The OntoREA© Accounting and Finance Model
A Retroactive DSRM Demonstration and Evaluation

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Motivation: A simple Forward case study

• Imagine you are a fruit shop owner and a client orders 100 kilos of Chiquita bananas to be delivered at Grote Markt 9 at the upcoming new year’s eve.

• What is the price per kilo that you have to ask for to be paid by the client at delivery date?
Introduction

• Problem: Missing demonstration and evaluation of the OntoREA© Accounting and Finance Model

• Design Science Research Methodology
  • Demonstration via real-case:
    – Stock forward contract example
  • Evaluation via adequate representation of derivative instruments:
    – Mapping of hedging portfolio approach
    – Consideration of Asset/Liability/Off Balance phases of forward contracts

• Model-driven Development context
  • From Platform Independent to Platform Specific Model
  • From Platform Specific to Implementation Specific Model
  • Prototypical application in RStudio/Shiny

• Conclusion
OntoREA Accounting and Finance Model in OntoUML

- Rigid REA-backbone:
- Resource, Event, Agent as <<Kind>> stereotype
- Balanced Duality as <<Relator>> stereotype
- Anti-rigid Economic Resources as <<Phase>> stereotype

### Peculiarities of derivative instruments: Replication via hedging portfolio

<table>
<thead>
<tr>
<th>Derivative peculiarities</th>
<th>Modeling in OntoUML</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Hedging portfolio of derivative</td>
<td>&lt;&lt;Collective&gt;&gt; Derivative Instrument with &lt;&lt;MemberOf&gt;&gt; relationship</td>
</tr>
<tr>
<td>1a) Long leg (Asset)</td>
<td>&lt;&lt;Kind&gt;&gt; Economic Resource/Asset</td>
</tr>
<tr>
<td>1b) Short leg (Liability)</td>
<td>&lt;&lt;Kind&gt;&gt; Economic Resource/Liability</td>
</tr>
<tr>
<td>2 Balanced reciprocity constraint</td>
<td>&lt;&lt;Relator&gt;&gt; Economic Contract</td>
</tr>
<tr>
<td>Fair Value = Sum (Long, Short leg)</td>
<td></td>
</tr>
</tbody>
</table>
Setting the OntoUML model of derivative instruments upon the OntoREA Accounting Model, gives the

OntoREA©
Accounting and Finance Model

1. Mapping of hedging portfolio as <<Collective>> stereotyped entity
2. Considering the modal-temporal behaviour of derivative instruments via the <<Phase>> stereotyped entities Asset, Liability and Off Balance

Using the model as Platform Independent Model
Derivative instruments: Definition and no-arbitrage

Contracting date: 01.01.2020
Expiration date: 31.12.2020
Initial stock price: 100
Initial interest rate: 4%
Long leg: Stock Asset 100
Short leg: Loan Liability 100
**Forward value: = A - L**  0 (Off B.)
Pricing date #1: 30.06.2020
Actual stock price: 100
Actual time to maturity: 6 months
Stock Asset: 100
Loan Liability: 101.98
**Forward value: = A - L**  -1.98 (L)
Pricing date #2: 31.12.2020
Actual stock price: 120
Actual time to maturity: 0 months
Stock Asset: 120
Loan Liability: 104
**Forward value: = A - L**  16 (A)
MDD: From Platform Indep. to Platform Spec. Model

- Transforming UML class diagrams into relational data models
  1. MemberOf-Relation via two Economic Resource classes
  2. Modal-temporal behaviour via Foreign Key constraint
  3. Distinction: Master-Transactional Data


- R data.table structure generated by R datamodelr-package
  1. MemberOf-Relation via two Economic Resource classes
  2. Modal-temporal behaviour via Foreign Key constraint
  3. Distinction: Master-Transactional Data
Generalization set constraint: Modeling modal-temporal behaviour of derivative instruments as

A) OCL constraint (PSM)
B) switch expression (ISM)

Algorithm. OCL invariant for the exclusivity of derivative instrument phases in PSM

```plaintext
class Derivative_Instrument
context d: Derivative_Instrument
inv exclusivePhaseReferences:
def assetExists: Boolean =
  Asset.allInstances()->exist (a|a.Derivative_ID = d.Derivative_ID)
def liabilityExists: Boolean =
  Liability.allInstances()->exist (l|l.Derivative_ID_d = d.Derivative_ID)
def offbalanceExists: Boolean =
  Off_Balance.allInstances()->exist (o|o.Derivative_ID_d = d.Derivative_ID)
(assetExists xor liabilityExists) xor offbalanceExists
```
MDD: RStudio/Shiny application
## MDD: RStudio/Shiny application

<table>
<thead>
<tr>
<th>Timestamp</th>
<th>Risky Asset Value</th>
<th>Fixed Asset Value</th>
<th>Forward Fair Value</th>
<th>Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020-01-01</td>
<td>100</td>
<td>-100</td>
<td>0</td>
<td>Off Balance</td>
</tr>
<tr>
<td>2020-06-30</td>
<td>100</td>
<td>-101.98</td>
<td>-1.98</td>
<td>Liability</td>
</tr>
<tr>
<td>2020-12-31</td>
<td>120</td>
<td>-104</td>
<td>16</td>
<td>Asset</td>
</tr>
</tbody>
</table>

**Input:** contract specification data

**Output:** Forward value over time

### Initial Pricing

- **Type Of Stock Derivative:** 0
- **Stock ISIN:** AT0001
- **Contract Size:** 1
- **Number Of Contracts:** 1
- **Exercise Or Forward Price:** 100
- **Expiration Date:** 2020-12-31
- **Interest Rate in %:** 4
- **Stock Volatility in %:** 0
- **Mark To Model:** 1

**Timeline**

- Asset
- Liability
- Forward Value

**Graph**

Graph showing the timeline from Jan 2020 to Oct 2020 with different values for Asset, Liability, and Forward Value.
Conclusion and outlook/future research

• Conclusion
  • Demonstration via real-case: Stock forward contract example
  • Evaluation via adequate representation of derivative instruments
    – Mapping of hedging portfolio as <<Collective>> stereotyped class with MemberOf-relationship to Economic Resources
    – Including temporal-modal behaviour of forward contracts with <<Phase>> stereotyped classes (Asset, Liability and Off Balance)

• Further research
  • Option pricing: Inclusion of dynamic adjustments of the hedging portfolio
  • Including an explicit hedging specification at policy level in REA business ontology (Geerts and McCarthy, 2006)