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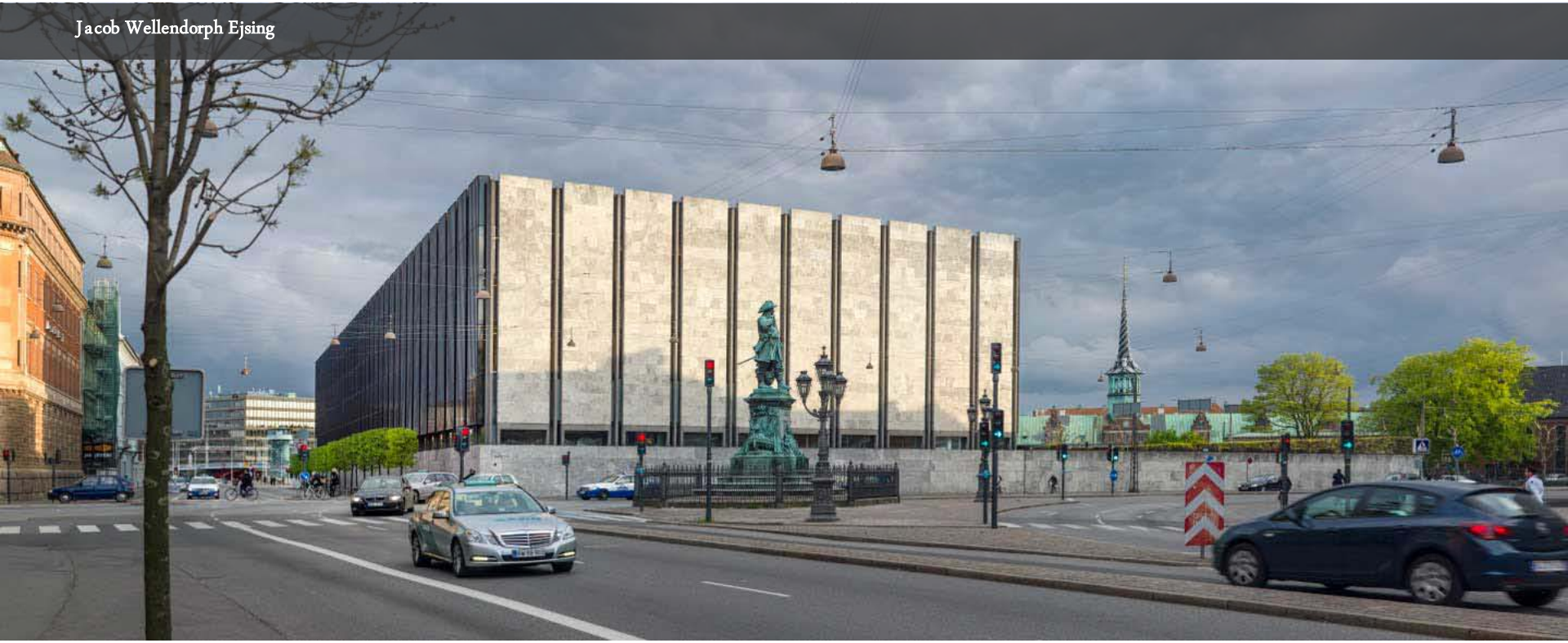
Approaches to cost/risk model development

World Bank Sovereign Debt Management Forum - October 29-31, 2012

Jacob Wellendorph Ejsing



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Agenda

- What questions are we trying to answer?
  - Deterministic vs. stochastic models
- Three approaches to implementing in-house cost/risk models

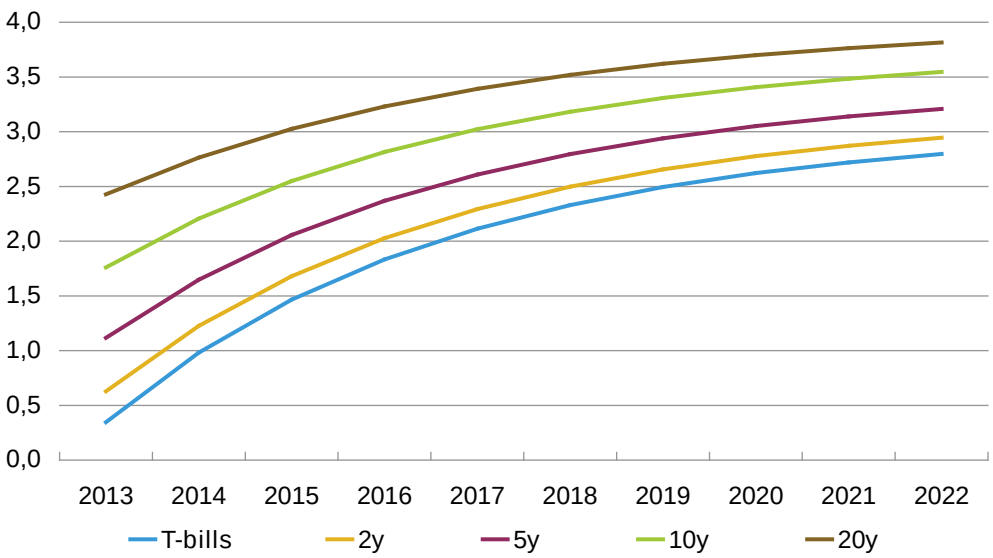
What questions are we trying to answer with cost/risk models?

- **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		
	2-year	5-year	10-year
2013	2016	2018	2023
2014	2016	2018	2025
2015	2018	2020	2025
2016	2018	2020	2027
2017	2020	2022	2027
2018	2020	2022	2029
2019	2022	2024	2029
2020	2022	2024	2031
2021	2024	2026	2031
2022	2024	2026	2033



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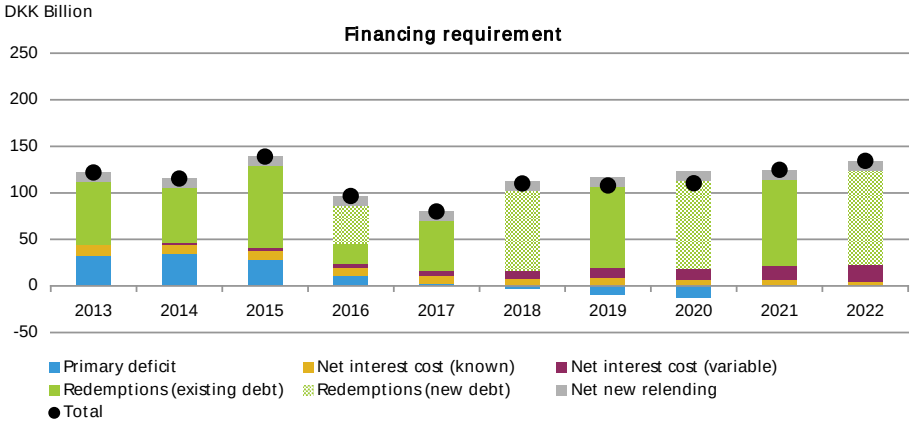
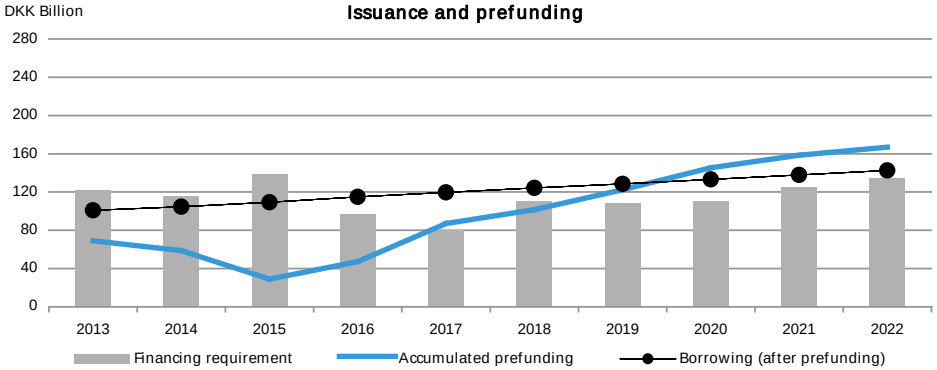
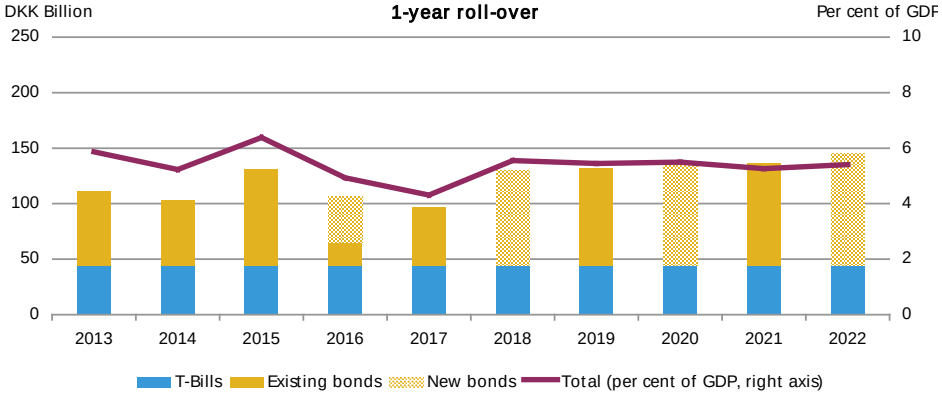
Projected bond issuance 2013 - 2022

Strategy: [20-20-60-0]

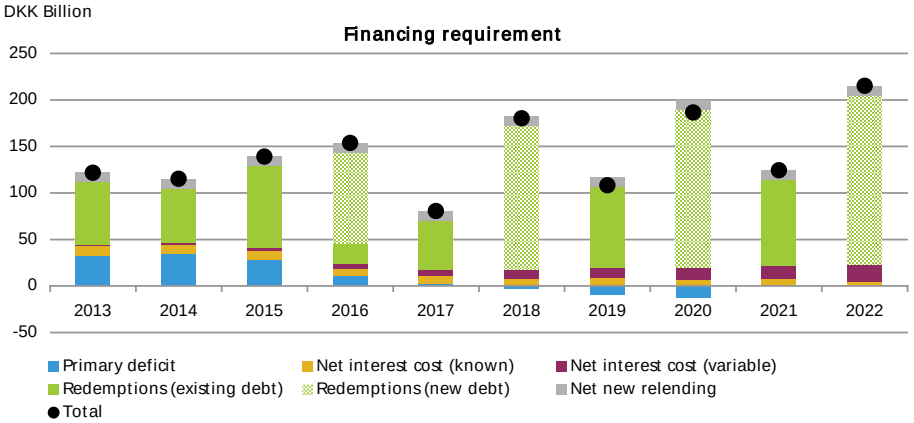


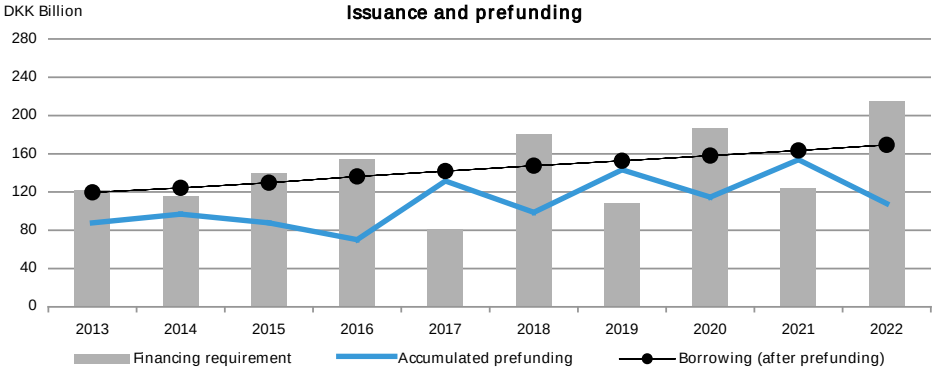


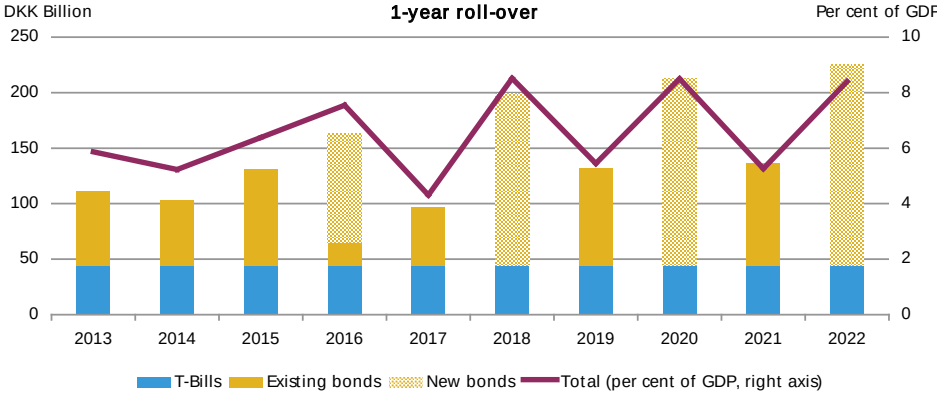


Projected bond issuance 2013 - 2022

Strategy: [40-20-40-0]







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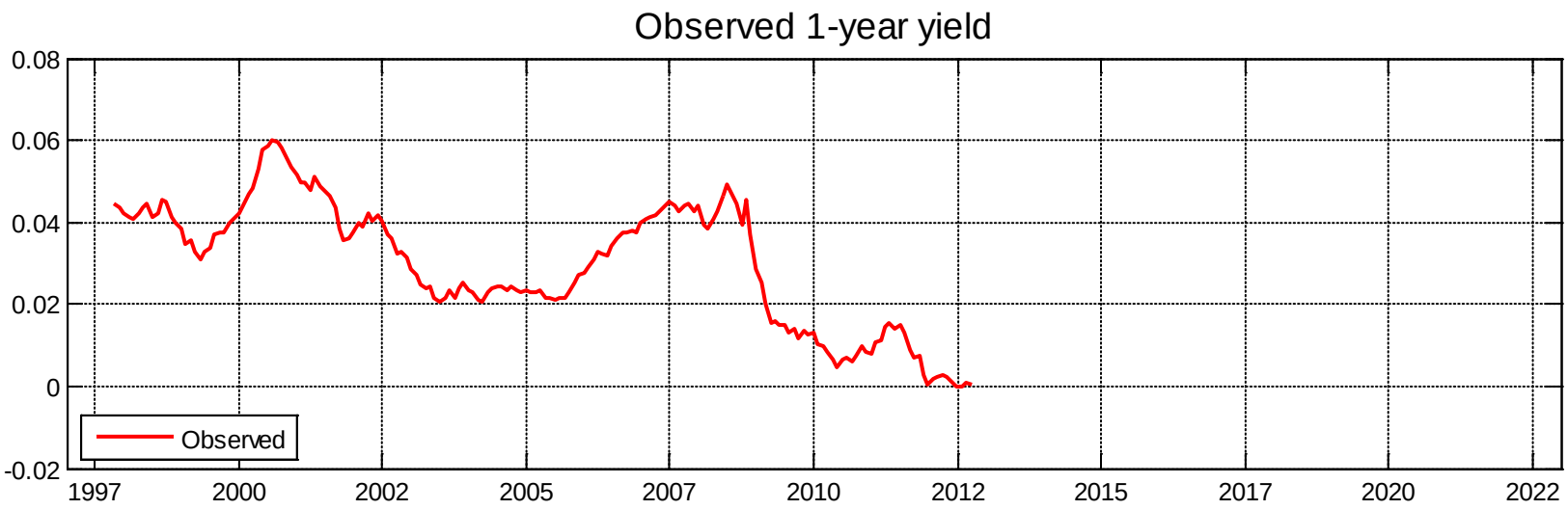
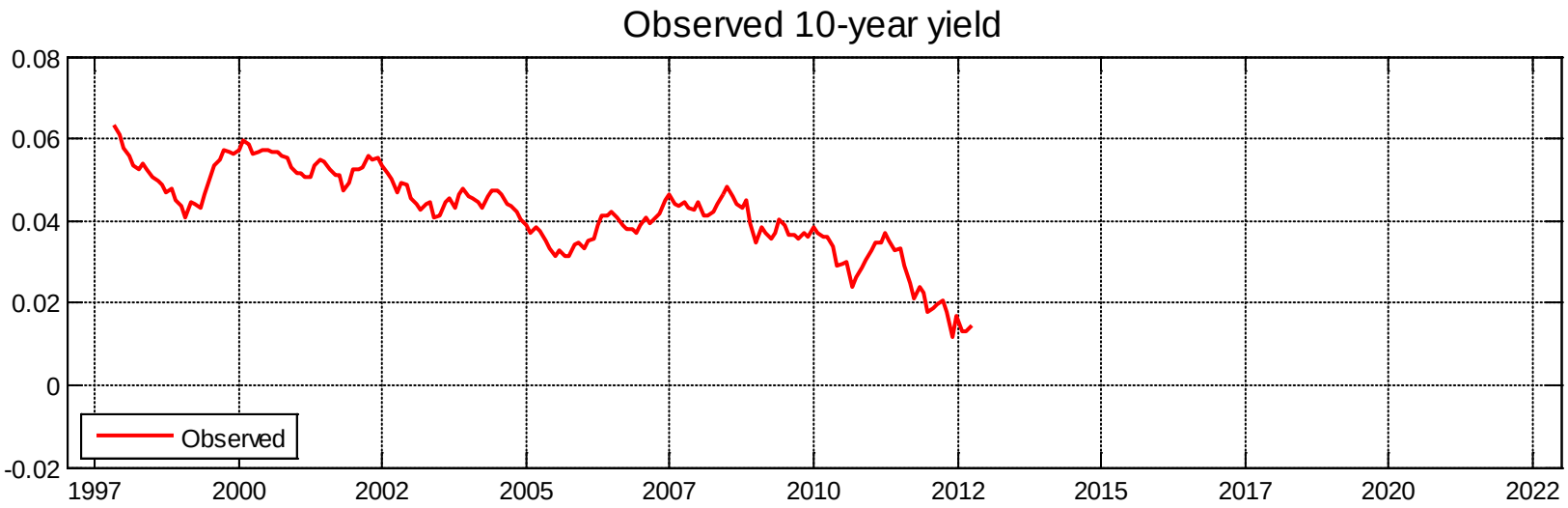
October 2012

Jacob W. Ejsing - Cost/risk model development

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 ...


Observed 1-year yield
0.08
0.06
0.04
0.02
0
-0.02
1997
2000
2002
2005
2007
2010
2012
2015
2017
2020
2022
Observed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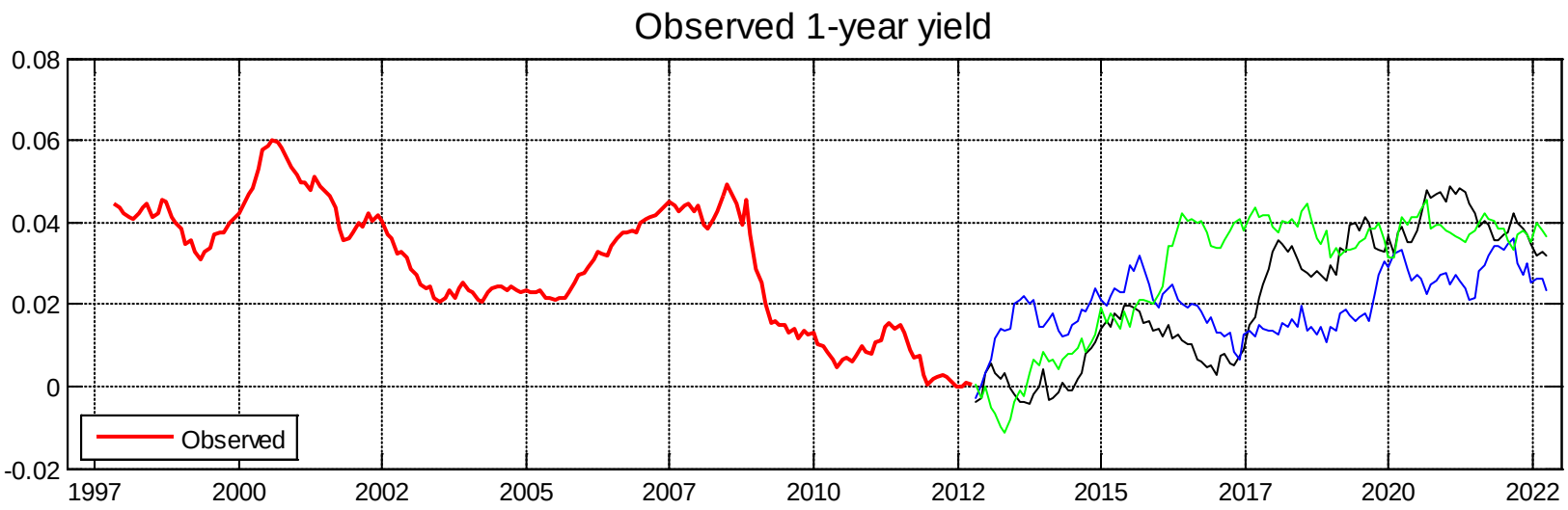
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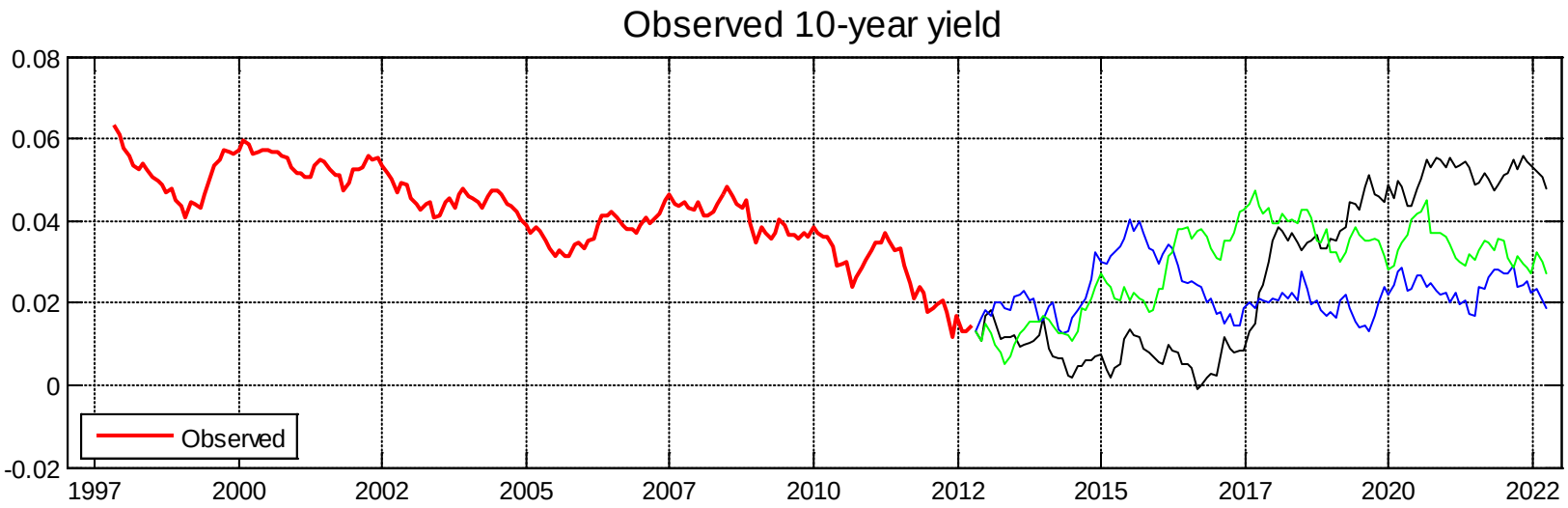
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0.06
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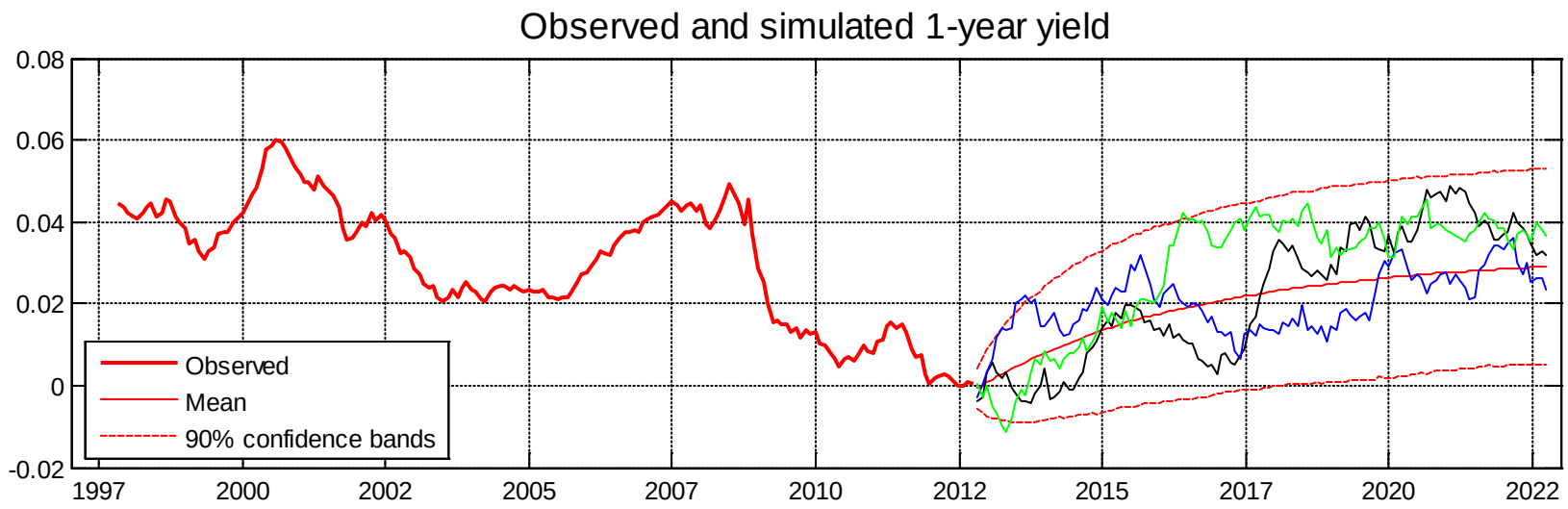
Observed and simulated 1-year yield
0.08
0.06
0.04
0.02
0
-0.02
1997
2000
2002
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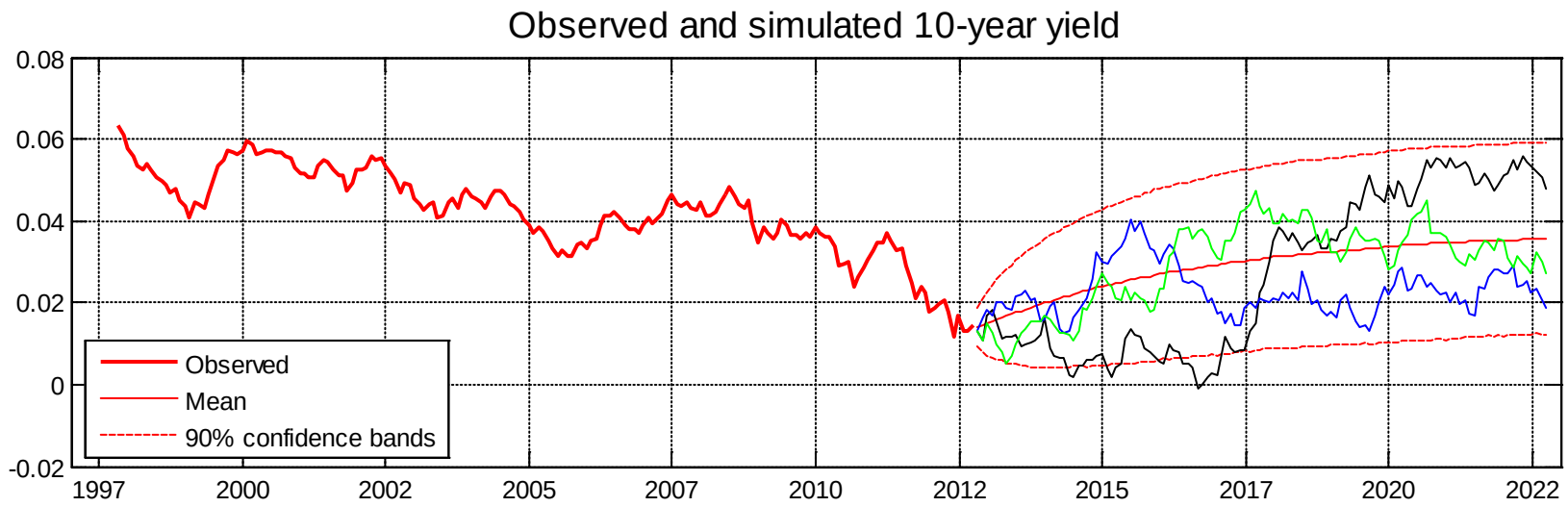
2017
2020
2022
Observed
Mean
90% confidence bands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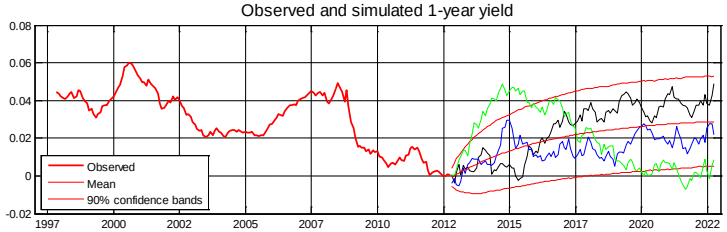

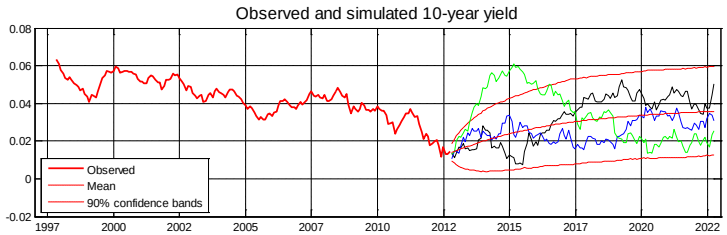

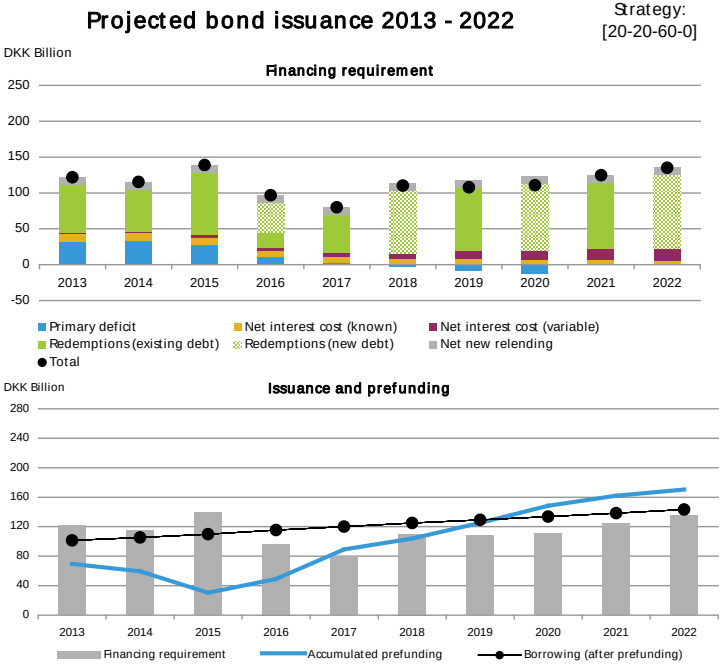

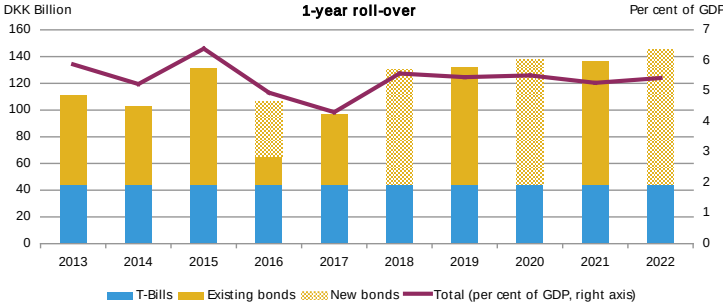

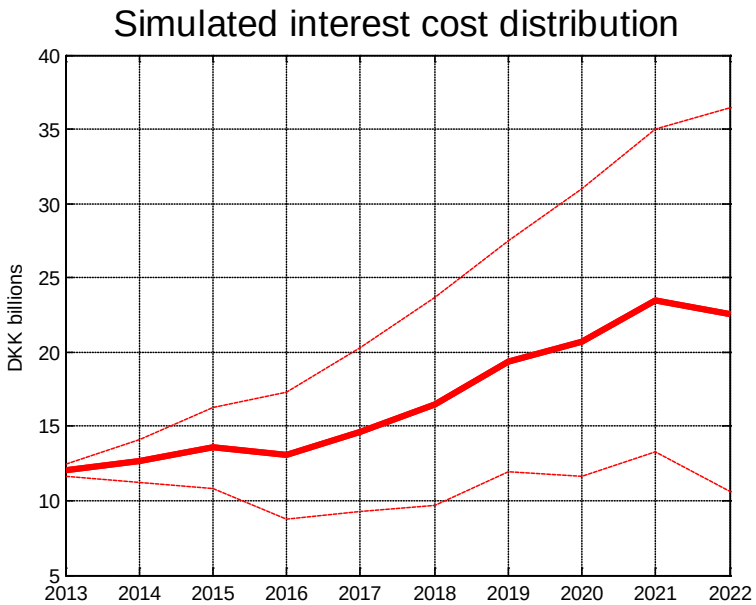

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Nuts and bolts:
How to build a model in practise?

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 ”hydrid” 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 determistic 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)

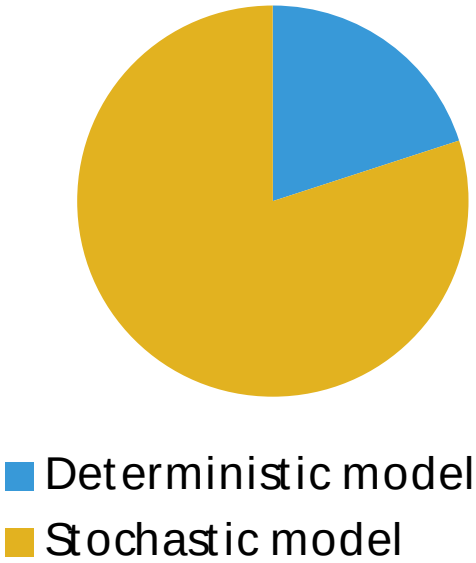
- Keep complexity of stochastic model low
  - Recent developments can help. For example, consider the new "Arbitrage-Free Nelson-Siegel" (AFNS) class of term structure models
    - See Christensen, Diebold, Rudebusch, Journal of Econometrics 164 (2011)
  - Simplest AFNS-model with three independent factors appears to work well

A few implementation tips

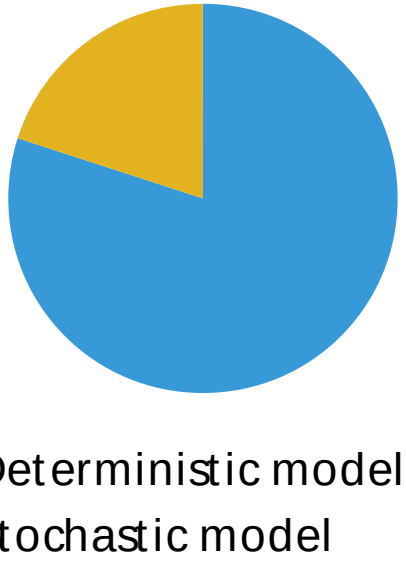
- Speeding up the hybrid approach
  - Build basic projection in Excel
    - But try to avoid too much VBA and links between workbooks
  - Use a proper programming language to
    - estimate/calibrate stochastic models (e.g. a dynamic term-structure model)
    - simulate a large number of scenarios and 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

Time spent modeling?



Insights gained?



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