obligations to which the counterparties agree. However, the actual cash flows turn out to be the product of the interaction between the contracts and the state of the risk factors: market risk, credit risk, and behavioral risk. Therefore, a financial instrument reference database that can support forward-looking financial analysis must be able to: 1) represent financial instruments as algorithms that accurately generate the cash flow obligations contained in a contract.; 2) those algorithms must be able to access the current state of risk factors to support current analysis; and 3) analysts must be able to easily specify alternative assumptions about the future state of the risk factors to generate state contingent cash flows to support forward looking analysis.

For example, a simple loan contract might express the amount of the initial loan, the term of the loan, the start date, interest rate (fixed or floating), payment patterns for interest (capitalized or periodic payments), and a principle repayment schedule (principle at maturity or periodic payments). Those terms of the contact would be contained in the algorithmic representation of the contract. However, these contract obligations by themselves do not determine what the real world cash flows will be. The actual payments under the contract will be a function of the contract terms and the state of the various risk factors that affect the payments. If the interest rate is fixed, there is no market risk variable used to determine the actual interest payment obligations. If the interest rate is adjustable or floating, the payment obligations can only be determined with reference to the market derived index used to set the interest rate at any point in time. Furthermore, the actual cash flows under the contract will also be affected by the credit risk of the obligor: the willingness and ability of the obligor to make contractual payments.

In the event a financial contract does not specify all cash flow contingencies, such as for a long-term fixed-rate U.S. mortgage or a savings account, additional risk factors come in to play. Long-dated U.S. fixed-rate mortgages typically include the option to prepay the mortgage without a fair market penalty. Such a mortgage might be prepaid at any point over the term of the mortgage. The terms of savings accounts give depositors the right to withdraw funds at short notice. Therefore, funds might be withdrawn at any time the account is open. Modeling the cash flows of such instruments requires the addition of a statistical representation of behavioral risk.

The Formal Model[2]

[2] Willi Brammertz and Allan Mendelowitz, "Regulatory Revolution: The Great Data Challenge", Risk Professional, August 2010

Input Elements

Analysis Elements

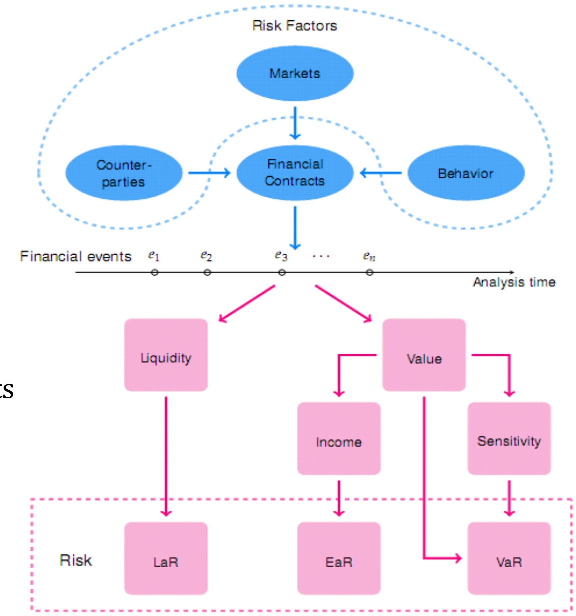

Figure 1

Figure 1 represents the architecture needed to create a Financial Instrument Reference Database consistent with the intent of DFA. The core of the model is the financial contract, a mutual promise of two or more counterparties to exchange cash-flows according to a set of rules. The rules can be represented as unambiguous algorithms that represent the commitments contained in the contracts. Since the "promises" of exchanging cash flows are the only hard facts of finance, they have to take center stage. However, the contracts are surrounded by and relate to the *risk factors* – markets, counterparties, and behavior.

- *Markets*: Many contracts such as floating rate bonds, options, etc., include rules that refer to market conditions, such as interest rates, foreign exchange rates, or stock or commodity indices. Market conditions are also used for discounting and valuation.

- *Counterparties*: While financial contracts represent hard facts, compliance with the strict terms of a contract is not assured. Counterparty risk is the risk that a counterparty may not fulfill the obligations of a contract. The new LEI system will play an important role in better understanding this risk: 1) it will provide a unique identifier for each legal entity that is a counterparty to financial contracts; 2) the data associated with each unique LEI will permit better judgments about the credit risk of the obligors; and, 3) the unique identification of the counterparties and the associated information about the make-up of corporate families will make possible more accurate aggregation of exposures to identify concentrations of risk.

- *Behavior*: Some rules governing the exchange of cash flows are not deterministic in the mechanical sense. The best examples, as mentioned earlier, are saving accounts from which funds may be withdrawn at short notice or long-term fixed-rate home mortgages in the United States, which may be prepaid without a fair-value penalty. Since such rules can only be formulated statistically they are part of the risk factors.

Market conditions, counterparty and behavioral information are called *risk factors;* at best their current conditions are known, and they can be expected to change in the future. Contracts and the risk factors are called input factors because they jointly determine the state contingent cash flows associated with any financial contract. The state contingent cash can be calculated if the mutual agreements of financial contract and their surrounding risk factors are known. In other words, the state contingent cash flows correspond to reading a financial contract under different risk factor conditions. Once the state contingent cash flows are generated it is possible to derive the analysis elements: liquidity, value, income, sensitivity and risk (lower part of Figure 1). In this approach we unambiguously separate inputs and analysis elements. Therefore, value is not an input but an output. In this system analysis elements, such as value, can be calculated under current risk factor conditions, and under different assumptions as to what the risk factors might be in the future, such as under shocked or stressed conditions. Furthermore, analysis elements can be computed under any model or approach that might be desired. For example, value can be calculated according to any valuation principle (nominal, fair value, amortized cost etc.), or in the case of options, using different pricing models.

The inputs permit the calculation of all analysis elements because they are completely dependent on them. However, the relationship between input and analysis elements is one-way. There is no way back to the inputs if a regulator or chief risk officer receives reports that include only analysis elements, such as market value of equity. With such reports the link between input and analysis elements is severed. And, the recipients of such reports cannot use them to undertake additional independent and forward-looking analysis.

A regulator who receives reports from a regulated entity that consist only of analysis elements can do little with the reports other than to observe the regulated entity's condition under the particular set of risk factors used to generate the reports. With such reporting regulators are not provided with the necessary inputs to independently assess the analysis conducted by the regulated entity. Furthermore, such reports do not provide regulators with the inputs that are required to do forward-looking analysis. For these reasons creating a model that focuses on and preserves the input elements is highly important from both a regulatory and an analytical perspective.

Forward looking financial analysis, whether for micro-prudential regulation, macro-prudential regulation, or firm-level risk management has to have access to the input factors. Central to those input factors is a standardized algorithmic representation of financial contracts extant in the market. Without such a standard the starting point for forward looking financial analysis – the state contingent cash flows – cannot be readily computed. With such a standard it is possible to perform any desired financial analysis in the risk-return framework.

Cutting the Gordian Knot of Financial Contract Complexity

Conceptually the basic model presented above is highly appealing. However, the challenge is to take the concept and turn it into something that can be operationalized in the real world. The financial market appears to be filled with an overwhelmingly large number of seemingly disparate and complex financial contracts. Creating a reference database for financial contracts and their non-ambiguous cash flow generating algorithms in the face of such complexity appears at first blush to be an overwhelming challenge. However, on closer examination there is a solution.

Because all financial analysis within a risk-return framework starts with state contingent cash flows, aspects of contracts[3] that do not directly bear on cash flow obligations can be set aside at this point. They are not important for the cash flow generating algorithms. This approach is analogous to an aircraft engineer who uses a scale model of a proposed new aircraft and a wind-tunnel to establish the aerodynamic properties of the new design. The wind-tunnel model can do an excellent job of revealing aerodynamic properties of the planned aircraft, but it cannot shed light on a host of other aspects of the proposed plane. Furthermore, many contracts that appear to be different because of legal classifications or product types may, in fact, generate the same cash flows patterns. For example a long-term fixed rate mortgage may seem like a different contract than an annuity. However, on closer examination, both the mortgage and the annuity have similar cash flow patterns. The complexity of the financial world is significantly reduced if we focus primarily on the cash flow patterns of different financial contracts. In fact, our work leads us to believe that most of the financial contracts can be represented with about 30 cash flow patterns. We refer to each of these cash flow patterns as a *Contract Type* (CT). Representing the 30 CTs in robust algorithms capable of capturing the specific details of any contractual obligation solves the problem of apparent complexity.

ACTUS: Algorithmic Contract Types Unified Standard

[3]See, Brammertz, et.al. 2009, Unified Financial Analysis, The Missing Links of Finance. Wiley Financial Series, Hoboken.

Creating a Financial Instrument Reference Data Base Suitable for the Analytical Use Case

With the financial support of the Alfred P. Sloan Foundation, Deloitte Consulting, and Zurich University of Applied Sciences we have undertaken a proof of concept for our approach to standardizing the algorithmic representation of financial contracts for the analytical use case. In this proof of concept we are:

- Developing a data dictionary suitable for the full set of CTs
- Identifying and programming the cash flow generating algorithms of a first set of 6 CTs
- Developing a Webpage interface for public access to the first set of CTs, the Data Dictionary, and instructional lectures that explain the ACTUS model and how to use it

A brief discussion of one contract type gives insight into how the approach will work.[4] To demonstrate the approach we will focus on the first of the CTs: Principal at Maturity (PAM). An algorithm is programmed to generate the cash flow obligations of any contract that can be best represented by the PAM CT. The wide range of contract elements that are included in the algorithm facilitates the wide applicability of the PAM CT. The following table breaks contract terms in to three categories. Only representative terms in each category are listed:

- Contract terms that must be defined for a contract represented by a PAM CT
    - Contract deal day: Date of the actual signing of the obligation
    - Initial exchange date: Date on which the first principal cash flow is paid
    - Principal: Principal or notional of the transaction
    - Interest rate: Nominal interest rate
    - Interest payment cycle: Initial and follow-on dates of interest payments
    - Maturity date
    - etc.
- Contract terms that may or may not be included in a contract represented by the PAM CT
    - Termination date and price: Only applicable for contracts sold into the secondary market before the maturity date
    - Interest rate reset rules and dates: Rate resets apply for variable rate contracts only
    - Capitalization: Only applicable for contracts with a capitalization period for interest payments

[4] For a more detailed discussion see: Willi Brammertz, "The Office of Financial Research and Operational Risk" in Victoria Lemieux, Editor, 2013 Financial Analysis and Risk Management: Data Governance, Analytics and Life Cycle Management, Springer, New York

    - etc.
- Contract terms that cannot be included in contract represented by the PAM CT
    - Amortization data
    - Call or put data
    - etc.

The appropriate terms for a particular contract represented by the PAM algorithm are entered into the program. Understanding how each CT relates to the various possible terms of a contract helps direct any real world contract to the right CT with which to represent it and serves as a quality check on the choice of CT. For example, if a contract has an amortization schedule it cannot be a PAM.

When different states of the risk factors are assumed and plugged into the algorithm, the state contingent cash flows are generated. The PAM CT has the ability to provide the state contingent cash flows for a broad range of contracts: fixed and floating interest rates; regular interest payments and capitalized interest; and any combination of the preceding. Furthermore, the PAM algorithm provides the foundation for other CTs. For example, the SWAP CT used to represent a plain vanilla interest rate swap is just the linking of two PAM CTs, a fixed-interest rate PAM and a floating-interest rate PAM.

At the **2013 Financial Stability Conference** we plan to present our model for a financial instrument reference database suitable for the analytical use case. In addition, we expect to be able to demonstrate a prototype of the website that will provide access to ACTUS, the data dictionary, and the first set of programmed CTs. We will demonstrate how a real world contract is mapped to the appropriate CT, how the system accesses risk factors, and how the algorithms then generate the state contingent cash flows. In addition we plan to present the objectives of the full project.

Beyond the Proof of Concept

The full project plans to accomplish over the next year and a half the following:

1) Identification and programming of the full set of 30 CTs in production level code to support high performance computing use of the ACTUS set of CTs in financial analysis.

2) Fully functioning ACTUS Website to provide full public access to the set of CTs to test how well real world contracts can be mapped to a CT and how precisely the CTs cash flows match the state contingent cash flows computed manually for real world contracts.

3) The formation of an ACTUS Open Source Community to take over responsibility for the ACTUS CT approach in order to:

   - Validate the model with a large scale empirical study to establish how completely the ACTUS CTs are able to represent the real world contracts extant in financial markets and how precisely the CTs are able to generate the state contingent cash flows of those contracts;
   - Continue development of the CT approach. If it is demonstrated that some additional CTs are needed for full representation of virtually all financial contracts, the open source community will oversee that further development.
   - Promote the ACTUS CT approach to standardized contract representation for use in firm level risk analysis, forward looking regulatory analysis, and making available the data needed for systemic risk monitoring.