Approaches to cost/risk model development


Jacob Wellendorph Ejsing
Agenda

• What questions are we trying to answer?
  • Deterministic vs. stochastic models

• Three approaches to implementing in-house cost/risk models
What questions are we trying to answer with cost/risk models?

- **Deterministic debt projection**
  - How will debt and interest costs develop
    - In a baseline scenario?
    - In a risk scenario?
  - For a given issuance strategy, how large will future redemptions be?
  - How do changes to the issuance strategy affect cost/risk outcomes?
Deterministic modeling:
Defining a medium-term baseline scenario

- Existing debt portfolio
- Projection of the primary budget balance
- Issuance strategy
- Projection of future yields

**Maturities**

<table>
<thead>
<tr>
<th></th>
<th>2-year</th>
<th>5-year</th>
<th>10-year</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>2016</td>
<td>2018</td>
<td>2023</td>
</tr>
<tr>
<td>2014</td>
<td>2016</td>
<td>2018</td>
<td>2025</td>
</tr>
<tr>
<td>2015</td>
<td>2018</td>
<td>2020</td>
<td>2025</td>
</tr>
<tr>
<td>2016</td>
<td>2018</td>
<td>2020</td>
<td>2027</td>
</tr>
<tr>
<td>2017</td>
<td>2020</td>
<td>2022</td>
<td>2027</td>
</tr>
<tr>
<td>2018</td>
<td>2020</td>
<td>2022</td>
<td>2029</td>
</tr>
<tr>
<td>2019</td>
<td>2022</td>
<td>2024</td>
<td>2029</td>
</tr>
<tr>
<td>2020</td>
<td>2022</td>
<td>2024</td>
<td>2031</td>
</tr>
<tr>
<td>2021</td>
<td>2024</td>
<td>2026</td>
<td>2031</td>
</tr>
<tr>
<td>2022</td>
<td>2024</td>
<td>2026</td>
<td>2033</td>
</tr>
</tbody>
</table>

*Note: for illustration only, not a reflection of actual policy*
Projected bond issuance 2013 - 2022

**Strategy:**

- [20-20-60-0]

**Projected bond issuance 2013 - 2022**

**Strategy:**

- [40-20-40-0]

---

**Note:** for illustration only, not a reflection of actual policy

Jacob W. Ejsing - Cost/risk model development

October 2012

DANMARKS NATIONALBANK
What questions are we trying to answer with cost/risk models?

• **Deterministic debt projection**
  - How will debt and interest costs develop?
  - For a given issuance strategy, how large will future redemptions be?
  - How do changes to the issuance strategy affect cost/risk outcomes (‘scenario analysis’)

• **Stochastic modelling**
  - Given the dynamics of the yield curve, what distribution of outcomes for interest cost can we expect? (example of "Cost-at-Risk")
  - Given joint dynamics of the macroeconomy and key risk factors, what distribution of budgetary outcomes can we expect? (”Budget-at-Risk”)
  - Example of a stochastic model of the term structure ...
Projected bond issuance 2013 - 2022

- Primary deficit
- Net interest cost (known)
- Net interest cost (variable)
- Redemptions (existing debt)
- Redemptions (new debt)
- Net new relending
- Total

Financing requirement

Issuance and prefunding

Simulated interest cost distribution

Note: for illustration only, not a reflection of actual policy
Nuts and bolts:
How to build a model in practise?

Three approaches

• Spreadsheet
• Programming
• Hybrid approach
The spreadsheet approach

- **Pros**
  - Excel is a standard tool already used intensively by staff
  - Good for prototyping and organizing initial ideas
  - Convenient graphical user interface "out-of-the-box"
  - Good choice for setting up a basic, deterministic model

- **Cons**
  - As complexity increases, spreadsheet solutions tend to become messy
    - Overview is rapidly lost
    - Difficult to document, validate and maintain
    - Can be more cumbersome to update
    - Can be too slow for stochastic models (less critical today)
The programming approach
e.g. Matlab, Python, etc.

- **Pros**
  - Allows for tailor-made data structures
  - Easier to expand and generalize models
  - Computational logic can be encapsulated and more easily be reused
  - More easy to test and maintain over time
  - Skills acquired can be extremely useful for other DMO tasks

- **Cons**
  - Does require staff with some knowledge of sound software development practices, including:
    - How to develop clear, modular code?
    - How to best testing and document code?
  - Can be more costly (licenses, training)
    - But: good open-source alternatives exist
Hybrid approach

- In practice, a "hybrid" approach can work very well
  - The role of Excel:
    - Use spreadsheet as the main user interface
    - Easy to enter input, e.g. fiscal and macro assumptions/scenarios
    - Reporting results: charts, tables, etc.
  - The role of the programming environment (Matlab, Python, etc.):
    - Complex numerical computations can be done efficiently using suitable data structures
    - Interfacing efficiently with the spreadsheet model

- A hybrid approach has important advantages:
  - Users can continue to interact with the well-known Excel user interface
  - Complex computations can be moved outside of Excel
Moving beyond the deterministic model

- Once a well-designed deterministic model has been built, adding stochasticity model *can* be relatively simple

- The deterministic model can be seen as a function $f(x)$
  - $f(x)$ returns measures of future costs, given input $x$
  - ‘$x$’ can be future path of yields (for given strategy), for example
  - Evaluate $f(x)$ for a number of well-chosen $x$’s (scenarios)

- Keep complexity of stochastic model low
  - Recent developments can help. For example, consider the new "Arbitrage-Free Nelson-Siegel" (AFNS) class of term structure models
    - Simplest AFNS-model with three independent factors appears to work well
A few implementation tips

- Speeding up the hybrid approach
  
  - Build basic projection in Excel
    
    - But try to avoid too much VBA and links between workbooks
  
  - Use a proper programming language to
    
    - estimate/calibrate stochastic models (e.g. a dynamic term-structure model)
    
    - simulate a large number of scenarios and compute distributions of interest
  
  - Connect to the deterministic Excel-model via ‘COM Automation Server’
    
    - In Matlab, have a look at the command ”actxserver”
    
    - Feasible to do 5000 cost simulations in about 2 minutes
Final thoughts

- Spend your time wisely!
- If you want a stochastic model, consider a hybrid approach