A supervision guide for student projects at AAU

Robert Smith and Verena Stingl

2021-06-21

Contents

Chapter 1

Supervision guide

This is a simple GitBook to assist students to write projects in partial fulfilment of the requirements of a degree in economics at Aalborg University.

The content is updated periodically, and can NOT be referred to as an official source. All regulations and study program guides take presidence over any content on this site.

The content is also personalised to the extent that I provide some information about when I will personally be unavailable. Apart from that, it is my hope that at least some of the content will be useful to students of all level.

1.1 License

Attribution-Non Commercial 4.0 International (CC BY-NC 4.0)

This is a human-readable summary of (and not a substitute for) the license.

Disclaimer

You are free to:

Share — copy and redistribute the material in any medium or format

Adapt — remix, transform, and build upon the material

The licensor cannot revoke these freedoms as long as you follow the license terms.

Under the following terms:

Attribution — You must give appropriate credit, provide a link to the license, and indicate if changes were made. You may do so in any reasonable manner, but not in any way that suggests the licensor endorses you or your use.

NonCommercial — You may not use the material for commercial purposes.

No additional restrictions — You may not apply legal terms or technological measures that legally restrict others from doing anything the license permits.

Notices:

You do not have to comply with the license for elements of the material in the public domain or where your use is permitted by an applicable exception or limitation.

No warranties are given. The license may not give you all of the permissions necessary for your intended use. For example, other rights such as publicity, privacy, or moral rights may limit how you use the material.

Chapter 2

Introduction to supervision

This is an introduction text that explains that I will be your supervisor for your project and outlines some guidelines for our collaboration.

As you can see from this text, my first language is English. So anyone that wants to work on their English writing, or just get more exposure to economics in English it might be a good opportunity for you – If you want to work outside of the country or in most multinationals here in DK it is typically a requirement (Danmarks Nationalbank included). You will not be assessed on your grammar, but you will need to make sense and write in a professional manner.

If you would prefer to work in Danish, you are of course welcome to.

To get the most out of the supervision I recommend that in addition to the introductory meeting, 3 group meetings should be sufficient.

0. **Introductory meeting:** We will go through literature search and a few useful tools for writing in a collaborative project. (I will try to do a digital/video guide so that you can watch / view / pause rewind the info as much as you please.)

Here I will also try to get to understand where you are as a group in terms of 5 main areas:

1. Your subject specific knowledge (this till be in terms of the specific topic that you have chosen to work on).
2. Your experience and knowledge of group project work.
3. Your skills in project and process management for getting the job done.
4. Your technical academic skills – Theory of science, methodology, methods and theory.

5. Your project writing skills – The practical writing tools, reference mangers, programming skills, collaboration tools etc.

1. **Meeting 1:** You need to have worked on and bring a complete problem statement (see the guide and tips below), we will discuss it in the first meeting.

2. **Meeting 2:** The literature review, and expected method should be done, and any data or materials you plan to use should be collected. We will go through your planned method and argumentation in the meeting.

3. **Meeting 3:** The analysis should be complete, and you should have some working points for your discussion / conclusions. We will go through your arguments verbally, and I will probe any major gaps I see in your thinking.

Chapter 3

Guidelines for supervision

1. Any team member can communicate with me via Teams on behalf of your group. I expect that all communication has been discussed an agreed upon.
2. Just as you can expect me to read and provide comments on the days of meetings, I expect you to respect the deadlines you choose.
    a. If you want something read before the meeting, it must be sent to me **at least 2 working days before the meeting**, **I.e. Midnight Thursday for a Monday meeting**. (Max 10 pages per meeting)
3. I will read and comment generally on the work but **will not make decisions for you**. Your ability to choose and apply the correct methods is part of what you will be assessed on.
4. Each meeting is planned for one hour.
5. **For every meeting you should bring with:**
    a. Your problem statement (as it evolves with your work).
    b. A list of literature that you have covered up to that point (only the literature you have already read).
    c. Any additional formalities (this will depend on how big your group is).
6. The date by which you will be ready for the next meeting.

3.1 Examinations

You can write and be examined in Danish or English. If you choose Danish, it might be the case that one of our Danish speaking staff will join in the

examination, 1x external examiner + me + possibly 1x Danish AAU examiner. This will depend on departmental resources, but you will not be disadvantaged in any way because of any limitations that I might have with the Danish language.

3.2 Leave periods (absenteeism)

I will be away from Aalborg for the following periods:

1. Weeks 13 and 14. Thursday 2021/03/25 to Monday 2021/04/12.

3.3 Teaching and time pressures

I will be teaching Mathematics 2 on each Wednesday of weeks 17, 18, and 19 – for these weeks the best days to meet will be Thursday or Friday.

3.4 Rough guide to project structures

This is a **very rough** guide to writing a project. It is intended to give you a very basic idea of what to include in a good project.

In terms of pages, each group will know how many people they have, the official **maximum number of pages** (by character count, 2400 key-strokes including spaces) are:

1 Person: 15 pages

2 People: 25 pages

3 People: 30 pages

4 People: 40 pages

Check the official guidelines here

Filling the pages is not the goal, and you will not be given a higher grade for filling all of your allocated pages with pointless text. You will also not be penalised if you can get your message across clearly in fewer pages. Keep in mind, that the average journal article is roughly 15 – 25 double spaced pages (around 8000 words).

You only need to address **one** problem, and to do it as well as possible.

The written project is intended **to communicate** that you have done your homework on your subject. This means that as a student **you should be able to demonstrate that you**:

1. Can identify an economic problem (or gap in the literature) that you think needs to be addressed (and why?!).

2. Can find, read and understand literature about the problem, and how others have dealt with it (reading and organising literature).
3. Can find the relevant information or data that you need to assess the problem, and that you know what to do with it when you do find it (number 2 helps with this) (data and methods).
4. Can present your findings in a well written document, where you give credit to all the authors that helped you to understand the problem (references).
5. If you make a statement, you either need to back it up with your own evidence, or someone else's.

Compressing all of that into 8000 words is much more challenging than filling 40 pages with unnecessary text and graphics. It also requires much more cooperation on and discussion of what needs to go into those pages to make them as effective as possible.

A good group member is one that can read a piece of writing critically and give constructive feedback – to do this effectively is necessary for all group members to be clear about the "red thread" in the project (the "why").

I would personally prefer that you write about 15 pages of really good work than 40 pages of low-quality work.

3.5 For a journal article size paper these are some rough guidelines:

The share of pages between the sections depends on how much space you *need*. I say *need*, because people reading your work want to get the clearest message, in as few words as possible. A (very) rough guide as to how many (academic) references each section could have is included in red text.

1. Abstract (+-150 words)
2. Introduction (0.75 – 1.25 pages) (Motivation, justification, explanation of why? (4 – 5 references))
3. Literature / theory (1.5 – 3 pages, depending on how theoretical your paper is) (Demonstrate reading (6 – 12 references))
4. Method (0.75 – 3 pages, depending on how complex the explanation needs to be) (Justify choice, explain details (4 – 5 references))
5. Results (1 – 3 pages) (Presentation of results (2 – 5 references))
6. Discussion (2 – 5 pages) (Interpretations, comparisons, perspectives (4 – 5 references))
7. Conclusion (1 page) (Link discussion to introduction (No new references))

(The max pages in this example is 16.5 pages – it is just an example, and the split between the sections will change depending on the type of research.)

(Min references in this example is 20, but this is on the high side. You won't have time to read as much as that. 8 – 15 references in total should be enough if you find some really good ones.)

Keep it simple! That is the best advice I ever got. . . and the hardest to follow, because you really need to be sure of what you're talking about to write clearly and simply.

Chapter 4

Time planning and limitations

Be aware of the time you have left to do the research. Data / information collection and organisation takes time, and you need to get started on it early if you want to be able to say anything useful by the time you finish writing your project up. If you are efficient in how you work this guide might help:

A brief guide:

1. Problem identification and reading: 1 week
2. Write literature review: 1 week
3. Write first draft of introduction: 2 days
4. Data collection: 1 week
5. Write method and methodology section: 3 days
6. Data cleaning and analysis: 2 weeks
7. Write results: 1 week
8. Write conclusion: 2 days
9. Re-write introduction: 2 days
10. Check document for references and errors: 1 day

Total: 8 weeks. From mid-March this would get you to mid-May, or from mid-September it would take you to mid-November.

The later you start, the later you finish, or… if you have a deadline… the more you have to sacrifice in terms of quality.

Remember to add time for:

- Reading and feedback

4.1 Reverse time-planning

A very powerful way to plan your project is to take the delivery date and work backwards.

Pick your delivery date, and then work out how much time you need for each of the jobs you need to do – but starting from the last job first.

I will also share a project planner with you all when we have shared supervision space established.

Chapter 5

Guide for report writing

Author: *Verena Stingl*

5.1 Structuring your report

While there are many ways to structure your report, there is typically an underlying logic related to how you "tell a compelling story" in any of these reports. The typical story flow is the following:

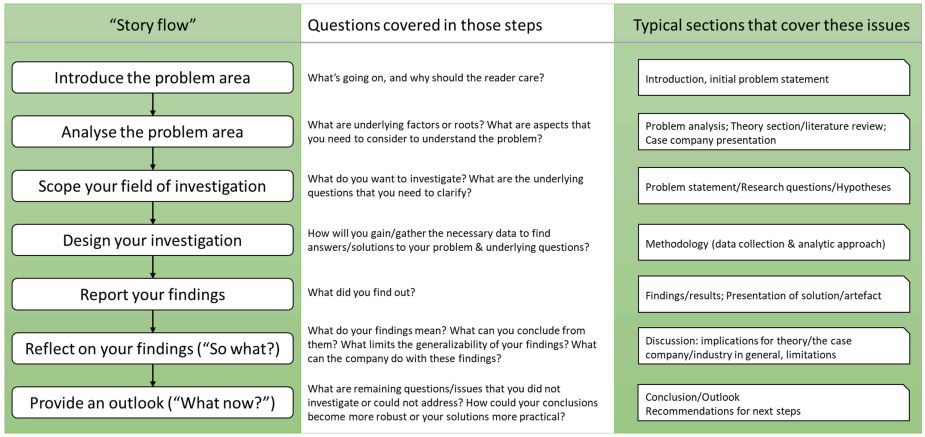


Figure 5.1: Story flow

5.2 General recommendations

- *A report is not a mystery novel.* Never leave the reader wondering why they are reading about some topic or why they should care. That means:
- Start your report on point with introducing the specific problem area, and what makes that area problematic. E.g. *"Day-to-day delivery operations operate under high fluctuations in demand. This variability creates challenges for both efficient stock keeping and staff planning, when actual needs are known less than 24h before they should be met."*
- Give an outlook how you will help understand and overcome the challenge, i.e. what the reader can expect to get out of this report.
- When you introduce a new section or theme, tell the reader why this is important - especially in the "literature" or "theory" section. E.g. *"Day-to-day delivery operations can cope with demand fluctuation through three approaches: improving forecasts, working with buffers, or increasing flexibility in their processes. In the following we are introducing these three approaches and under which condition they are sensible strategies, and thereafter will discuss them in the context of our case company."*

5.3 Define your golden thread (rød tråd)

This should ideally be done before starting detail writing and make sure that it does not make twists and loops. A report should have a clear argumentative structure, that means:

- If a section does not help the reader to understand better what the problem is, what you did to tackle it, or what your problem solution really is, it probably has no place in the report.
- If a section requires knowledge from later in the report to be understandable, it is probably badly placed
- If you cannot formulate a conclusion regarding the current section that will build a bridge to what you will tell in the next section(s), it is probably not necessary to have that section.
- If a section repeats what has been written earlier in the report, you should probably cut down on the redundancies

5.4 Create signposts

It is massively helpful for the flow of the text to start a section with a purpose statement, and conclude it with some sort of summary. However, there are good and bad ways to do it.

Good ways to start provide the reader with a frame in which they can "mentally" place the details provided later in the section. Bad ways just state the obvious and take up space. For example:

- BAD way to start a section: *"The purpose of this section is to introduce the methodology and give an overview of the collected data."* does not tell you anything that a section header could have implied; does not connect to what has been written before.

- GOOD way to start a section: *"To investigate this problem further, we relied on a combination of qualitative and quantitative data collection methods that provided insights on the current warehousing practices. Specifically we…"* → links to the previous section (i.e. the problem introduced before), gives an outlook on what will be covered ("qualitative and quantitative data collection methods") and why this is relevant (to understand more about the current warehousing practices).

Good ways to end provide the reader with a reminder of the most important points of the section, and how it relates both to the general theme and to what will come after. Bad ways, again, just state the obvious and take up space. For example:

- BAD way to end a section: *"In this section we have presented the theory on forecasting, buffering, and flexible process design."* → tells nothing more than a section heading would have told you. Does not build a bridge to the next section.

- GOOD way to end a section: *"Each of the discussed approaches for dealing with demand fluctuation comes with specific advantages and disadvantages that are dependent on the context of the organization. In the following section we will discuss how these approaches could be relevant for the case of [case company]."* → Highlights what the important points of the theory section were (applicability of the different approaches is dependent on context) and links to whats coming next (using the newly build understanding of which approach can succeed where to analyse the options of the case company)

5.5 Use precise and professional language

Colloquialisms can take attention away from otherwise thorough work and can make the report appear unprofessional. A great resource for finding the right words is the "Academic Phrasebank" by Manchester University: https://www.phrasebank.manchester.ac.uk/

5.6 Make convincing claims

Especially in the introduction, you have to make claims about the case company or the industry that they are working in, for example regarding trends, or specific challenges or problems. In this section you want to persuade the reader that they should care, so make sure that your claims are convincing and specific (e.g. by using numbers or quotes instead of mere descriptions and by referencing to trustworthy sources). For example:

- Unconvincing claim: "*Demand in construction material has skyrocketed*" What does "skyrocket" mean? Where and when has demand increased? What's covered by construction material?
- Convincing claim: "*Due to increased home renovations during the Corona pandemic, the demand for construction material in Denmark has increased by X% (of sales volume in DKK) in Q1 2021 compared to Q1 2020 (REFERENCE TO SOURCE). While all types of construction material have seen a rise in demand, the groups [material 1], [material 2] and [material 3] have had the highest increase by X%, Y%, and Z%."*
- Unconvincing claim: *"The most important aspect to manage when introducing green policies are social issues"* What is meant by "social issues" and "green policies"? Who does the managing? Why exactly is it important (and more so than other aspects)?
- Convincing claim: *"To reduce overall green-house gas emissions within a society, policies need to address technological, economic, and social issues (REFERENCE TO RELIABLE SOURCE). Social issues here refer to the potential (negative) consequences of these policies for some groups within society, or all people in society. Fears of such negative consequences could trigger substantial civil opposition to these policies, even as technological solutions become increasingly available. Acknowledging this risk, EU commission's vice-president Frans Timmermans recently stated in an interview with the Guardian* '[We] should make the social issue the pivotal issue in all of this. [..] This could become the biggest stumbling block' *(REFERENCE TO INTERVIEW)."*

5.7 Filling the pages is not the goal

You will not be given a higher grade for filling all of your allocated pages with pointless text. You will also not be penalised if you can get your message across clearly in fewer pages.

5.8 Don't try to save the world

You only need to address one well-scoped problem, and address it in a manner that is reasonable in relation to your time and skill. Thus, you will have to

make decisions on what aspects of the problem area you focus on, and which areas you will not tackle in your project.

Similar you will make decisions regarding which solution paths to follow and which to abandon. Clearly articulate your decisions, mention briefly those aspects/solutions that you are aware of but have decided not to investigate (either in the problem definition and/or in the discussion). Don't write long theoretical sections on issues/approaches that were out of scope for you! For example:

- In the problem statement: *"There are a number of known barriers to the adoption of digital technologies in manufacturing, typically grouped as technical, structural, and cultural barriers [REFERENCE]. For this project, we focus only on technical barriers in our solution development. However, we will consider potential implications of structural and cultural barriers in the discussion of this report."*
- Concluding the theory section: *"Advanced forecasting techniques can be a promising approach to manage demand fluctuation in context where [CONTEXTS WHERE IT WORKS]. However, as we have described in the company background, [case company]'s demand is driven by [DIFFERENT FACTORS]. Thus, we will focus instead on approaches related to increasing the process flexibility as an alternative approach to handle their daily demand fluctuations."*
- In the discussion: *"Our project has helped to identify the main technological barriers for the adoption of [technology X] in [case company]. We have made several propositions how to overcome these technological barriers in moving forward in their digitalization, such as [EXAMPLES]. However, our propositions have not yet considered structural and cultural barriers, such as the fit of the technology with current processes and business models, or potential fear of changes related to the digitalization. Thus, in developing implementation plans for these propositions, we advise [case company] to investigate into potential barriers related to their organizational structure and culture. Specifically, throughout our project, we have noted [… your thoughts on these other barriers]"*

5.9 Reading & revising is just as important as writing

I will of course read and comment on your report, but I will never go to the detail level that you can provide to each other (and I will not re-read sections on which I have commented earlier in the project). So set time aside to read the sections of your colleagues (or assign one or two of the group members the role of reviewer). Read critically against questions such as:

- Is the golden thread (rød tråd) clear?

- Does the argument have a logical structure?
- Are the claims convincing?
- Is the language appropriate?
- Is there text that serves no purpose?

Then give constructive feedback – be specific and give examples (and be nice). For example:

- *"In the second paragraph you introduce [Theme X] but it is a bit unclear how this connects to the paragraph before. Maybe you could add…"*
- *"I remember we had a quote from the production manager, we could use it to strengthen the argument you make here.."*

Chapter 6

Data sources for project inspiration

6.1 Economic time-series databases

1. The Bank for International Settlements
   - https://www.bis.org/statistics/index.htm
2. OECD - stat-bank
   - https://stats.oecd.org
3. AMECO - Annual macroeconomic of the European Commission's Directorate General for Economic and Financial Affairs
   - https://ec.europa.eu/info/business-economy-euro/indicators-statistics/economic-databases/macro-economic-database-ameco_en
4. The World Bank open data source
   - https://data.worldbank.org
   - Sub-components for microdata, DataBank and a data catalogue
5. Eurostat Database
   - https://ec.europa.eu/eurostat/data/database
6. Danish Data - Kim Abildgren's historical database
   - https://sites.google.com/view/kim-abildgren/historical-statistics
7. Jorda-Schularick-Taylor Macrohistory Database
   - http://www.macrohistory.net/data/

6.2 Income and income inequality databases

1. World Inequality Database
   - https://wid.world/
2. United Nations University WIID – World Income Inequality Database

   - https://www.wider.unu.edu/data?fbclid=IwAR0X8Sj1rcjM5ovy2triA5Y0wo3iApFzV7CEas_ktj139oofcQHjI_ts9F4
3. Luxumborg income database
   - https://www.lisdatacenter.org/our-data/

6.3 Datasets available via CALDISS

It is certainly a good idea to visit the CALDISS website or speak with a representative, as they offer some great introductory courses and access to some great data.

1. Refinitiv Eikon (Financial Time Series Data - Much like the Thomson Reuters Datastream)
   - https://www.caldiss.aau.dk/faciliteter/data/eikon/
   - Home page for additional information
     - https://eikon.thomsonreuters.com/index.html

6.4 AAU based databases

1. Surveybanken
   - https://www.surveybanken.aau.dk

6.5 Diverse datasets

1. The Harvard Dataverse
   - https://dataverse.harvard.edu/dataverse/harvard
2. Kaggle - datasets used for machine learning and AI applications
   - https://www.kaggle.com/datasets
3. The New York Times Github repository
   - https://github.com/nytimes
4. FiveThirtyWight Github page
   - https://github.com/fivethirtyeight
5. The MIT Observatory of Economic Complexity - Economic trade data
   - https://oec.world
6. The Google public data explorer (run in Chrome)
   - https://www.google.com/publicdata/directory
7. European Union Open Data portal
   - https://data.europa.eu/euodp/en/data/
8. GESIS data, including
   - Eurobarometer data
     - https://www.gesis.org/en/eurobarometer-data-service/search-data-access/data-access
   - International Social Survey Programme (ISSP)
     - https://www.gesis.org/en/issp/home

9. European Social Survey data
    - https://www.europeansocialsurvey.org/

Chapter 7

Rough guide to writing a problem statement

Coming up with a good question does not mean coming up with a question that will change the world. It means coming up with a question that you can answer **in the time you are allowed**, and **with the tools you have (or have time to learn)**.

A note on how to get started with your problem selection – try to be curious. It is going to take some active effort.

Most of you have identified an area of interest, rather than any specific question. These are just a few pointers to help you to identify a good problem.

- If you want to read a pretty good "how-to" guide, try this one: https://www.wikihow.com/Write-a-Problem-Statement

You need to actively apply yourselves to *finding* a question:

7.1 Step 1: Brainstorm / ideation

- Find a meeting room and mind-map an area of economics that you are interested in.
- A very high-level overview of the courses (like the table of contents in your textbooks) you have done so far should help you to understand the tools that you have, which you can use to answer whatever question you end up asking.
  - Some of these tools will be theories, models, data types and sources. The learning outcomes of your courses are also a good guide (check Moodle).

- If you really want to be active in your search for problems, and deal with real life issues – pick up a phone and make some calls to people in the area or industry you want to look at. These kinds of discussion can be really motivating and insightful.
- As a group you can really benefit by getting ideas and input from each other. This does not need to take a long time but does require effort.
- Don't get caught up by not deciding what to do – get into a room, set a time frame and get finished with the choice early.

Some interesting possible approaches can be seen here – many of these are related to innovation to products, but the general ideas can be used to create research ideas too:

- "The 7 All-time Greatest Ideation Techniques"
  - https://innovationmanagement.se/2013/05/30/the-7-all-time-greatest-ideation-techniques/
- "The master ideation toolbox - 10 tools to unleash creativity from anyone."
  - https://uxdesign.cc/the-master-online-ideation-toolbox-part-1-2-47401c3ad861
- "Our favorite ideation tools"
  - https://www.boardofinnovation.com/staff_picks/our-favorite-ideation-tools/
- "Ideation in Design Thinking: Tools and Methods" - 05/02/2017 - by Rafiq Elmansy
  - https://www.designorate.com/ideation-design-thinking-tools/

7.1.1 Digital tools for getting your project started

There are a heap of tools available:

7.1.1.1 Tools that can help with brainstorming and project management

1. Trello
2. Padlet
3. Notion
4. Prezi
5. Wonder
6. Mural

7.1.1.2 Tools that can help with content creation for questionnaires / interactive quizzes

1. Mentimeter
2. Peergrade
3. MS Forms (Integration of Forms with Teams and OneDrive)
4. Fyrebox
5. Coogle
6. Kahoot

7.1.1.3 Communication tools for collaboration

1. OSX apple screen sharing (with control option)
2. OSX Facetime
3. Slack
4. MS Teams
5. Facebook messenger (A Facebook company)
6. Disqord
7. Skype / Skype for business
8. WhatsApp (A Facebook company)

7.1.1.4 Additional learning tools for self-learning or training

1. DataCamp
2. Khan Academy
3. Udemy
4. Coursera
5. Edx
6. Google Analytics Academy
7. Microsoft Learn - For Power BI

7.1.2 Courses in Econometrics at AAU

The following main methods are covered in each of the semesters, and economic analyses should be conducted that reflect a knowledge up to at least the level of technical analysis of each semester.

7.1.2.1 Methods notes - Econometrics 4. semester

1. OLS - simple linear regression
2. OLS - multiple linear regression
3. Linear regressions in matrices
4. Inference and hypothesis testing
5. And 6. OLS - Assymptotics, functional form and prediction
    1. Goodness of fit
6. Multiple regression analysis with qualitative data
    1. Using dummy variables

7. Heteroskedasticity.
8. Normal distribution model specification.
    1. Proxy variables measure error.
9. Non-nested models, missing data, outliers, least absolute deviations, estimations and multicollinearity.
10. Instrumental variables - 2 stage least squares.
11. Instrumental variables continued - 2 stage least squares with heteroskedasticity.
12. PROBIT and LOGIT

7.1.2.2 Methods notes - Econometrics 5. semester

1. Time series and seasonality trends
2. Cyclical correlation in univariate time-series
3. AR and MA processes
    1. ACF and PACF
4. Stationarity
5. ARIMA - Autoregressive Integrated Moving Average Model
6. Mandatory exercise in forecasting
    1. Properties and evaluation
7. Multivariate time series analysis
    1. Engel-Granger
    2. ARDL - Auto-regressive distributed lag models
8. Dynamic models with non stationary variables
    1. Cointegration and error correction models
    2. Spurious regression
9. Further extension
    1. Cointegration and bounce test
10. VAR
    1. Vector

7.2 Step 2: Getting that problem statement clear

Where to start?

Read. This starts with a good literature search.

Some reflective questions that I recommend you consider before the meeting:

1. **What are you investigating (you have a problem statement for this already - but it still lacks some clarity)?**
   i.e. What do you mean by: "årsagen"? What do you mean by: "handel med omverden"? How do you define globalisation? When you say "påvirke", what do you mean?

Is it all people in the USA? All industries? Aggregate economic measures?
When you talk about effects, it usually implies that there is some kind of causal relationship… When looking at national economic aggregates - there are many possible "causes" for changes. Political, social, economic, technological, etc.

2. **Why is it important to investigate this?**
    1. Who would care about this result? i.e. why are you doing this research? what is the motivation behind finding an answer to this question?
    2. What is the problem that you are actually trying to throw some light on?
3. **How have others explored this?**
    1. What did they find?
    2. What are some of the conclusions that have been drawn?
    3. Are there some concerns/issues with how other people have investigated it?
4. **How could you possibly explore this question?**
    1. Are there some alternative explanations that have not been considered?
    2. Are there some other perspectives that have been ignored? For example… if the USA is able to strengthen it's trade position, what are the consequences for smaller countries that compete in the same markets?
    3. Is there some new data available that illuminates a new part of the problem?
    4. Are there better measures available for inequality / trade performance / competitiveness / etc. ?
5. **How are you going to make the choice about what road to take?**
    1. If you had all the money and time in the world, how would you investigate this problem?
    2. What are the first steps / minimum requirements needed to be able to answer the question?
    3. What options are real possibilities in the time that is left?
    4. Who is going to do what?

7.3 Using the introduction as the route to the problem statement

A good introduction leads to a good problem statement, but this is only possible if you have some good material to work with.

7.3.1 Example flow of a good introduction

1. You could list some shocking figures or numbers that highlight that there is some area / issue that we should be concerned about. It could also be some clear contradiction or controversy in the literature that needs clarification - but this requires some careful reading. (This defines the problem area that you want to address - normally these are the effects of some other problem that can be identified.)

2. You could then explain that some people see (explain) these facts/figures from the perspective of A / B / C . . . and conclude that X / Y / Z. Another group of researchers suggest that there may be another way to interpret these figures.. they say. . . etc. (This highlights existing theories in the literature - these could be conflicting explanations for the effects that are observed by different researchers. Always remember that research can have a particular agenda, i.e. to promote efficiency of markets, or to critique main-stream literature - so be a little critical when reading. Every researcher is trying to sell their ideas.)

3. Next, you could explain that 'these' different approaches suggest that this problem could be investigated by doing E/F/G. (Identification of possible ways of addressing the issue - There are a variety of quantitative and qualitative methods, and some people rely more on some than on others. This section should still be able to refer to how other people have addressed the issue. Here is where you narrow down what might be a good way to look at the problem.)

4. More specifically, therefore, we want to investigate how / if / what the effects of / etc. (By this stage you should be able to be specific about the exact part of the problem that you are interested in addressing, and all of the arguments for why it is interesting should already have been made.)

7.4 Some general notes about writing a problem statement

The general structure of questions in most economic analyses is: What is, has been, or will be the impact of **A** on **B**?

7.4.1 Where do you find a problem in macroeconomics?

Many economic queries attempt to measure social consequences, and most often try to assign a financial value to those consequences. Sometimes this is phrased as a "comparative outcome" or "alternative scenario". Normally this means that one option is *better* than another. This is not surprising, since pretty much all macroeconomic variables are aggregated financial values or derivatives thereof.

Other ways to frame a question could be:

1. Why is one option better than the other? How can you tell?
2. How does a change in X affect income for the economy / households / teachers?
3. How many people are employed?
4. Labour productivity?
5. How is the standard of living affected?

These are justification options (evidence) to motivate *why* an investigation is a good idea. Just remember that you need to be able to find the evidence to back up your arguments. As noted in the example of an introduction flow above, your selection of a method should be the logical conclusion of your reading.

7.4.2 Answering the Why?

Why is it that investigating this problem will be beneficial? To answer the question generally requires awareness of:

1. What?
2. When?
3. Where?
4. Who?
5. In what way?
6. How?

These things are the specifics of the problem statement, but they will not provide you with the answer to why it is important.

The best place to find an answer to *why?* is to read some of the most recent work on the topic you have found. Anything that has been published has been read and edited by at least 5 people by the time it goes to a journal. The arguments in those articles should therefore be pretty reasonable.

Once you understand your *why?* you can start with the specifics

7.4.3 What?

For example: If you chose to research currency markets, some of the sub-categories could be (What?):

- Trading platforms
- Exchange rate policies
- Regulations
- Common currency areas
- Clearing and settlement systems
- Speculation
- Risk-mitigation / hedging

This delimitation is often determined by the problem area that you identify. Normally illustrated by something interesting or concerning, which leads you to think that investigating the area might be interesting.

You can go the other way around, and check what has been written about recently or is currently being funded at the EU or national levels. Read some of the latest literature relating to it and then identify if there is a similar problem in an area that has not yet been investigated.

A third possibility is to open up some of the really amazing data repositories of major institutions and see if some of those can inspire you.

7.4.4 When?

You need to be carefully aware of what time period you choose to investigate, as it has direct consequences for the types of conclusions you can make from your analysis. If you look at 1950 -1970 consumption data, you can't really say anything intelligent about the use of disposable income in 2020.

Historical analysis is crucial in economics, but you should always be aware of how the structure of the economies of the world have shifted over time.

Education rates, the type of institutions that exist, levels of unemployment, the size of government, etc.

A trendy catch phrase for this kind of context is PESTLE, an anagram for how the context of countries change:

1. Political
2. Economic
3. Social
4. Technological

5. Legal
6. Environmental

Please **don't write this list out and do a PESTLE analysis** in your projects, it is just to tell you that there are many changes that take place over time. And that you need to think specifically about time in your problem statement.

7.4.5 Where?

This is quite obvious but is not only related to geographical borders. For example, a study could be:

- National
- Municipal
- Regional
- Global
- Local (or micro)

7.4.6 Who?

Which groups are involved in your project, and who is it that will be interested in reading the results of your research? Who will the research / problem investigation be useful or interesting for.

- Demographic specific (Ex., students, low-income families, employees at public institutions)
- Institution specific (Ex. Banks, the national bank, the stock exchange, or one specific institution)
- Industry specific (Ex. Mining, agriculture, home owners associations, mortgage institutes, or alternatively at a "sector" level, such as households, firms, government etc.)
- Country specific
- Etc.

7.4.7 In what way?

You also need to know what kind of impact or relationship you are looking for. Is it,

- *How much of the behaviour of A can be explained by B*?
- Is it a *theoretical or empirical issue* or are you interested in?

- Or *how much influence will A have on B? Or vice versa, or both*?
- Is it causal? Are you arguing that one thing is *causing* another thing? – you have to be quite careful trying to do these ones.

7.4.8 How?

Finally, you need to be able to explain how you are going to investigate the problem. You should consider your tools and your course on methodology (and philosophy of science) to be able to figure out how will you answer the question.

You can boggle your brain a bit with the wiki-page on philosophy of science here:

https://en.wikipedia.org/wiki/Philosophy_of_science

Recall that methodology is layered, a very simplistic way to think about it is as a hierarchy:

> Philosophy of science

-> Methodology

--> Theory

----> Methods

You can watch a few videos about what this is:

1. This one is pretty good, but a little dry: https://youtu.be/IvwkMxgahA4
2. Daniel Hausman - This one has some interesting perspectives (but is much better in 2x speed): https://youtu.be/EfF6WD8s_ps (but he doesn't really list any specific philosophies)
3. Paul Hoyningen-Huene at Leibniz Universität Hannover has a whole course on it if you get really caught up in it - https://www.youtube.com/watch?v=tP8teUgZcBY&list=PLGV2ddg-PFGvWKDeTyrUji7TXY8y1SHjl (He is pretty entertaining and you could learn a lot in his course – and have a few laughs at dad jokes – in 22 lectures)
4. Marc Lavoie – This might help if you are interested in locating the theory you are using in either heterodox or orthodox categories of economic methodology. Disclaimer: I do not believe this is a constructive way to categorise methodology, but it is a common way. https://youtu.be/DEROFQIao4o

The philosophy of science defines what kind of results will be considered valid. For example, is it valid to make a conclusion about the future based on the past (i.e. to use data to make predictions)?

Some examples of this are:

- Cartesian / Euclidian philosophies of science

- The Babylonian mode of thinking
- Critical realism
- Scepticism
- Logical positivism

This colour coded conceptual map of philosophy might put some of the terms you come across into perspective (with some spin on "education"):

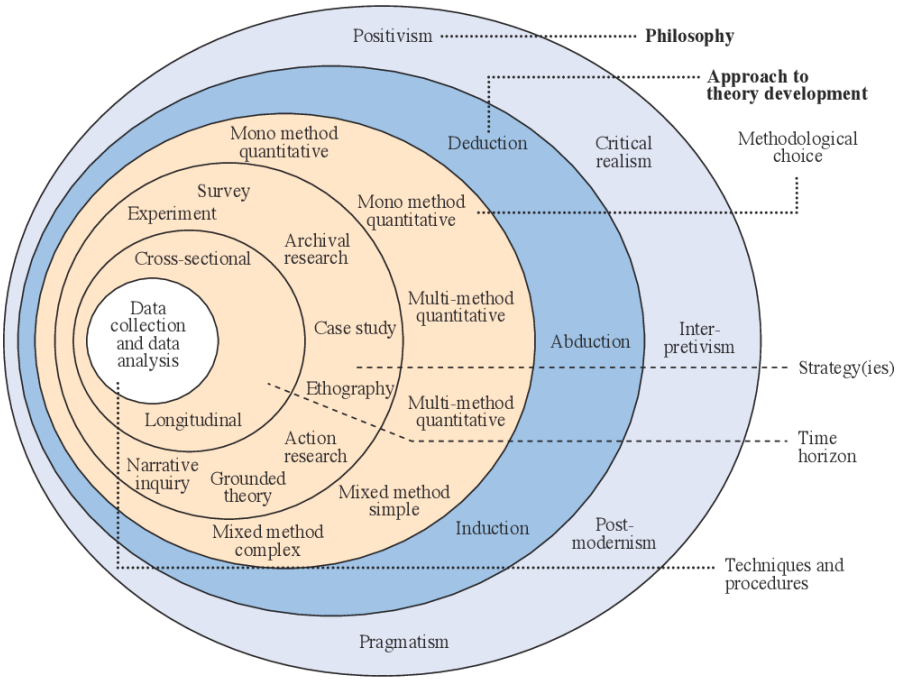
https://cmapspublic3.ihmc.us/rid%3D1196256709922_36526043_8120/1196256715039I908793757I8261Iimage

Theories use methods, and methods are part of a particular methodology, and the methodology is made valid by the theory of science inside which it fits.

Methods are at the bottom of the pyramid, and can be quantitative or qualitative, or a combination of both. It is important to be aware of what you are doing and using. They are normally used to motivate one or another theory.

This stuff can be extremely dry and boring, or it can also be super interesting (if you are into it). It is how we know, that we know, that what we know, is really something factual – or what a fact is in the first place. It is closely related to metaphysics, epistemology and ontology. None of which will help you cook an egg in the morning, but you might find the study as fascinating as I do (even if I will never suck up the energy to finish reading Immanuel Kant's *Critique of Pure Reason*).

This Saunders et al. research onion is a pretty useful way to think about each of the decisions we make when constructing out research. Starting from the outside moving inwards:



e 1. Research onion[1]

Source: Saunders, Lewis and Thornhill (2019), Research methods for business students

Chapter 8

Alternative platforms for writing projects

This is a brief list of options when writing a project. Some options are best suited to complex data work, such as Rmarkdown, whereas others are better suited to collaborative writing, such as Overleaf, MS Word via MS Teams.

Each of these platforms are presented in short videos below. There are some clear advantages to using some rather than others. For each you will need to have some knowledge about how the program works in order to use it, and this might require a time investment.

My preference is to recommend open-source options that allow for efficient collaboration and / or reproducible research.

Free / open source options

1. Overleaf / LaTeX
2. RMarkdown
3. Google Docs (but you pay in terms of data security)

Paid / Subscription options

1. MS Word

8.1 Overleaf (LaTeX)

Overleaf offers a number of excellent guides for getting started, but for those that would like an explanation from me of some of the basics, please feel free to watch the following videos.

One of the most powerful features of Overleaf is the ability to who any change is attributed to, and to roll back changes incrementally. This is possible due to the built in version control features that the platform offers.

1. Video: How open an account in Overleaf
2. GitHub: Template documents and resources
3. Video: Integration of Mendely with Overleaf
4. Integration of Git with Overleaf (Quite a heavy Spanish accent, but a good guide)

8.2 RMarkdown

RMarkdown is a derivative of Markdown syntax, and is a very simple way to write. The video guide below covers a lot of ground, and uses the GitHub template that follows as an example.

1. Video: Getting started with Rmarkdown
2. GitHub: Project template for single or multi-file projects

8.3 MS Word via MS Teams

MS Word files can be dropped into the "General" chat area of any Team created using the MS Teams app. These files can then be edited simultaneously by all team members.

Chapter 9

Reference and bibliography management

With the aid of technology, it is not possible to very easily and efficiently manage and utilise the literature sources that you need when writing an academic project.

The first step is finding the appropriate literature, which is explained in more detail in the chapter below. This section is included in advance as it is useful to select the bibliography management software in advance of completing a literature search.

Each of the more popular reference management software tools have a variety of advantages and disadvantages, depending on what program you choose to work in.

My own preferences are shaped by my experience with each program - and a desire to make sure that the content I create will be accessible to me always, regardless of whether I am at the university or not. If better options exist I would be most interested in hearing about them.

The first two software options enable in-text referencing and automatic generation of reference lists in MS word. The last option, of manually collecting your reference data, is the most inefficient, but has some benefits. The videos below will link to the Loom hosting service, and provide a guide to Mendely. Refworks can do pretty much everything that Mendeley can, but it is expensive to use once you leave the university.

Order of preference

1. Mendeley
2. Refworks

3. Manual storage

9.1 Videos of reference software

1. Video: Mendeley in 5 minutes: Part 1 Video: Mendeley in 5 minutes: Part 2 Video: Mendeley in 5 minutes: Part 3
2. Use of in-text referencing in Ms Word
3. In-text referencing, and creating a reference list in Ms Word
4. Integration of Mendely and Overleaf
5. GitHub Example: Citation options and text edit options in Overleaf
6. Video: Reference lists in RMarkdown
7. Video: Citation options in RMarkdown (Same video as in 6. above)

Chapter 10

Literature searching

Literature searches can be completed in a number of ways. There are several very useful free literature search options, as well as more expensive options that you will have access to as a university student.

10.1 Free search options

1. Google Scholar
2. Semantic Scholar

10.2 Paid search options

These options are very effectively combined and the University library website. Where the *Primo* service can be used to search a wide variety of databases for a specific search string (or phrase).

1. Aalborg University Universitetsbiblioteket

The university site also allows students to access each of the available underlying databases individually and use the special search features that are available for each. Several of these databases allow for bulk exportation of bibliographic information, and can be easily synchronised with referencing software described in the section above.

2. Databases and suppliers

A short video introdution to literature search is included as a video reference below. This link will take you to a video recorded and stored on the **Loom** hosting platform.

10.3 Literature search videos

1. How to conduct an efficient literature search
2. How to construct the key search criteria for your literature search
3. How to save and export search results

Chapter 11

Appendix: Literature search construction

11.1 Project title

Stock-flow consistent models – property and mortgage

11.2 Description of subject

Stock flow consistent model to cover mortgage debt of the household sector

11.3 Problem statement for project

Debt to disposable income levels in several Danish sectors have risen to the highest ever recorded levels, while the Danish central bank (Danmarks nationalbank), the IMF and Finanstilsynet all report that there are no serious threats to financial stability. Financial deregulation, relaxation of borrowing criteria and product innovation have been cited as the leading causes of this trend. This thesis aims to explore credit creation and macro-financial risks related to the expansion of household debt in Denmark by examining institutional sector and individual household balance sheets.

11.4 Search criteria development – summary

1. Step 01: List all concepts
2. Step 02: Group words into "Blocks" of concepts
3. Step 03: Check for any synonyms
4. Step 04: Add Boolean operators

5. Step 05: Prioritise blocks according to subject
6. Step 06: Selection of appropriate databases
7. Step 07: Perform search block by block
8. Step 08: Combine search blocks
9. Step 09: Refine search parameters based on results
10. Step 10: Document search results and search limiters
11. Step 11: Compare results and refine search parameters
12. Step 12: Export final list of documents
13. Step 13: Repeat steps 07 to 12 for each database
14. Step 14: Remove duplicates identified from different databases
15. Step 15: Remove non-relevant documents based on title and abstract
16. Step 16: Read core literature
17. Step 17: From core reading, find and read any key literature identified by other authors.

11.5 Search criteria development

11.5.1 Step 01: List all concepts

1. Stock Flow Consistent Models
2. Structural Econometric Models
3. Mortgage debt
4. Housing market
5. Macroeconomic models
6. Post Keynesian theory
7. Denmark
8. Households
9. Sector balance analysis
10. Household debt

11.5.2 Step 02: Group words into "Blocks" of concepts

1. "Stock Flow Consistent Models" OR "Structural Econometric Models" OR "Sector balance analysis"
2. "Macroeconomic"
3. "Mortgage debt" OR "Housing market"
4. "Post Keynesian theory"
5. "Denmark"
6. "Households"
7. "debt" OR Credit"

11.5.3 Step 03: Check for any synonyms (and use MS Word to check for spelling errors)

1. "Stock Flow Consistent Models" OR "stock flow consistent" OR "Stock-flow consistent" OR "SFC models" OR "SFC" OR "Structural Economet-

ric Models" OR "Structural econometric" OR "SEM models" OR "Sector balance analysis" OR "SBA" OR "Sector financial balances"
2. "Macroeconomic model" OR "National model" OR "aggregate model"
3. "Mortgage debt" OR "mortgage bonds" OR "Mortgage credit" OR "mortgage borrowing" OR "Housing market"
4. "Post Keynesian" OR "Post-keynesian"
5. "Denmark" OR "Danish" OR "Nordic" OR "Scandinavian"
6. "Households"
7. "debt" OR Credit"

11.5.4 Step 04: Add Boolean operators

1. "Stock Flow Consistent Model*" OR "stock flow consistent" OR "Stock-flow consistent" OR "SFC model*" OR "SFC" OR "Structural Econometric Model*" OR "Structural econometric" OR "SEM model*" OR "Sector* balance analysis" OR "SBA" OR "Sector* financial balance*"
2. "Macroeconomic model*" OR "National model*" OR "aggregate model*"
3. "Mortgage debt" OR "mortgage bonds" OR "Mortgage credit" OR "mortgage borrowing" OR "Housing debt"
4. "Post Keynesian" OR "Post-Keynesian"
5. "Denmark" OR "Danish" OR "Nordic" OR "Scandinavian"
6. "Household*"
7. "debt" OR Credit"

11.5.5 Step 05: Prioritise blocks according to subject

Starting with the most relevant first

("Stock Flow Consistent" OR "Stock-flow consistent" OR "SFC model*")

OR

("Structural Econometric" OR "SEM model*")

AND

("Macroeconomic model*" OR "National model*" OR "aggregate model*" OR "sector* model")

AND

("Mortgage debt" OR "mortgage bonds" OR "Mortgage credit" OR "mortgage borrowing" OR "Housing debt" OR "Housing market" OR "Property market" OR "Property Prices")

AND

("Post Keynesian" OR "Post-Keynesian")

AND

("Denmark*" OR "Danish" OR "Nordic" OR "Scandinavia*")

AND

("Household*" OR "private sector")

AND

("debt" OR "Credit")

Optional alternative to add to SFC ("Sector* balance analys*" OR "Sector* financial balance*")

11.5.6 Step 06: Perform search block by block

11.5.7 Step 07: Combine search blocks

11.5.8 Step 08: Document search results and limitations

11.5.9 Step 09: Compare results and refine search parameters

11.5.9.1 1. Scopus

Scopus (371 results)

Search string:

ALL(("Stock Flow Consistent" OR "Stock-Flow Consistent") AND (macroeconomic* model*)) AND DOCTYPE(ar OR re OR bk OR ch OR cp OR sh) AND (LIMIT-TO(LANGUAGE, "English"))

Scopus (138 results)

Search string:

TITLE ("Stock Flow Consistent" OR "Stock-Flow Consistent" OR "SFC") AND ALL ("propert*" OR "hous*" OR "mortgage") AND DOCTYPE (ar OR re OR bk OR ch OR cp OR sh) AND (LIMIT-TO (LANGUAGE , "English"))

Scopus (6 results) + housing

Search string:

TITLE ("Stock Flow Consistent" OR "Stock-Flow Consistent" OR "SFC") AND ALL ("housing") AND DOCTYPE (ar OR re OR bk OR ch OR cp OR sh) AND (LIMIT-TO (LANGUAGE , "English"))

Scopus (3 results) + mortgage

Search string:

TITLE ("Stock Flow Consistent" OR "Stock-Flow Consistent" OR "SFC") AND ALL ("mortgage") AND DOCTYPE (ar OR re OR bk OR ch OR cp OR sh) AND (LIMIT-TO (LANGUAGE , "English"))

Scopus (26 results) + property housing mortgage

Search string:

TITLE (“Stock Flow Consistent” OR “Stock-Flow Consistent” OR “SFC”) AND ALL (“propert*” OR “hous*” OR “mortgage”) AND DOCTYPE (ar OR re OR bk OR ch OR cp OR sh) AND NOT (“Chromatography” OR “lipid solid fat” OR “solid fat content” OR “silico-ferrite off calcium” OR molecular* OR “service function chaining” OR “service-function chaining” OR “chemistry” OR “space-filling curve” OR “Sequential Function Chart*” OR “SFC binder”) AND (LIMIT-TO (LANGUAGE , “English”))

Scopus (23 results) + property housing mortgage

Search string:

TITLE (“Stock Flow Consistent” OR “Stock-Flow Consistent” OR “SFC”) AND ALL (“property market” OR “housing market” OR “mortgage debt”) AND ALL (“economics”) AND DOCTYPE (ar OR re OR bk OR ch OR cp OR sh) AND (LIMIT-TO (LANGUAGE , “English”))

11.5.9.2 2. EBSCOhost (Business Source Premier, Academic Source Premier) (119 results)

(Search options: Also search in full text of the articles)

(Limits: Academic search premier Language: English Publication Type: All Document Type: Article, book chapter, proceeding, report)

(Limits: Business search premier Language: English Publication Type: Academic journal, Book Document Type: Article, book entry, proceeding, report, working paper)

EBSCOhost (119 results)

Search string:

(“Stock Flow Consistent” OR “Stock-Flow Consistent”) AND (macroeconomic* model*)

EBSCOhost (25 results) (included)

Search string:

(“Stock Flow Consistent” OR “Stock-Flow Consistent” OR “SFC”) (Limit: TITLE) AND (macroeconomic* model*)

EBSCOhost (9 results)

Search string:

(“Stock Flow Consistent” OR “Stock-Flow Consistent”) AND (macroeconomic* model*) AND (“Denmark*” OR “Danish” OR “Nordic” OR “Scandinavia*”)

11.5.9.3 3. ProQuest

ProQuest (529 results)

Search string:

("Stock Flow Consistent" OR "Stock-Flow Consistent" OR "SFC") AND (macroeconomic* AND model*) AND (LA(English))

ProQuest (43 results)

Search string:

TI("Stock Flow Consistent" OR "Stock-Flow Consistent" OR "SFC") AND ALL (macroeconomic* AND model*) AND (LA(English))

Source type

Conference Papers & Proceedings, Dissertations & Theses, Scholarly Journals, Working Papers

Document type

Article, Book, Book Chapter, Conference Paper, Country Report, Literature Review, Report, Technical Report, Working Paper/Pre-Print

Language

English

11.5.9.4 4. JSTOR

JSTOR (96 results) (selection included – JSTOR requires click to export)

Search string:

(("Stock Flow Consistent" OR "Stock-Flow Consistent") AND (macroeconomic* model*)) AND la:(eng OR en)

JSTOR (19 results)

Search string:

(ti:("Stock Flow Consistent" OR "Stock-Flow Consistent" OR "SFC") la:(eng OR en)

JSTOR (13 results)

Search string:

(ti:("Stock Flow Consistent" OR "Stock-Flow Consistent" OR "SFC") AND (macroeconomic* model*)) AND la:(eng OR en)

11.5.9.5 5. Web of Science

Web of Science (67 results)

Search string:

("Stock Flow Consistent" OR "Stock-Flow Consistent") AND (macroeconomic* model*)

Web of Science (24 results)

Search string:

("Stock Flow Consistent" OR "Stock-Flow Consistent" OR "SFC") (Limit: TITLE) AND (macroeconomic* model*)

Web of Science (1 results)

Search string:

("Stock Flow Consistent" OR "Stock-Flow Consistent") AND (macroeconomic* model*) AND ("Denmark*" OR "Danish" OR "Nordic" OR "Scandinavia*")

11.6 Summary

Total of 146 documents found

Chapter 12

Presentations

Each semester students approach me asking what "I would prefer they present?". This really is not a question of preference, but there seems to be enough inconsistency in expectations to make it worth while asking the supervisor what to do.

Some supervisors must have an expectation that something new is presented - or this would not arise as a question.

12.1 First and foremost: Check the learning and knowledge objectives for the project!

The only thing you can be graded against are the formal descriptions in the study or project description. These are often quite broad, but these are the grounds that need to be covered **at a minimum** for the project to pass.

These objectives can be met by either the written or the oral contibutions of the student. So if you have failed to complete part of the objectives in the written part - you might consider covering the ground in the presentation. Although this might not be the most effective strategy, since there is a good chance you will be asked questions that reflect those objectives in the question and answer part of your defence.

12.2 So what is the purpose of the presentation?

The presentation is an opportunity to communicate the contribution that you have made. It is also an opportunity to set the stage for the defence that follows.

Ideally you want to make an interesting and compelling presentation. Interesting in the sense that the content should be interesting to listen to, and compelling

in the sense that you need to convince the people listening that you know what you are talking about.

That may seem like subjective and useless information - but first impressions matter, and a strong presentation that is well delivered creates a firm foundation for a good strong defence.

12.3 Something old or something new?

You each have 8-10 minutes to convince the examiner that you have done something interesting and or useful.

This could be presenting the work you have already submitted in written form - bearing in mind that the examiners will have read the project. This can be beneficial if the written project does not capture the full extent of the work and findings of the research. Although, you should also be able to explain why it was never included in the written part in the first place.

An example of this could be a complex economic model, with perhaps 50 or 100 equations - where a full explanation of all intricacies would result in a very (impractically) long document that failed to capture the main point of your research.

12.4 It's about communicating value

As mentioned above, it can help to think about the idea that you have 15 minutes to convince the examiners of the value of the work you have done.

The remainder of the exam will be sufficient time to ask a good mixture of questions on the project, during which you will get a chance to "defend" the work that you submitted in written form.

It's not a sales pitch, but you do need to "sell your work" in some sense of the expression - sometimes the best way to do so is focussing on the work that you have already done, and sometimes that is to present something additional to the work done - but as I personally do not have a preference, and will not penalise anyone for doing one or the other.

12.5 What not to do

Do not show up un-prepared - plan what you want to say, figure out how you are going to say it, and practice the presentation a couple of times before the defence.

The corollary of the point above is the only thing that I do not recommend, which is to spend all of your presentation time highlighting all of the flaws in

your work - it is good to have perspective on the work, but if the perspective is all negative it can create a highly critical atmosphere.

I.e. if you spend all of your presentation time making your work sound poor, it can keep the focus there for the remainder of the defence. If, on the other hand, the shortcomings are, for example, "challenges to be overcome in future projects" and oversimplifications in your model are "areas that you want to develop the model further", then you are able to direct the focus towards progress and achievement, rather than inadequacies in your work.

12.6 What is of value in academia?

This is a rather dangerous question to try to answer in a little blurb on the internet, but I will hazard a short suggestion. The only reason I am mentioning anything like this here is that after submitting your written assignment, you might realise that some part of the assignment was lacking in quality.

There are a few things that good quality academic work often demonstrates, some of which can be highlighted indirectly in a presentation of your project:

1. A careful consideration of the area of research and in doing so found a particular issue you would like to investigate or address.
    - **Example:** "We approached the _____ area of economics since we were interested to find out _____"
2. Consultation of academic literature on both the area in question and the specific problem.
    - **Example:** "One of the first authors to investigate the issue, *'Name'*, raised _____ concerns, which still apply to research in the area today"
3. Consultation of literature on previous attempts to investigate the problem and the methods that previous researchers have used.
    - **Example:** "Several approaches have been taken to investigate the topic, *'name'* first used _____, and *'name'* was able to mitigate some of the problems faced by…. in …"
4. A clear understanding of the choice of method, the method itself and the limitations thereof.
5. A careful and appropriate application of a method to the problem, taking care not to over-reach in the interpretation of results.
6. A clear line of reasoning from start to finish.

Chapter 13

Data retrieval and plotting

The examples used in this section (excluding the plotly interactive plots at the bottom) can all be found in a complete RMarkdown file called "SingleDocument.Rmd" in one of my other GitHub repositories, here.

13.1 Example data sourcing and manipulation

One of the benefits of online database API access is that you can readily source up to date data directly from web locations without having to save files locally in advance.

Most of the major data providers have easy to handle R packages for directly importing data while building your document. The following code chunk requires several packages to be installed:

13.1.1 Loading the required packages

The first `sapply` function is just a nice abbreviation that can be used to run the `require`command for all of the packages listed in the preceding vector. It can of course be modified to run any function.

The second part is particularly useful when writing PDF documents, as you can set the standard chunk options up front in your document and adjust all image settings at once if you choose to change your document setup.

These packages are mostly used in setting up additional plot options for ggplot 2 for aesthetic purposes, like controlling the colour palette, the location and size of the legend etc. All of that plotting code is included just before the plots below.

13.1.2 Collecting the data from the Danmarks Statistik API

```
##############################################################################
# Danmarks statistik example
##############################################################################

# This uses a package called statsDK, which needs to be built from Mikkel Krogsholm's
#
#    install.packages("devtools")
#    library(devtools)
#    devtools::install_github("mikkelkrogsholm/statsDK")

# Fetching interest rate data, and filter for mortgage products
##############################################################################
dk_mortgage_interest_raw_data <- data.table(sdk_retrieve_data(table_id = "DNRNURI",
                                                              DATA = paste0(c("AL51EFFI
                                                              INDSEK = paste0(c("1400"
                                                              VALUTA = "z01",
                                                              LØBETID1 = "ALLE",
                                                              RENTFIX = paste0(c("1A",
                                                              LAANSTR = "ALLE",
                                                              Tid = "*")) %>%
    select(-c(VALUTA, LØBETID1, LAANSTR, INDSEK)) %>%
    #mutate(Value = str_replace_all(INDHOLD, pattern = "..", "")) %>%
    mutate(Value = as.double(INDHOLD, na.rm = TRUE)/100,
           RENTFIX = str_replace_all(RENTFIX, pattern = " - - ", "")) %>%
    mutate(RENTFIX = str_replace_all(RENTFIX, pattern = " - ", "")) %>%
    mutate(RENTFIX = str_replace_all(RENTFIX, pattern = "- ", "")) %>%
    mutate(RENTFIX = str_replace_all(RENTFIX, pattern = "Over 6 months and up to and in
    mutate(RENTFIX = str_replace_all(RENTFIX, pattern = "Over 1 year and up to and incl
    mutate(RENTFIX = str_replace_all(RENTFIX, pattern = "Over 2 years and up to and inc
    mutate(RENTFIX = str_replace_all(RENTFIX, pattern = "Over 3 years and up to and inc
    mutate(RENTFIX = str_replace_all(RENTFIX, pattern = "Over 5 years and up to and inc
    mutate(Interest_Fixation = str_replace_all(RENTFIX, pattern = "Over 10 years", "Fi
    mutate(Date = str_replace_all(TID, pattern = "M", "")) %>%
    mutate(Date = paste0(Date, "01")) %>%
    mutate(Date = as.Date(Date,format='%Y%m%d'))  %>%
    mutate(Interest_Fixation = factor(Interest_Fixation, order = TRUE,
                                      levels = c("01 year",
                                                 "02 year",
                                                 "03 year",
                                                 "05 year",
                                                 "10 year",
                                                 "Fixed"))) %>%
```

```
    select(-INDHOLD, -RENTFIX, -TID) %>%
    filter(!is.na(Value))


DK_yield_curves_rates <- dk_mortgage_interest_raw_data %>%
    filter(DATA != "Administration rate (per cent) (not indexed)",
           !is.na(Value)) %>%
    select(-DATA)
```

13.1.3 Adding some extra plotting options

This section includes some additional code that makes writing a document a little more user friendly.

The first part includes some directory specifications, based on the location that the user saves this file.

The second part includes a number of ggplot2 theme and colour palette modifications that can be modified for personal preference.

- The line-width for all line plots in the document.
- Palettes with shades of red, black, blue for 4 5 and 6 variables.
- A mixed colour palette of 10 colours for categorical variables.
- Alternative legend placements inside the plotting area. (This saves a lot of space in the final document).
- Percentage formats that work with latex and ggplot2.
- Simplified command to introduce dashed lines for 5 and 6 variables.
- A theme adjustment to reduce font size in all plots.

```
##############################################################################
# Set up some extra features for plots that will be used later

plot_line_width = 0.85

##############################################################################
# Set colour palettes
##############################################################################

blackpalette <- c("0, 0, 0",
                  "125, 125, 125",
                  "75, 75, 75",
                  "225, 30, 0")
bluepalette <- c("0, 50, 130",
                 "0, 170, 255",
                 "0, 200, 255",
                 "0, 55, 255")
redpalette <- c("255, 45, 0",
```

```
                "255, 200, 0",
                "255, 155, 0",
                "255, 100, 0")

blackpalette_five <- c("0, 0, 0",
                       "185, 190, 200",
                       "115, 115, 115",
                       "75, 75, 75",
                       "225, 30, 0")
bluepalette_five <- c("0, 50, 130",
                      "0, 150, 255",
                      "0, 175, 255",
                      "0, 200, 255",
                      "0, 55, 255")
redpalette_five <- c("255, 45, 0",
                     "255, 200, 0",
                     "255, 175, 0",
                     "255, 145, 0",
                     "255, 100, 0")

blackpalette_six <- c("0, 50, 130",
                      "0, 0, 0",
                      "185, 190, 200",
                      "115, 115, 115",
                      "75, 75, 75",
                      "225, 30, 0")
bluepalette_six <- c("0, 50, 130",
                     "0, 100, 255",
                     "0, 130, 255",
                     "0, 165, 255",
                     "0, 200, 255",
                     "0, 55, 255")
redpalette_six <- c("255, 45, 0",
                    "255, 240, 0",
                    "255, 210, 0",
                    "255, 180, 0",
                    "255, 155, 0",
                    "255, 100, 0")

randompalette <- c("91, 163, 111",
                   "84, 135, 158",
                   "76, 99, 143",
                   "204, 157, 2",
                   "156, 0, 0",
                   "110, 99, 194",
```

```
                    "11, 132, 176",
                    "237, 133, 28",
                    "23, 87, 11",
                    "49, 163, 79")

blackpalette <- sapply(strsplit(blackpalette, ", "), function(x)
    rgb(x[1], x[2], x[3], maxColorValue=255))
bluepalette <- sapply(strsplit(bluepalette, ", "), function(x)
    rgb(x[1], x[2], x[3], maxColorValue=255))
redpalette <- sapply(strsplit(redpalette, ", "), function(x)
    rgb(x[1], x[2], x[3], maxColorValue=255))

blackpalette_five <- sapply(strsplit(blackpalette_five, ", "), function(x)
    rgb(x[1], x[2], x[3], maxColorValue=255))
bluepalette_five <- sapply(strsplit(bluepalette_five, ", "), function(x)
    rgb(x[1], x[2], x[3], maxColorValue=255))
redpalette_five <- sapply(strsplit(redpalette_five, ", "), function(x)
    rgb(x[1], x[2], x[3], maxColorValue=255))

blackpalette_six <- sapply(strsplit(blackpalette_six, ", "), function(x)
    rgb(x[1], x[2], x[3], maxColorValue=255))
bluepalette_six <- sapply(strsplit(bluepalette_six, ", "), function(x)
    rgb(x[1], x[2], x[3], maxColorValue=255))
redpalette_six <- sapply(strsplit(redpalette_six, ", "), function(x)
    rgb(x[1], x[2], x[3], maxColorValue=255))

randompalette <- sapply(strsplit(randompalette, ", "), function(x)
    rgb(x[1], x[2], x[3], maxColorValue=255))


##############################################################################
# Define random colours for plots and theme settings
##############################################################################

random_srv_palette <- c("91, 163, 111",
                        "84, 135, 158",
                        "156, 0, 0",
                        "204, 157, 2",
                        "110, 99, 194",
                        "11, 132, 176",
                        "76, 99, 143",
                        "237, 133, 28",
                        "23, 87, 11",
                        "11, 132, 176",
                        "49, 163, 79")
```

```
random_srv_palette <- sapply(strsplit(random_srv_palette, ", "), function(x)
    rgb(x[1], x[2], x[3], maxColorValue = 255))

##############################################################################
# Set plot options
##############################################################################
# Create alternative legend placements inside the plots

legend_bottom_right_inside <- theme(legend.spacing = unit(0.02, "cm"),
                                    legend.background = element_rect(colour = "white",
                                    legend.key.size = unit(0.5, 'lines'),
                                    legend.justification=c(1,0),
                                    legend.position=c(1,0))

legend_top_right_inside <- theme(legend.spacing = unit(0.02, "cm"),
                                 legend.background = element_rect(colour = "white", siz
                                 legend.key.size = unit(0.5, 'lines'),
                                 legend.justification=c(1,1),
                                 legend.position=c(1,1))

legend_top_left_inside <- theme(legend.spacing = unit(0.02, "cm"),
                                legend.background = element_rect(colour = "white", size
                                legend.key.size = unit(0.5, 'lines'),
                                legend.justification=c(0,1),
                                legend.position=c(0,1))

legend_bottom_left_inside <- theme(legend.spacing = unit(0.02, "cm"),
                                   legend.background = element_rect(colour = "white", s
                                   legend.key.size = unit(0.5, 'lines'),
                                   legend.justification=c(0,0),
                                   legend.position=c(0,0))

##############################################################################
# Create percentage number format settings object for plots
##############################################################################

# This setting is specifically important for LaTeX generated PDF documents, as the esc

pct_scale_settings <- scales::percent_format(accuracy = NULL,
                                             scale = 100,
                                             prefix = "",
                                             suffix = "\\%",
                                             big.mark = " ",
                                             decimal.mark = ".",
                                             trim = TRUE)
```

```
##############################################################################
# Define dash types for plots
##############################################################################
#  0 = blank, 1 = solid, 2 = dashed, 3 = dotted, 4 = dotdash, 5 = longdash, 6 = twodash

plt_line_types_5 <- c("solid", "dashed", "dashed", "2222", "2222")
plt_line_types_6 <- c("solid", "dotdash", "dashed", "dashed", "2222", "2222")

##############################################################################
# Define additional plotting theme settings for server data
##############################################################################

theme_extra <- theme_minimal() +
    theme(text = element_text(size=8))+
    theme(axis.text.x = element_text(angle=90, vjust=0.5))+
    theme(plot.title = element_text(hjust = 0.5))
```

13.1.4 Plotting the data

Creating a plot for the data depends quite critically on the structure of the data that you provide to the function. ggplot2 is most effective when you keep your data in "long-format", which basically means that all descriptive and categorising variables have their own columns and the "values" that each observation take are located in a single long column. This is structure is terrible for human comprehension but much easier to process programatically.

The plot that follows is a line plot of Danish interest rates. Note the places where you need to record the "fig.caption" and "caption" labels. `fig.cap = "Danish interest rates"` is included in the code chunk, whereas, `caption = "Source: Statistics Denmark (Danmarks Statistik), own calculations"` is included in the `labs`options for the plot.

```
# Plot the data with GGPlot
##############################################################################
DK_rate_curves <- ggplot() +
    geom_line(data = DK_yield_curves_rates,
              mapping = aes(x = Date,
                            y = Value,
                            group = Interest_Fixation,
                            colour = Interest_Fixation),
              lwd = 0.5) +
    labs(x = "Interest fixation term", y = "Rate of interest",
         caption = "Source: Statistics Denmark (Danmarks Statistik), own calculations") +
    scale_colour_manual(values = randompalette) +
```

```
    #scale_colour_gradient(low = "#ffffff", high = "#050f80") +
    #facet_wrap(~Growth) +
    scale_y_continuous(labels = pct_scale_settings) +
    theme_extra +
    theme(legend.direction = "vertical",
          legend.box = "horizontal") +
    legend_top_right_inside +
    guides(col = guide_legend(nrow = 3,
                              byrow = FALSE,
                              title = "Interest fixation"))
DK_rate_curves
```

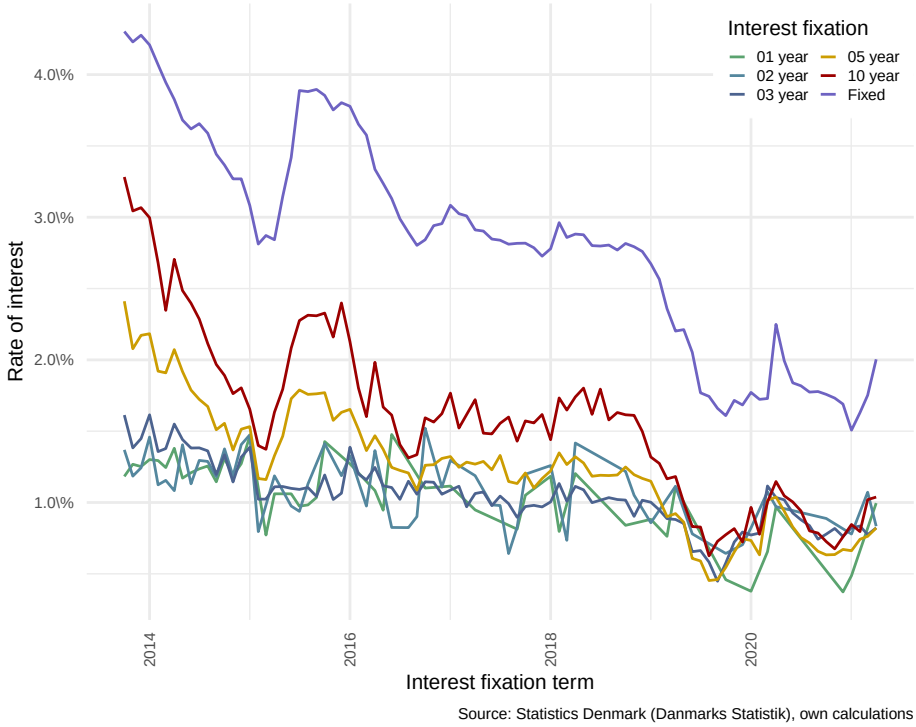
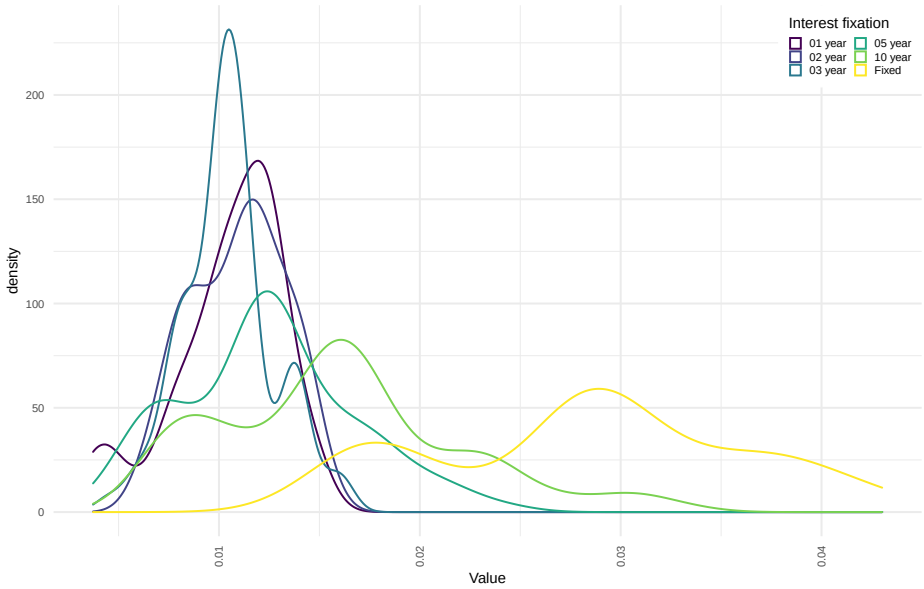


Figure 13.1: Danish interest rates

13.1.5 Density plots using ggplot2

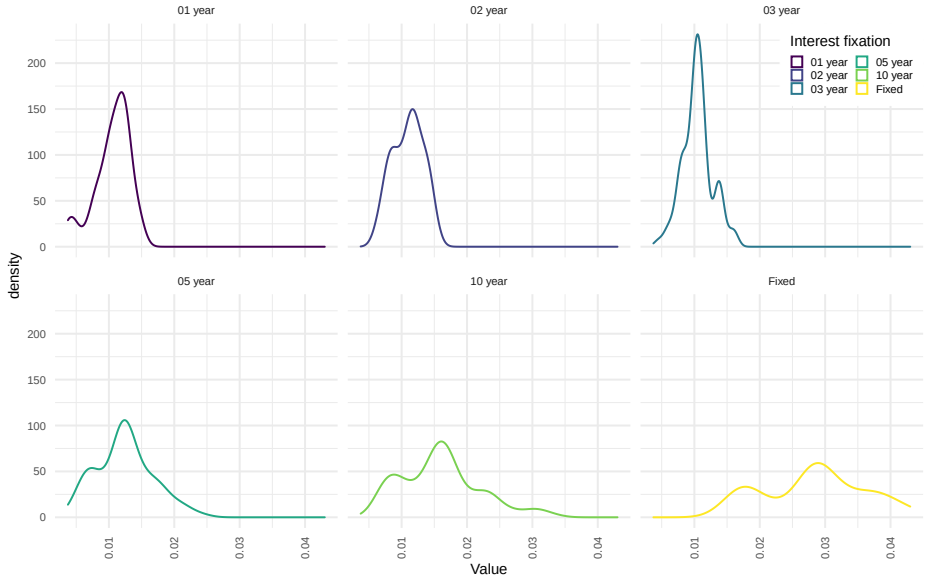
ggplot2 offers a wide range of automatic image processing options. Including density plots.

```
density_plot_interest_rates <- ggplot() +
        geom_density(data = DK_yield_curves_rates,
                     mapping = aes(x = Value,
                                   group = Interest_Fixation,
                                   colour = Interest_Fixation)) +
    theme_extra +
    legend_top_right_inside +
    guides(col = guide_legend(nrow = 3,
                              byrow = FALSE,
                              title = "Interest fixation"))
density_plot_interest_rates
```



And the ability to automatically create a tiled "faceted" plot of underlying groupings.

```
density_plot_interest_rates <- ggplot() +
        geom_density(data = DK_yield_curves_rates,
                     mapping = aes(x = Value,
                                   group = Interest_Fixation,
                                   colour = Interest_Fixation)) +
    facet_wrap(~Interest_Fixation) +
    theme_extra +
    legend_top_right_inside +
    guides(col = guide_legend(nrow = 3,
                              byrow = FALSE,
                              title = "Interest fixation"))
density_plot_interest_rates
```



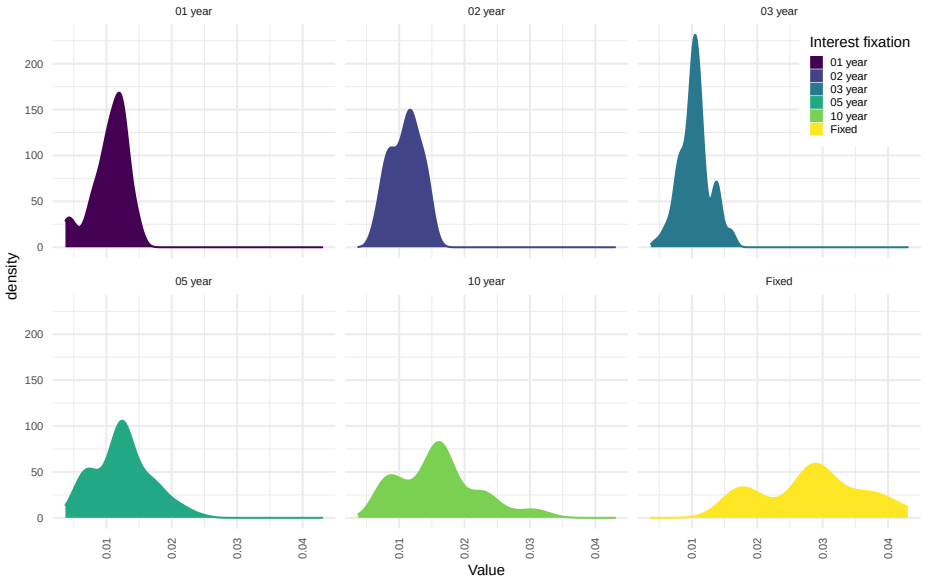
With minor modifications to the `aes` (aesthetics) properties, you can automatically change all plots to be filled in for these density plots. The Fill aesthetic is not available for all `geom`'s, so you will need to investigate the options for the ones that you are interested in.

You can see that I have also modified the number of rows in the legend to 6, to keep the legend narrower - since it overlaps the data in the top right corner. Additional legend options can be seen here. The identical legend settings and titles for `col` and `fill` prevent duplicate legends from being created. you can test this out by modifying one of the title texts.

The two options `theme_extra`, and `legend_top_right_inside`, are created above in the additional charting options section, and illustrate one way to keep your plotting code a little cleaner.

```
density_plot_interest_rates <- ggplot() +
        geom_density(data = DK_yield_curves_rates,
                     mapping = aes(x = Value,
                                   group = Interest_Fixation,
                                   colour = Interest_Fixation,
                                   fill = Interest_Fixation)) +
    facet_wrap(~Interest_Fixation) +
    theme_extra +
    legend_top_right_inside +
    guides(col = guide_legend(nrow = 6,
                              byrow = FALSE,
                              title = "Interest fixation"),
           fill = guide_legend(nrow = 6,
```

```
                                byrow = FALSE,
                                title = "Interest fixation"))
density_plot_interest_rates
```



13.2 Example table

The `kableExtra` package provides some exceptionally simple quickformatting options for both html and PDF table generation. (Link to explainer page here)

The above sourced interest rate data can be quickly laid out in a table as follows:

```
pre_created_table <- DK_yield_curves_rates %>%
          arrange(Interest_Fixation) %>%
          spread(key = Interest_Fixation, value = Value)

pre_created_table %>%
  kbl(caption = "Table of interest rates over time") %>%
  kable_styling(bootstrap_options = c("striped", "hover"))
```

13.3 Interactive html plots with Plotly

A scatter plot with labels on all points can be easily created (some axis limits for the data were necessary below). I also wanted uniform dot sizes and so simply used `Value / Value` which returns `1` for all dot sizes.

```
library(plotly)

a <- as.numeric(min(DK_yield_curves_rates$Date)) * 24 * 60 * 60 * 1000
b <- as.numeric(max(DK_yield_curves_rates$Date)) * 24 * 60 * 60 * 1000

fig <- plot_ly(DK_yield_curves_rates %>%
    filter, x = ~Date, y = ~Value,
  # Hover text:
  text = ~paste("Interest rate: ", Value, '%<br>Fixation:', Interest_Fixation),
  mode = "markers",
  color = ~Value, size = ~Value/Value
) %>%
  layout(xaxis = list(range = c(a, b)))

fig
```

Modifying this plot to return lines, we just need to arrange the data in the correct order to ensure that the lines traced follow the correct pattern.

```
library(plotly)

a <- as.numeric(min(DK_yield_curves_rates$Date)) * 24 * 60 * 60 * 1000
b <- as.numeric(max(DK_yield_curves_rates$Date)) * 24 * 60 * 60 * 1000

fig <- plot_ly(DK_yield_curves_rates %>%
    arrange(Date),
```

Table 13.1: Table of interest rates over time

Date	01 year	02 year	03 year	05 year	10 year	Fixed
2013-10-01	0.01183	0.01369	0.01613	0.02411	0.03282	0.04302
2013-11-01	0.01268	0.01185	0.01383	0.02078	0.03044	0.04229
2013-12-01	0.01252	0.01243	0.01448	0.02172	0.03067	0.04276
2014-01-01	0.01301	0.01459	0.01615	0.02183	0.02997	0.04208
2014-02-01	0.01294	0.01124	0.01357	0.01921	0.02680	0.04069
2014-03-01	0.01245	0.01155	0.01378	0.01909	0.02347	0.03945
2014-04-01	0.01380	0.01083	0.01550	0.02072	0.02705	0.03826
2014-05-01	0.01171	0.01405	0.01441	0.01918	0.02486	0.03681
2014-06-01	0.01209	0.01131	0.01382	0.01788	0.02397	0.03619
2014-07-01	0.01236	0.01295	0.01383	0.01723	0.02286	0.03656
2014-08-01	0.01256	0.01288	0.01362	0.01673	0.02114	0.03589
2014-09-01	0.01145	0.01181	0.01197	0.01510	0.01968	0.03442
2014-10-01	0.01309	0.01376	0.01334	0.01555	0.01891	0.03366
2014-11-01	0.01189	0.01186	0.01144	0.01368	0.01763	0.03269
2014-12-01	0.01272	0.01406	0.01318	0.01514	0.01804	0.03269
2015-01-01	0.01465	0.01474	0.01387	0.01532	0.01654	0.03083
2015-02-01		0.00796	0.01023	0.01168	0.01399	0.02812
2015-03-01	0.00772		0.01024	0.01161	0.01373	0.02872
2015-04-01	0.01061	0.01187	0.01110	0.01328	0.01633	0.02842
2015-05-01			0.01112	0.01465	0.01794	0.03145
2015-06-01	0.01061	0.00975	0.01099	0.01728	0.02083	0.03419
2015-07-01	0.00974	0.00938	0.01092	0.01789	0.02276	0.03888
2015-08-01	0.00983	0.01130	0.01105	0.01758	0.02313	0.03881
2015-09-01	0.01035		0.01043	0.01762	0.02309	0.03896
2015-10-01	0.01427	0.01412	0.01193	0.01770	0.02328	0.03854
2015-11-01			0.01021	0.01576	0.02160	0.03752
2015-12-01		0.01188	0.01065	0.01632	0.02399	0.03803
2016-01-01	0.01271	0.01328	0.01388	0.01653	0.02127	0.03778
2016-02-01			0.01200	0.01513	0.01803	0.03652
2016-03-01		0.00975	0.01159	0.01364	0.01602	0.03576
2016-04-01	0.01084	0.01364	0.01246	0.01468	0.01983	0.03336
2016-05-01	0.00946		0.01117	0.01373	0.01669	0.03237
2016-06-01	0.01477	0.00825	0.01105	0.01246	0.01613	0.03131
2016-07-01			0.01022	0.01225	0.01406	0.02989
2016-08-01		0.00824	0.01149	0.01207	0.01313	0.02893
2016-09-01		0.00901	0.01058	0.01087	0.01335	0.02803
2016-10-01	0.01101	0.01521	0.01145	0.01261	0.01594	0.02842
2016-11-01			0.01142	0.01265	0.01564	0.02941
2016-12-01		0.01108	0.01058	0.01309	0.01623	0.02955
2017-01-01	0.01115	0.01296	0.01087	0.01322	0.01767	0.03084
2017-02-01			0.01114	0.01247	0.01522	0.03025
2017-03-01			0.00970	0.01283		0.03009
2017-04-01	0.00948	0.01188	0.01063	0.01269	0.01721	0.02911
2017-05-01			0.01074	0.01288	0.01486	0.02903
2017-06-01		0.00983	0.00978	0.01229	0.01481	0.02847
2017-07-01		0.00979	0.01045	0.01330	0.01555	0.02839
2017-08-01		0.00642	0.00992	0.01147	0.01599	0.02811
2017-09-01	0.00813	0.00827	0.00896	0.01133	0.01430	0.02817
2017-10-01	0.01051	0.01198	0.00972	0.01207	0.01572	0.02818
2017-11-01			0.00980	0.01102	0.01558	0.02786
2017-12-01			0.00969	0.01168	0.01617	0.02727

```
    x = ~Date,
    y = ~Value,
    color = ~Interest_Fixation,
  # Hover text:
  text = ~paste("Interest rate: ", Value, '%<br>Fixation:', Interest_Fixation),
  mode = 'lines'
) %>%
  layout(xaxis = list(range = c(a, b)))

fig
```

Chapter 14

SFC model presentation

Flexible rate mortgage loans: An SFC model of the impact of mortgage credit innovations on Danish balance sheet stability

Abstract

Innovations in mortgage lending options have expounded in recent decades, resulting primarily in a reduction in the initial monthly costs associated with borrowing, and made home ownership possible for socio-economic groups that were previously excluded from the market. These changes have also drastically changed the composition of household balance sheets, both at a micro and a macro level, and the volume of outstanding debt relative to household income expanded aggressively leading up to the global financial crisis in 2007-8. The innovations unfortunately also simultaneously transferred significant risks to borrowers. This paper investigates the present day macroeconomic consequences of the change in composition from fixed- to adjustable-rate mortgage (ARM) debt that occurred in Denmark between 2003 and 2009. A state-of-the-art Stock-Flow Consistent model is adapted to allow for changes in the composition of debt, and to permit shifts in the proportion of debt between fixed-interest and ARM products. The risks to financial stability are evaluated through the imposition of two plausible shocks to the economy: the first is a two percentage point rise in borrowing costs; and, the second is a 20 per cent decline in property prices. The model allows for a clear observation of the transmission channels, and the stocks and flows most at risk, and the results suggest that the expansion of ARM mortgage credit has increased the instability of the household sector. An interesting observation was that a positive net lending response can be misinterpreted as positive developments in the absence of the broader economic context. The paper is supplemented by a new presentation method for SFC model responses, where a cross-section of proportional responses are ranked, ordered and categorised in tabular form.

14.1 Introduction

Private sector debt continues to be a concern in many developed countries, in particular mortgage debt. Debt levels expanded in most developed countries during the period leading up to the financial crisis, in the household sector this was driven primarily by the extension of mortgage credit (as can be seen in Figure 14.31, Section 14.9.1). The proportion of mortgage debt to total debt increased in all countries from around 1960, but accelerated dramatically during the 1990s and 2000s (Jordà et al., 2017). That growth was unfortunately not matched by growth in household incomes, and debt-to-income continued to expand for all countries until the great financial crisis in 2007-08 (see Figure 14.32 in Section 14.9.2). In most countries, the supply of credit slowed or even reversed as liquidity in overnight markets dried up during the financial crisis[1].

The growing debt, particularly relative to income, carries several significant risks to financial stability. These include several demand related risks, such as the future need to deleverage and the associated intertemporal substitution of demand (Justiniano et al., 2015; Raberto et al., 2012; Seppecher and Salle, 2015), deterioration of balance sheets and potential risks to refinancing requirements (Bernanke, 2007; Scanlon et al., 2008; Disyatat, 2011), and sensitivity of interest payments to rate changes (Sheehy, 2014). There are also possible contagion effects across financial markets of default (or non-performance on loans), asset price adjustments and possible deterioration of financial intermediary capital positions (Danmarks Nationalbank, 2016). As seen in credit-default-swap market during the 2007-08 financial crisis, the possible collapse of liquidity in certain markets can also generate global instability. At a sectoral level there is also the general risk of the accumulation of large imbalances, such as government or foreign deficits, that can take many years to unwind.

While there are a number of parallels between various housing finance systems, the stability of each is unique to a variety of in and out of country conditions. The European Network of Housing Research (ENHR) (Lunde and Whitehead, 2014) found that Political, geographical and institutional factors were not sufficient to explain significant differences in developments across 21 OECD countries since 1989. They (Lunde and Whitehead, 2014, pp. 4) noted that "housing finance systems are very specific to each country, reflecting different histories, legal systems, institutions, economic conditions, policies and politics." It is therefore necessary to explore the particular dynamics that are at play in each country.

This paper focuses on the Danish system, which makes an excellent country for a number of reasons. Firstly, the Danish housing finance system has been no stranger to innovation, with a number of legislative and product changes introduced since 2003. It is also a relatively small and open economy with

[1] It should also be noted that since GDP fell in 2007-08 in most countries, the peak in debt-to-GDP ratios in 2007-08 does not necessarily represent growth in debt, but partly a fall in GDP.

strong international trade ties and close ties with the European Union. Thus, a number of parallels can be drawn between the Danish system and several other countries with advanced mortgage financing systems. Denmark is also one of the very few countries that has reliable data for institutional sector balance sheets in granular detail from 1995, and sub-sector level data from 2003. This data allows one to study the problem from comprehensive empirical data. It also allows one to construct a model that integrates the complex interactions and feedback mechanisms of the five institutional sectors that is founded on observable empirical relationships[2].

In this paper I modify an existing empirical stock flow consistent (SFC) model for the Danish economy first presented by Byrialsen and Raza (2019). As explained by Godley and Lavoie (2012), these models maintain strict stock and flow consistency, in the sense that all flows are accounted for in a complete system of accumulations in the stocks of all five major institutional sectors. It attempts to capture the aggregate drivers of macroeconomic interactions as they happen in real time, although it uses *ex post* aggregate accounting values to estimate these relationships.

The completeness of the model requires that some of the variables in the model are passive to changes in others. The choice of the active variables over the passive (residual) variables is determined by a combination of accounting identities and economic theory, in this case, Post Keynesian theory. The grounds for this decision are discussed in Section 14.2.

Since the household sector is at the core of the analysis in the model, most sectors are passive to changes in the household sector, and it combines the attractive features of econometrics (structural econometric models, SEMs) with path dependency and Post Keynesian behaviours. In the strict sense the model does not demonstrate causality. Rather, it estimates the expected co-movement of certain economic aggregates based on historical evidence and theoretical expectations. These estimates inform several parameters in a medium sized system of equations[3].

The core focus of the investigation in this version of the model is the Danish mortgage system, and the expected macroeconomic consequences of innovations in the mortgage product range offered to Danish borrowers. The model in Byrialsen and Raza (2019) is the most advanced empirical SFC model available for Denmark, and thus provides the best possible point of departure. The model is under continuous development, and there are some limitations imposed by the largely exogenous nature of rates of return (including interest rates) and asset prices. A secondary goal is to identify any potential improvements to the

[2]In addition, administrative registers make it possible to explore the trajectory of various product ranges in far greater detail, although these are only available after 2009 for mortgage bond debt.

[3]This model has 131 equations, there are thus 131 endogenous variables (including checks) and 78 exogenous. There are in also several equations included as checks and balances, but which do not impact the functioning of the model.

existing model with respect to mortgage credit markets.

The original structure is modified to include a split in household debt between fixed and flexible rate products. This allows for the evaluation of the effects of proportional shifts in credit composition. In particular, to investigate the short-term implications for the accumulation of stocks in the household sector of a shift in the proportion of debt from flexible-interest-rate debt to fixed-interest-rate debt, and vice versa[4]. The exogenous nature of rates of return and financial asset prices is both an advantage and disadvantage. On the one hand they allow for specific channels in the model to be highlighted, free of disturbance of from inter-connected markets. On the other hand, it implies that market rates and price fluctuations are not propagated automatically. This makes the overall model results less realistic.

One of the major benefits of the SFC framework is that it allows for path dependent accumulation of imbalances. Although there are some limitations (as discussed below), it is thus possible to fully account for feedback effects from accumulations in selected asset classes, albeit within a simple structure. The analysis that follows may also be of value in the assessment of mortgage financing structures in a macroeconomic framework, and contributes to the growing literature on empirical SFC models.

The remainder of the paper is structured as follows, Section 14.2 presents a review of the literature, and Section 14.3 provides context for the Danish mortgage market. Section 14.4 describes the model, and explains some of the key innovations made in this paper, and Section 14.5 explains the scenarios for shocks applied to the model. In Section 14.6 the effects of the shocks are described for each of the scenarios, taken from the perspective of each of the main institutional sectors. Section 14.7 contains a discussion of the main observations from the model, and Section 14.8 concludes. The first appendix, Section 14.9, contains a number of additional charts and figures, and the second appendix, Section 14.10, provides a full exposition of the model employed, together with explanations for the major innovations.

14.2 Literature and theory

14.2.1 Stock flow consistent models

Stock flow consistent (SFC) models are a relatively new branch of macroeconomic model, and as mentioned above, are characterised by strict adherence to double entry accounting rules. They resemble structural econometric models, but the expected behaviours that are modelled are typically informed by Post

[4]By making a simple split in the proportion of debt in flexible and fixed rate instruments, and adjusting the rate of interest on each separately, it offers a relatively simple means by which to incorporate a wide variety of credit market and macro-prudential policy tools into an empirical SFC model - many of which can be achieved via a weighted proportional adjustment of the interest rate on each of the debt types.

Keynesian theory. Godley and Lavoie (2007)[5] is widely regarded as the catalyst for the recent growth in research using the SFC framework, and since 2007 the number of models has grown rapidly.

As noted by Nikiforos and Zezza (2017, pp. 3), "accounting consistency is just one side of the SFC approach, with a demand-led economy and an explicit treatment of the financial side being the other." Dos Santos (2006), Caverzasi and Godin (2013), Caverzasi and Godin (2015) and Nikiforos and Zezza (2017) provide surveys of the literature, each progressively covering the most recent publications. These studies provide a comprehensive review of both the topic and methodological coverage of SFC research. SFC models can be separated into three broad categories; theoretical models, which are typically much simpler and are used for the exploration of theoretical propositions; simulated calibrated models, which are larger models that are constructed to have similar features to real economies, but where the underlying data is constructed for illustrative purposes; and, empirical models, where the entire model is based on real-world data. While each form presents challenges, empirical models face additional challenges with regards availability and reliability of data. Where data is available, the researcher is faced with the challenge of appropriate aggregation.

There are relatively few fully empirical SFC models in the literature, and the number of models for which comprehensive data was available is even lower. The model presented below is an empirical model, based on the one constructed by Byrialsen and Raza (2019). Unlike many other empirical SFC models, it is constructed from the ground up, rather than adapted from one of the more broadly used Godley and Lavoie (2012) models. This approach mirrors that suggested by Zezza and Zezza (2019), where the full complexity of national accounts data is used as the point of departure. The explicit treatment of the financial side entails significant simplification of the wide variety of financial instruments that are available.

Much like many other modelling forms, the complexity of an SFC model has implications for how easily the results can be interpreted. The greater the number of interdependent features, the lower the transparency of transmission mechanisms. In summary of a central banker forum, Pill (2001, pp. 25) noted that some participants argued that large "eclectic" macroeconomic models often "lack the simplicity, internal consistency and intuitive appeal which are prerequisites for providing good policy advice". In contrast, others "suggested that preparing policy guidance in the context of a single model allowed a holistic and rich picture of the economic situation to be obtained." This conflict between holistic context and intuitive simplicity was a key part of the decision to keep rates of return exogenous in the present model. It also provides some explanation of the aggregation process. A careful investigation of the size and relative importance of various stocks and flows was conducted to render the model to workable size. Further details regarding the actual aggregation of different categories financial and real flows are provided in Section 14.4.

[5]The original work has been revised and re-published as Godley and Lavoie (2012).

This process requires detailed data, particularly in terms of the balance sheets and flow-of-funds between the institutional sectors. This data is available for very few countries for a long enough time-period to be able to estimate statistical relationships, and Denmark is one of those countries. The model is based on annual data from 1995 to 2017, and there are thus a maximum of twenty two observations in any estimation and the extent to which the model effectively follows the data is comprehensively illustrated in Byrialsen and Raza (2019).

14.2.2 Post Keynesian theoretical foundations

The theoretical basis of the model informs the behaviours in and ordering of equations. Since the publication of Godley and Lavoie (2012)'s first edition in 2007, the number of SFC models developed globally has grown exponentially, and due to the Post Keynesian roots of the framework, the bulk of these models could be referred to as Post Keynesian Stock Flow Consistent models (PK-SFC models), PK will henceforth be used refer to the "Post Keynesian" school of thought. PK theory is typically juxtaposed with the New Neo-Classical synthesis, or New Keynesianism in order to highlight the points of difference. Such a discussion is beyond the scope of this paper[6], and a brief summary of the key characteristics of PK systems will need to suffice here, with a special focus on those parts used to inform the model below.

In terms of the trajectory of the economy, PKs typically reject the notion of a long run equilibrium in favour of path dependency, and argue that present decisions and institutional structures materially change the nature of the economy in the future. For the present model, this is reflected in the focus on short to medium term (typically the first period or two after a shock, but up to approximately 5 years). They argue also that the economy is significantly more complex than the sum of its parts (Chick, 2003), and sometimes liken it to an organic entity, or the complex interactions of an ecosystem. Economic trajectories can therefore be altered by active intervention and long term historical averages are therefore not predictive of future events. This is reflected in the model below by a lack of long-run mean reversion or stabilising elements in the model. The most significant omission relative to mainstream literature is the inter-temporal optimisation of household consumption. There are no utility functions, and there is no long-run or inter-temporal optimisation of behaviour.

For economic policy concerns, the implication is that financial and social imbalances cannot self-correct (at least not without significant social, political or economic consequences), and market mechanisms are not able to manage these issues automatically. To the contrary, unchecked imbalances that are perpetuated by market structures are problematic. Just as the accumulation of poor quality private debt prior to the 2007-08 GFC proved to be.

PKs often refer to Keynes (1937), who stated that the future is fundamentally

[6]For a full discussion of these comparisons the reader is referred to Dow (1985), Dow (2001), Chick and Dow (2001) and Chick (2003).

uncertain. It is therefore crucial to understand the economy as it presently stands, and to have some idea of what future economic conditions are desirable. It should thereafter be possible to actively plan for and develop a desirable future economic landscape, without the need for projections of the distant future, or acceptance of any long-run equilibria or natural rates. From a modelling perspective it is therefore not necessary that a model be stationary in order to be useful, it is more important that it should be representative of the present reality.

In terms of the sequence of events inside PK models, they emphasise the importance of demand (or rather effective demand[7]) in the economy, and are predominantly demand driven rather than supply driven - although, more recent works have put more emphasis on supply side constrains (Ryoo and Skott, 2008). Keynes's animal spirits and short term expectations drive investors to either increase or decrease investment. This is also related to the PK theory of an endogenous demand and supply of money in the economy. The demands of possible borrowers are tested against credit worthiness and all viable demand for credit is (or can be) accommodated by the banking sector. New lending creates new money, and therefore the demand for investment funding drives the growth in money. In this model, this analogy is applied to the household sector in that the demand for new housing investment drives the demand for mortgage credit.

There are several estimated equations in the model, and the motivations for each are discussed in a full presentation of the model in Section 14.10, in the appendix. The structure of the estimated equations are informed by PK and country specific literature, and refined to reflect the reality of the data.

14.2.3 Credit markets and global financial conditions

From a broader international perspective, the period leading up to the crisis has been called "the great moderation" (as noted by, Buttiglione et al. (2014, pp. 28)) and was an extended period of unprecedented economic growth and apparent stability of financial markets. As noted by Englund (1999), this was accompanied by the relaxation of lending requirements and credit worthiness checks, and as Scanlon et al. (2008) identified, rising property prices and expectations of capital gains. There was a gradual reduction of interest rates, and the cost of borrowing (the long-run cost of capital falling steadily from the 1970s). According to Scanlon et al. (2008), a simultaneous development on a global

[7]Intended here to include both consumption and investment, as explained by Keynes (1937). A slightly broader definition than Smith (1776, pp. 73)'s effectual demand, which refers to commodity purchase, but with a very similar line of reasoning, where in Smith's commodity markets buyers with the capacity to pay for a good "may be called the effectual demanders, and their demand the effectual demand; since it may be sufficient to effectuate the bringing of the commodity to market. It is different from the absolute demand. A very poor man may be said in some sense to have a demand for a coach and six; he might like to have it; but his demand is not an effectual demand, as the commodity can never be brought to market in order to satisfy it."

scale was an increased belief in the market mechanism, extensive privatisation and deregulation of financial markets[8]. The onset of the global financial crisis (GFC) later revealed significant flaws and systemically risky interdependencies between markets. Even though the initial effects were felt by all countries, the effects, both in terms of intensity and real economic and financial trajectories, differed greatly. (Lunde and Whitehead, 2014)

In the post-crisis period, there have been significant changes to the regulatory landscape, and the extent of mortgage lending has slowed or reversed in many countries. At the height of the crisis, liquidity in key financial instruments, particularly credit default swaps, dried up almost instantly (Nationalbank, 2009). Ultimately this triggered quantitative easing (QE) policies in both the USA and Europe, with the Fed and the ECB buying immense quantities of financial assets and market-making with the assistance of larger banks. On the regulatory front, banking prudential and capital adequacy requirements were tightened significantly. The period from 2009 to 2018, while not as extreme as the period preceding the crisis, has however, continued to show strong growth in property prices, with more than half of the OECD countries in the sample showing year-on-year growth rates of over 2%, as can be seen in 14.4.

US and European QE policies also led to excess liquidity in global financial markets. The low short-term rates have gradually resulted in record low long-term rates of return, placing added pressure on fund management and investment companies to search for yield in unconventional investments[9]. These policies and other commitments by European central banks and the ECB have contributed significantly to persistent low interest rates in market based mortgage lending systems. While the rate of growth in the level of debt relative to income appears to stabilised in many countries, the magnitude of household debt continues to expand. The risks associated with this debt depend not only on the magnitude of the debt, but also very strongly on its composition.

A correlated development has been the expansion of the product range offered by mortgage lenders. Leading up to 2007, innovations were made to almost every aspect of mortgage lending, and the vast majority of these changes have contributed to a reduction in the initial payments on mortgages for the borrower. According to Scanlon et al. (2008), while the innovations were different according to each specific country, some broader characteristics were similar across developed nations. Two key aspects to these innovations were that they made initial payments on mortgages cheaper, and secondly, they increased the flexi-

[8] One such development in Denmark was the 1993 relaxation of home equity extraction laws (Andersen and Leth-Petersen, 2019).

[9] Where performance guarantees have been provided, such as for defined benefit pension schemes, some institutions face negative spreads and the risk that they might not be able to foot the bill at the end of the day. Now in 2019, eleven years after the financial crisis, ECB (2019) announced, on 12 September 2019, a further reduction of ECB deposit facility rates to -0.5%, and the marginal lending facility to remain at 0.25%. In addition, net purchases of financial assets will begin again in the "asset purchase programme (APP) at a monthly pace of €20 billion as from 1 November".

bility and range of options available, and thus transferred significant elements of risk to the borrower. André (2016) also explains that house price bubbles are often related to periods of financial de-regulation, and highlights the introduction of interest-only (periods without capital repayments) loans in Denmark in 2003 as an example.

These international developments were not applied uniformly to all countries, or even in specific geographical areas. Lunde and Whitehead (2014) found, rather surprisingly, that in contrast to a geo-political grouping, for example with other Scandinavian countries, Denmark was closer to Finland, Poland and Russia in terms of real economic and housing financing conditions after the 2007-08 financial crisis. An additional point was that the introduction of adjustable rate mortgage (ARM) products introduced a small but significant possibility of systemic risk to the Danish mortgage system[10]. ARMs were first introduced in 1996, but and are just one of several innovations that were introduced to the Danish market.

Affordability of housing also became a prominent issue and tax incentives for interest payments on mortgages were common. According to Scanlon et al. (2011), real house prices in Denmark fell 14.9% from the peak in 2007 to Q4 2008. House prices rose in all OECD countries from 2000 to 2007[11], with Slovakia (22.41% year-on-year (yoy)), Ireland (16.65% yoy), Estonia (15.89% yoy), Hungary (13.52% yoy) and Latvia (11.22% yoy) as the most extreme examples, while Denmark rose at 3.11% yoy. From 2007 to 2009, house prices stabilised in most countries, and collapsed in a few with Estonia (-17.06% yoy) and Ireland (-12.57% yoy) showing the largest collapses. As noted above, Danish house prices reached a trough in Q4 2008 at -14.9%.

The asset and property price bubbles and collapses of recent years appear therefore to be closely related to developments in credit markets, and as is briefly explained below, the over-extension of private balance sheets and the risk of significant declines in property prices (the bursting of a bubble) could have serious consequences for both individual borrowers and the broader economy. Some of the key credit market innovations that occurred are discussed in the next section, together with some of their main advantages and disadvantages.

14.2.4 Key innovations and developments in product scope

Amongst the most common innovations noted by Scanlon et al. (2008) included the following. The introduction of flexible-interest rates, and a variety of length of interest rate fixation periods. The introduction of interest-only periods, where

[10] In particular, they referred to potential for market failure through liquidity risks for products with 30 year loan guarantees but with interest reset each year. Lunde and Whitehead (2014)

[11] Data for OECD countries for the periods 2000 - 2007, 2007 - 2008, and 2008 - 2018 can be seen in Table 14.4, in Section 14.9.3.

repayment of capital or principal are postponed temporarily. Full term interest-only loans, with the principal payable on maturity - these are sometimes linked to investment vehicles designed to accumulate greater capital than the amount contributed (i.e. with an expected positive spread above the rate of interest). Longer terms of debt, some up to 50 years. Reduced up-front cash (or own) contribution requirements. Increased percentages allowed to be allocated to bond financing, typically at a significantly lower interest rate than would otherwise be available from a bank. Exceptionally low interest rate levels have also seen some innovations in terms of price. Zero-interest 20 year fixed-rate loans as well as negative interest rate flexible-rate (ARM) bonds are at the time of writing available in the Danish market.

Some of the key drivers of these innovations were, as noted by Alpanda and Zubairy (2017), the availability of new technology, which permitted significantly more complex products to be managed effectively. Government deregulation, and the associated greater market orientation. Rising asset prices and problems with housing affordability. In the post-crisis period, innovations have been driven by some additional factors, including record low interest rates and quantitative easing. Interest rates in developed economies, particularly northern Europe, have been set to record low levels. This has had the dual impact of reducing the cost of borrowing and significantly reducing lender revenues.

14.2.4.1 Advantages of innovations

The advantages of these innovations have been felt most by borrowers, particularly those groups of borrowers that were previously unable to afford initial payments on home loans (Scanlon et al., 2008). As mentioned above, mortgage repayments are in many countries now more affordable in the short term. The flexibility of repayment options has made it possible for borrowers to structure their mortgages according to their expected cash flow requirements, this is especially helpful for borrowers with irregular incomes.

The introduction of interest-only periods, allow borrowers that have limited capacity to change their income levels, particularly the elderly, to maintain a stable standard of living (Scanlon et al., 2008) - in effect consuming part of their home equity without the need to liquidate the asset. Interest-only periods also allow younger families to absorb temporary increases in living costs, without necessitating the sale of the family home. For example the cost of children, education, or other foreseeable and unforeseeable expenses.

The lengthening of the term of mortgage debts also reduces payments for the full term of the debt, making housing more accessible to groups that would otherwise not have been able to afford it. More sophisticated investors also have the opportunity to benefit from the innovations, where in very low interest environments, they might be able to borrow and invest at higher rates of return than the cost of borrowing. Unfortunately these advantages come with a cost.

14.2.4.2 Disadvantages of innovations

The disadvantages described below are considered as compared with a standard fixed-rate annuity mortgage. In general, the innovations in mortgages place significantly greater onus on the borrower to fully understand the product that they choose to take. Several of the benefits described above are also only true for the initial stages of the debt contract, as principal repayment is often built into later stages. These products also introduce additional risk in several forms, including interest rate risk, credit risk, market risk and significant potential opportunity costs - each will be discussed briefly below.

Interest rate risk
Perhaps the simplest and most direct effect, which would not be felt by a fix interest rate borrower, is that flexibility of interest rates expose the borrower to future increases in interest expenses, and therefore negative effects to disposable income if interest rates rise.

Credit risk
Interest-only periods may reduce monthly outlays, but they also prevent the accumulation of equity by the borrower. This means that there is less of a buffer, making them more sensitive to negative shocks. Negative shocks may include an increase interest rates, the loss of income, illness of self or family members, breakdown of relationships (possibly divorce) or a fall in property prices.

Market risk
Borrower solvency is determined on the basis of outstanding debt relative to the value of the property held as collateral, or loan-to-value (LTV) ratio. In the case of property price declines, traditional borrowers would have built a buffer to absorb a decline in collateral value. By contrast, the lack of equity accumulation for interest-only borrowers means that the outstanding debt would not have fallen relative to collateral. Any borrowers with LTVs close to the limit would risk falling into negative equity, and possibly insolvency. Scanlon et al. (2011) found that the groups that were most likely to be negatively affected in a crisis were those who had withdrawn equity (potentially via refinancing), or those who had bought close to the top of the market - resulting in high loan-to-value ratios and increased probability of falling into negative equity.

Opportunity cost
Taking Denmark as an example, the borrower is endowed with several rights, one of which is that any mortgage bond is callable at any time, and at which time, the borrow can choose to either pay the remaining par value of debt, or to repurchase the same (or similar) bond sold at time of borrowing. What this means is that if interest rates rise after the date of borrowing, there is an opportunity for mortgage borrowers to settle their debt at a significantly reduced capital value. This reduction of debt can also be accomplished by refinancing at a later stage if interest rates were to rise sufficiently to outweigh the costs of refinancing. Borrowers with flexible rate mortgages lose this opportunity, since

interest rates on flexible rate bonds are reset more frequently basis, and thus price adjustments are negligible.

In summary, the increased complexity introduced by innovations requires the borrower to have a more sophisticated knowledge of financial matters and to take on more responsibility for the security of collateral and repayment of capital. As has been reported by Scanlon et al. (2008), it is doubtful whether most borrowers are sufficiently equipped to deal with these challenges. Where they do not have sufficient knowledge or skill, households become dependent on financial advisers and service providers to ensure that they have the most appropriate products.

The credit-asset-price virtuous cycle
The self-reinforcing cycle of ease in credit markets and growth in asset prices is well documented. Bernanke et al. (1999) and Disyatat (2011) explained this in the context of the financial accelerator, rising property, and asset prices more generally, incentivise borrowing via balance sheet improvements and positive sentiment. In some cases borrowing is speculative, in order to benefit from the rising tide. Low interest rates and greater ease of access to mortgage debt simultaneously increase the pool of participants that demand assets, driving prices progressively higher. This virtuous cycle is mirrored by a similar decline in property prices and availability of credit on the way down. Conditions in credit markets and asset prices are thus difficult to separate.

14.3 Mortgage credit in Denmark

As mentioned above, the Danish mortgage lending market has also experienced a number of the innovations, and is a particularly interesting case due to a relatively unique approach to mortgage lending. The system is characterised by what is called the balance principle, which Laustsen (2009) describes as a traditional fund matching principle for mortgage lending. Denmark is unique in that this traditional principle has been respected for over 200 years. As noted by Laustsen (2009, pp. 1), it results in "Transparent pricing in the form of a direct transfer of market-based prices to the individual borrower and market-based prepayment terms. And to the issuer: Limited and transparent risks."[12] As noted by Haldrup (2017, pp. 2), a mortgage deed in Denmark is a "money-creating debt contract", but in Denmark, this is financed from the existing money stock[13].

[12]The mitigation of risk includes differences in term structure of assets and liabilities, refinancing risk, option risk across variations of bond type, liquidity risk, foreign exchange risk, and interest rate risk. The instruments issued include SDOs (særligt dækkede obligationer, covered bonds), SDROs (særligt dækkede realkreditobligationer, covered mortgage bonds) or ROs (traditionelle realkreditobligationer, traditional mortgage bonds). (Laustsen, 2009)

[13]Another important consideration is that mortgage bond financing is only available for a portion of the debt, depending on the nature of the property, and the nature of the purchase. See Falch et al. (2017) and Skinhøj et al. (2018) for a detailed description of the covered bond and covered mortgage bond market in Denmark. Further information is available on similar Nordic products in Holbek et al. (2017).

These stable mortgage lending and covered bond markets have, since 1996, experienced a number of product[14], operational[15] and legislative[16] innovations. The IMF (Sheehy, 2014) conducted an assessment of the risk related to the structure of mortgage debt in Denmark in 2014, and found that there was a strong shift after 2003 towards flexible rate mortgages. This strong shift was warned against, and the financial supervisory authority, in collaboration with banks, began to reduce the exposure of HH to flexible rate products. While the problem was recognised, the level of flexible rate mortgage bond exposure remains high, with roughly 70% of outstanding mortgage debt to be repriced within the next five years. As in most other countries, the rights and protections of the borrower have been enhanced by several additional legislative changes[17], several of which have been implemented in order to keep up with the rapid innovations in mortgage markets described above.

14.3.0.1 Composition of Danish mortgage debt

The composition of Danish real estate debt is rather complex to measure in its entirety, as there is a strong possibility that first-time home buyers will take an additional bank loan against their physical property for approximately 15% of the market value. In the data below, this portion of the debt is not included, and thus, the total debt outstanding represents a somewhat lower total than that official measures of total household debt used in the model that follows[18].

[14] 2003, loans with interest-only (IO) periods. 2004, loans with interest rate caps and adjustable rate mortgages (ARMs, or floating-to-fixed rate options). 2007, ratchet coupons.

[15] 2006 additional auctions in March and September. 2014, additional auction in June.

[16] English translations of financial regulation acts are available from https://www.dfsa.dk/en/Rules-and-Practice/Translated_regulations/Acts, however, there have been additional alterations since then. Legislation permitting multiple purpose use of mortgage debt against fixed property was introduced as early 1993.

[17] As noted by Laustsen (2009, pp. 12), these include 1.) EU Capital Requirements Directive (CRD) and the UCITS Directive together set out the EU's definition of covered bonds. EU Directive 2006/48/EC of 14 June 2006 relating to the taking up and pursuit of the business of credit institutions, and EU Directive 2006/49/EC of 14 June 2006 on the capital adequacy of investment firms and credit institutions (dubbed the Capital Requirement Directive – CRD). 2.) Executive Order no 718 of 21 June 2007 – Executive Order on bond issuance, balance principle and risk management. 3.) The par rule, applied from the final report of the committee on business and commerce of the Danish parliament prior to the adoption of the act in May 2007. Prepayment of loans funded by SDO issuance must "… take place on reasonable terms and according to a practice that does not deviate from the terms applicable to housing loans today. this means that prepayment may take place by way of a buyback of the underlying bonds or at a price that does not deviate significantly from par, in part out of consideration for ARMs-like products. If a loan is not linked to listed bonds, prepayment may take place at par." 4.) Act no 577 of 6 June 2007 – Act amending the Financial Business Act and various other acts (SDOs) – and pertaining explanatory notes and final report.

[18] The data used for the model is aggregate data sourced from Eurostat, and does not provide the level of granularity presented here. It does, however, separate long- and short-term debt, and the majority of bank loans for the purpose of property purchase are included in the long term category. These bank loans are also flexible-interest rate products, and could thus be included in the flexible portion of mortgage debts outstanding. Unfortunately we do not have data that makes it possible to identify this debt separately, and thus it is excluded in the present section.

The following data are constructed from administrative registers, which allows for a more granular view of recent developments than is typically available. The actual data are significantly more detailed than that presented here, but further disaggregation makes visual comparison difficult due to the relative (in)significance of some subcategories of debt. The two main dimensions on which we are interested in splitting mortgage debt are the term remaining on the debt and the length of time for which the interest rate is fixed (referred to as '*interest fixation*' below). The interest fixation for ARM products shortened dramatically leading up to 2007, but has lengthened somewhat since the crisis, Unfortunately, the detailed micro-data is only available after 2009, which means that details during the expansion of mortgage debt are not available.

At a national level, the total level of debt split by interest fixation, can be seen in Figure **??**. The first thing to note is that the nominal level of mortgage debt, in panel (a), has continued to rise throughout the period from 2009 through 2017.

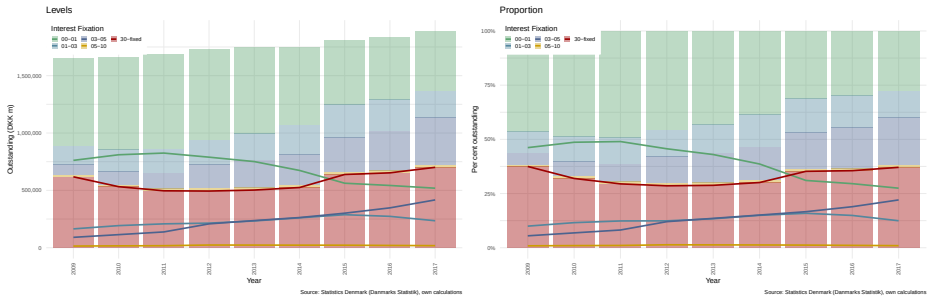


Figure 14.1: Mortgage debt in Denmark: All term lengths

This can also be considered in proportional terms, where the percentage of debt outstanding in each category is easier to read. As can be seen in Figure **??** part (b) above, the 30-fixed category, which covers all fixed rate products[19], was still in decline as a proportion of total outstanding mortgage debt from 2009 to 2012.

The most concerning factor, and one raised by Sheehy (2014), in an IMF stability report, was the growing proportion of debt that would reprice within relatively short intervals. At the start of 2011, debt with an interest fixation of less than and up to 1 year (the green line) was by far the largest contributor. This was recognised by both domestic and foreign prudential regulators as a risky development, and in collaboration with the banking sector and real estate finance companies a variety of measures were implemented to reverse this trajectory. (Sheehy, 2014)

[19] Due to the choice of data categorisation in the real-kredit register from Statistics Denmark, all contracts with fixed-interest are recorded as a 30 year fixation period.

These patterns can further be decomposed into a variety of term structures. As can be seen from Figure 14.2, the proportional composition of debt is significantly different for each of the term groupings[20]. We will not explore this too deeply, as the relative importance of each category varies dramatically.

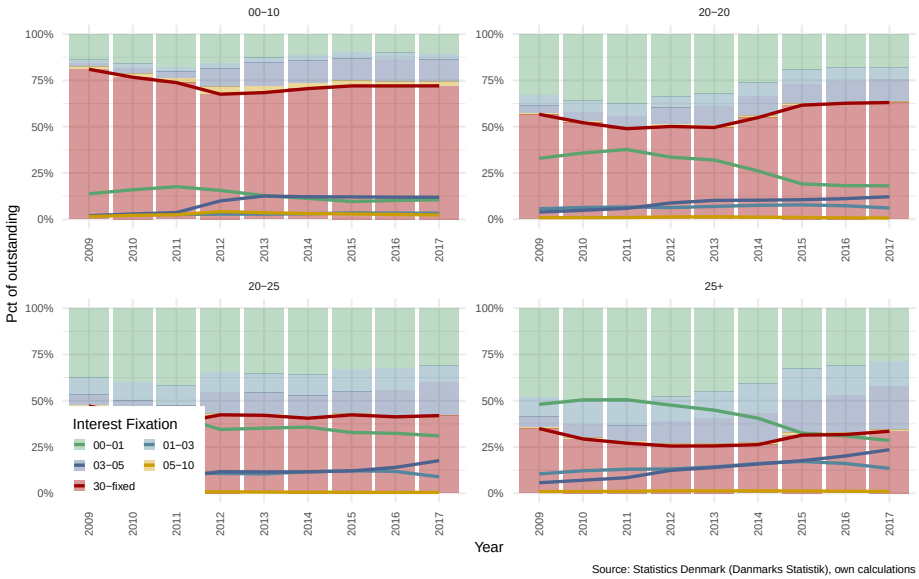


Figure 14.2: Composition of mortgage debt in Denmark: Split by term

Figure 14.3 illustrates the total outstanding debt in each of the term categories, it can quite easily be seen that by far the largest portion of debt has a term to maturity of over 25 years. In Denmark, the maximum term for which mortgage debt can be acquired is 30 years, thus all debt in this category in each year was issued under five years prior to the year in question. Roughly only one sixth of all outstanding mortgage debt has a term to maturity of less than 25 years.

Of the debt with greater than 25 years to maturity, it can be seen from Figure 14.2, that only approximately 30% of this outstanding debt has an interest fixation period of longer than 5 years. This together with approximately half of the other 15% results in a total of just over 37% of all outstanding mortgage bond debt. This means that the remaining 63% of mortgage debt will adjust together with interest rates. The outstanding mortgage bonds will also adjust in price, which effectively means that in the event of an increase in interest rates, nominal debt outstanding will remain fairly constant for the 63% that has flexible interest products, and debt service costs will rise commensurate with the rise in rates. The aggregate opportunity cost related to capital adjustments

[20]Debt is separated by term to maturity of between 0 and 10 years, from 10 to 20 years, from 20 to 25 years and those with a term greater than 25 years.

for borrowers in this case is potentially very large.

By 2017, the proportion of debt with an interest fixation period of 1 year or less had fallen to approximately 25% of all outstanding debt. A significant improvement from just under 50% for 2010 and 2011.

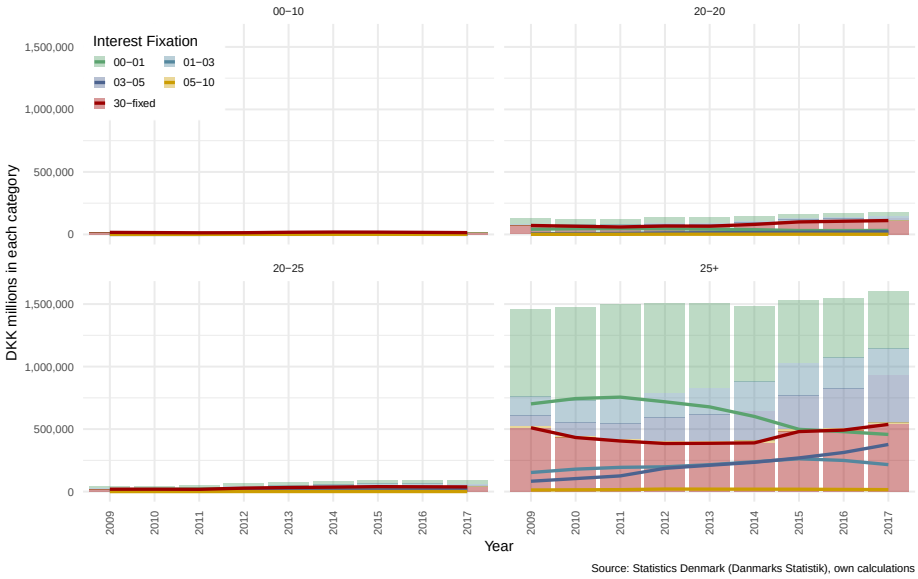


Figure 14.3: Levels of mortgage debt in Denmark: Split by term

Based on the distribution that can be seen in Figure 14.3 above, the remainder of the paper uses a much simpler term and interest fixation categorisation. In order to capture all long term debt, all outstanding debt with a term longer than 10 years is included in long term debt, while all shorter terms maturity are included in the short term category. Similarly, interest fixation periods of less than 10 years are included in the short fixation period category, of which the overwhelming majority is fixed for less than five years. All interest fixation periods of longer than 10 years are included in the fixed-interest category. Because the level of mortgage debt with a shorter term is so low (largely irrelevant), this additional categorisation is dropped. Any shorter term mortgage debt is also likely to have similar characteristics of longer term debt that has short interest fixation periods. As such, it is assumed that the only fixed interest debt held by HH is held in the form of mortgage debt. It is therefore possible to categorise all debt in terms of the "interest fixation" dimension.

This is supported by Figure 14.4, where the proportion of debt in the shorter term category is essentially negligible in comparison with the longer term outstanding portion.

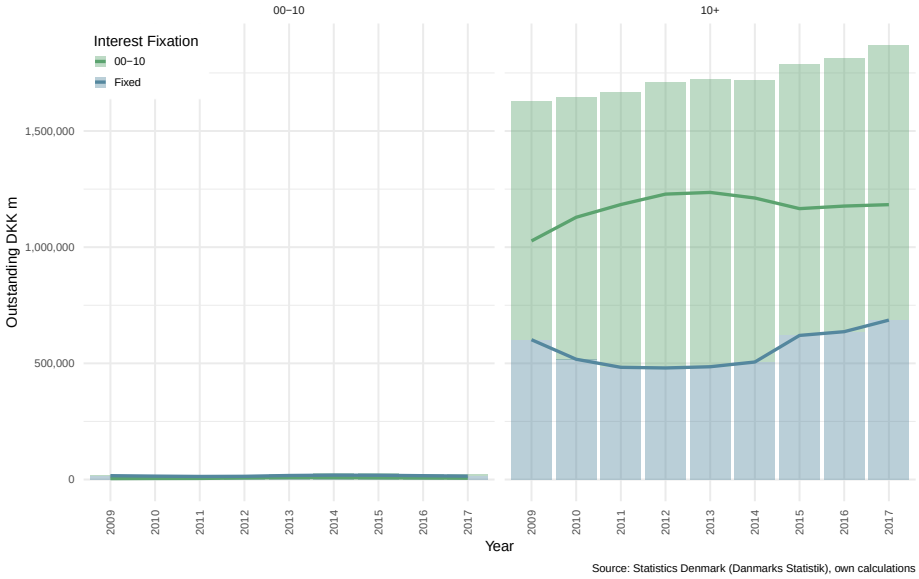


Figure 14.4: Composition of mortgage debt in Denmark: Simplified, panels by term

Figure 14.4 shows the nominal outstanding amounts in the short and long term to maturity categories. As can noted above, the short-term-to-maturity debt to the left is of negligible interest for the analysis that follows, and so most of the figures below focus purely on the long term-to-maturity (10+ category) to the right.

Figure 14.5, part (a), reflects the relative proportions of fixed and flexible-interest fixation periods in each interest fixation category. The debt with interest-fixation periods of less than 10 years will be referred to as adjustable rate mortgages (ARMs) or flexible-rate mortgages below.

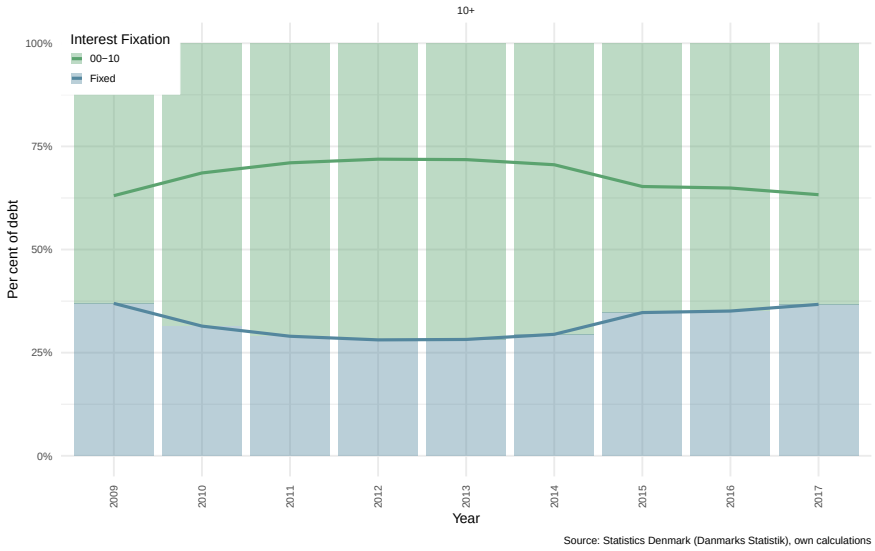


Figure 14.5: Outstanding mortgage debt and interest payments: Term of 10+ years

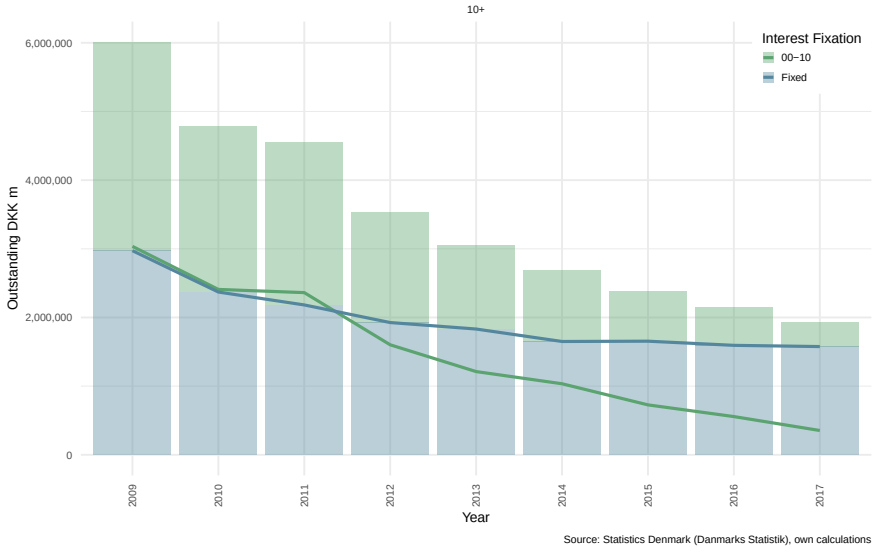


Figure 14.6: Interest payments

The cost of the outstanding debt has not followed the same pattern. Figure 14.5 part (b) above, shows that the total interest expenses paid on shorter ARM debt has declined in nominal terms from roughly equivalent to the fixed-interest debt

in 2011 to just a fraction of total interest paid on fixed-interest products by the end of 2017.

This can then be represented as an average rate of interest by calculating the amount paid divided by the total outstanding debt. In Figure 14.7, the short-term-to-maturity characteristics are shown on the left to illustrate the these products follow market rates more closely. Again, however, it is the panel to the right that we are most interested in, where it is possible to see that longer term ARM debt paid an average rate of just under 0.5%, while fixed rate longer term debt paid on average approximately 2.4% in 2017. The spread has interestingly remained relatively constant between the two average rates, but the proportional decline in the ARM average rate has been approximately -86%, while the same for fixed rate products has been approximately -50%. It appears, from this illustration, that a fall in official interest rates has passed through to mortgage markets at roughly the same speed in fixed and ARM products[21].

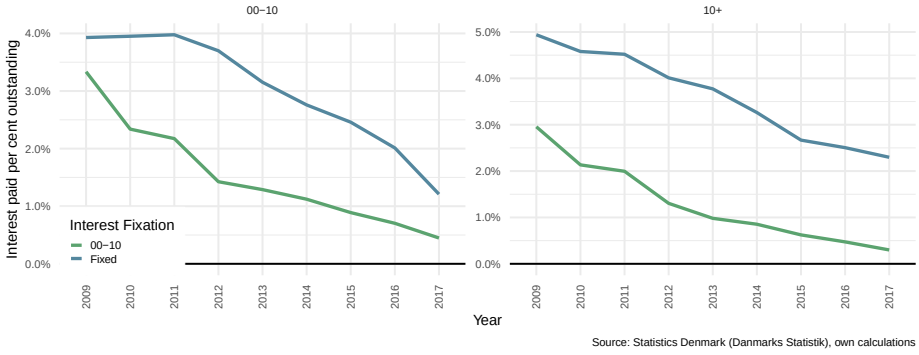


Figure 14.7: Interest paid per cent of mortgage debt outstanding: By term

As can be expected, in the Danish environment, as interest rates fall and the option to refinance remains available to households, the rate of interest on fixed-interest securities has followed the flexible rate of interest downwards - with a relatively constant spread of approximately 2% points. Unfortunately we do not have data on how this spread alters during a rising interest rate period. It can be seen that there was some delay in convergence in shorter terms to maturity. This is expected as the costs associated with refinancing existing contracts are likely to outweigh the benefits of a reduction in interest expense on smaller capital values, or on products with shorter terms to maturity (i.e. fewer interest payments remaining).

[21] Although it is beyond the scope of this study, a useful experiment would be to estimate the total expected effect on household equity positions for an increase in interest rates, taking refinancing opportunities into account. Unfortunately data is not available to simply measure this impact directly, but it could be accomplished with reasonable assumptions. Measuring interest payments relative to debt in isolation unfortunately cannot capture this effect.

In a rising rate environment borrowers again have the incentive to refinance in order to take advantage of falling bond prices, since in Denmark the borrower has the option to either pay back the cash capital value or to repurchase an equivalent bond to the one issued on the date of borrowing (otherwise known as a prepayment or buy-back option). If interest rates rise sufficiently to make it profitable, and if they have accumulated sufficient equity, the borrower has the opportunity to make a substantial reduction in the outstanding capital amount. Thus, unless rates remain unchanged, or only vary marginally, for an extended period of time, the proportion of outstanding debt that has been recently refinanced will typically be quite high[22].

14.3.0.2 Affordability of debt

The debt-service ratio (DSR) is shown in Figure 14.8, and calculated as the ratio between total outgoing property income payments to annual HH disposable income. In aggregate terms, it is unsurprising that the DSR has fallen continuously for the Danish household sector since the GFC. It is presently at the lowest level since 1995, and according to data collated by Abildgren (2017), the lowest level ever. Thus in relative terms, while debt may be at record high levels relative to income, the aggregate cost of servicing that debt is at an all time low.

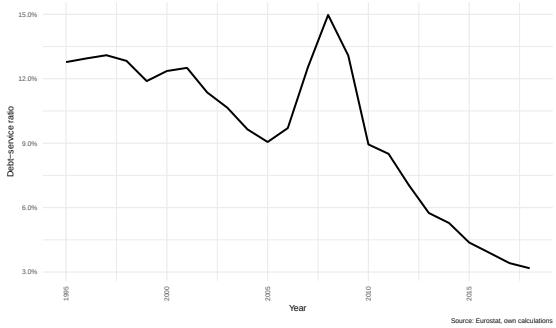


Figure 14.8: Debt-service ratio: Denmark

This paradox between the level of debt outstanding and the declining DSR is discussed in analysis in Section 14.6 The implications for the economy as a whole and for the household sector depend on the macroeconomic linkages between the sectors and the drivers of agent decision-making in the model structure.

[22]This is indeed the case at present, after interest rates declined gradually, but ultimately to a record low level in 2019. At the time of writing it is possible to borrow at a fixed rate for 30 years (the longest term to maturity available at present) of 0.5% p.a. against 80% of the market value of a primary residence. As can be seen from Figure 14.3 in the text above, approximately 85% of mortgage debt outstanding has more than 25 years remaining to maturity. In other words, 85% of all mortgage contracts in Denmark (by value) were issued inside of the previous 5 years.

14.4 The model

The model implemented in this section is based on Byrialsen and Raza (2019), which is at the time of writing the most advanced empirical Stock-Flow-Consistent (SFC) macroeconomic model of Denmark. The full model together with an explanation for each equation and the logical connections between each of the sectors, flows and stocks is provided in Section 14.10, in the appendix.

Throughout this section some of the equations and explanations thereof are duplicated for explanatory purposes. It will provide only a brief summary of the core features of the model, and the highlight the main changes made for this analysis.

The model consists of the five main institutional sectors, namely the household sector (HH) non-financial corporate sector (NFC), the financial corporate sector (FC), the general government (G), and the rest of the world (ROW). It was developed between 2017 and 2019 with a focus on the Danish HH. As such, the behaviours of all sectors are significantly simplified, except in so far as they engage directly with HH. The model is fully empirical, in the sense that all variables included in the model are available as a dataset, against which the performance of the model can be tested.

One feature is worth noting up front. As mentioned in the introduction, the full model has 131 endogenous and 78 exogenous variables. Included in the exogenous variables are all rates of return and all financial asset prices. The most important implication is that correlated asset price and market movements are not endogenous in the model, and this limits the analysis to very short-term model responses.

14.4.1 Data

The data used for the model in this article is sourced from a combination of Eurostat data, OECD data, and AMECO data. The period for which annual data is available in sufficient detail is from 1995 to 2017. This data is then processed in a series of aggregations. The data and the model accounting structures follow the ESA 2010 (Statistical Office of the European Communities., 2013) accounting structure, and the contents of the financial balance sheet can be summarised as:

Monetary gold and special drawing rights (F1), Currency and deposits (F2), Debt securities (F3), Loans (F4), Equity and investment fund shares (F5), Insurance, pensions and standardized guarantee schemes (F6), Financial derivatives and employees stock options (F7) and Other accounts (F8). These data are aggregated according to Table 14.1.

The financial markets are thus highly aggregated in the model with effectively only three asset classes. IB covers all securities that provide a financial return that is analogous to interest, as does NIB. The only difference is that for NFC,

Table 14.1: Aggregation of ESA balance sheet categories

Assets	Eurostat Code (ESA 2010)
Interest bearing (IB)	F_1, F_2, F_3, F_4, F_7 or F_8
Net interest bearing (NIB)	F_1, F_2, F_3, F_4, F_7 or F_8
Net equities (NEQ)	F_5
Pension (PEN)	F_6

GOV and ROW, as part of the aggregation process, only the net position in these assets and liabilities are considered.

The other two major asset classes are equities and pension funds. All except HH equities are expressed as net equity assets and liabilities, NEQ, and for HH they are expressed as equity assets, EQA, as they cannot issue equity liabilities by definition. Pension assets are expressed as PEN, and are recorded as net pension assets ($NPEN$) for ROW.

14.4.2 Major changes

The most significant change in this version of the model is the introduction of a split between fixed and flexible rate mortgage debt. This relatively simple alteration allows one to test the sensitivity of HH balance sheets to a change in debt composition. The drivers of debt remain the same, and the rates of return on all other assets have been left unchanged.

This is to isolate the channel through which the change in the cost of borrowing affects households in the short term. This makes it possible to identify the transmission channels and magnitude of each shock more clearly. It is one of the advantages of fully exogenous rates of return and asset prices, but comes at the cost of more realistic inter-market ("pass-through") responses.

14.4.3 Balance sheet and transactions flow matrices

As with all SFC models, the balance sheet matrix represents the distribution of ownership of assets (+) and liabilities (−) in the modelled economy. As can be seen from Table 14.2, the sum of all rows, with the exception of fixed capital, are zero. This reflects that each asset (except fixed assets, K) is exactly offset by a liability held by another sector.

The financial asset classes mentioned above are assigned to each sector according to assumptions of which sector issues or holds each type of security. FC holds the majority of counterpart financial securities, and in all sectors except HH, financial assets and liabilities are recorded in net terms (assets minus liabilities).

The interest bearing liabilities of HH are, as noted in the previous section, by a vast majority, long term debt. This is separated into fixed-interest ($IBL(FI)^F$) and flexible-interest ($IBL(FL)^F$) (or, ARM) mortgage liabilities.

Table 14.2: Balance sheet matrix: BSM

Stocks	NFC	FC		GOV	HH		RC
		Assets	Liabilities		Assets	Liabilities	
Interest bearing (IBA / IBL)			$-IBL^F$		$+IBA^H$		
Financial Stocks							
Interest bearing Fixed		$+IBA(FI)^F$				$-IBL(FI)^H$	
Interest bearing Flexible		$+IBA(FL)^F$				$-IBL(FL)^H$	
Net interest bearing (NIB)	NIB^N	NIB^F		NIB^G			NI
Net equities (NEQ)	NEQ^N	NEQ^F			NEQ^H		NE
Pensions (PEN)			$-PEN^F$		$+PEN^H$		NPI
Financial net wealth (FNW)	FNW^N	FNW^F		FNW^G	FNW^H		FN
Fixed Stocks							
Fixed assets (K)	K^N	K^F		K^G	K^H		

Horizontal consistency captures the idea that all accounts are recorded as dual entry accounting records, and the sum of all sector positions in any financial asset class should be zero. Vertical consistency represents the financial position of each sector, where financial net wealth (FNW) is the sum of all assets and liabilities and will either be a net positive or negative value. The sum across sectors of the FNW of all sectors is also zero.

The transactions flow matrix is presented below. This matrix, much like the balance sheet matrix presented above, observes the requirements of horizontal and vertical consistency. In this table, all items that result in a positive flow of funds for the sector in question are marked with a plus sign (+), and all those that result in a flow outwards of funds are marked with a minus sign (−).

The expenditure approach to GDP is captured in the first five lines of the table, and can be captured as,

$$Y = C + I + G + (X - M) \tag{14.1}$$

Where C is consumption, I is investment, G is government expenditure, X is exports and M is imports. All in nominal terms to reflect the actual flows of funds in each period. The income approach to national expenditure is captured in the following six lines in the table up until the row called *Savings*. Each row name reflects the flow that is applicable to each sector. The full detail of how these flows are defined can be found in the full model description in Section 14.10, in the appendix.

Capital income (rK), transfers (STR), capital transfers (KTR), acquisitions less disposal of fixed assets (NP) and net lending (NL) are presented without a particular sign attached to each sector. The reason for which is that each sector both receives and pays social transfers, and although GOV is the primary

Table 14.3: Transactions flow matrix: TFM

Flows	NFC		FC		
	Current	Capital	Current	Capital	Curr
Private consumption	$+C$				
Government consumption	$+G$				$-C
Investment	$+I$	$-I^{N}$		$-I^{F}$	
Exports	$+X$				
Imports	$-M$				
\midrule GDP	Y				
\midrule Taxes	$-T^{N}$		$-T^{F}$		$+T^
Gross operating surplus	$-B2^{N}$		$+B2^{F}$		$+B2^
Wages	$-WB^{N}$				
Capital income	rK^{N}		rK^{F}		$rK^
Transfers	STR^{N}		STR^{F}		$STR^
Pension adjustments			$-CPEN^{F}$		
\midrule Savings (per sector)	$-S{N}$	$+S{N}$	$-S{F}$	$+S{F}$	$-S{
\midrule Capital transfers		KTR^{N}		KTR^{F}	
Acquisitions less disposal FA		NP^{N}		NP^{F}	
Net lending		NL^{N}		NL^{F}	
\midrule Σ	0	0	0	0	0

counterpart for all of these, the size and net sign of these transfers can change over time. The same is true for KTR and NP. Net lending (NL) is a passive (residual) value and is determined by the balance of funding requirements between the sectors over time, and can therefore also swing between negative or positive as a flow.

The three rows after the *Savings* row illustrate adjustments to the level of savings (S) as a result of capital transfers (KTR), purchase and sale of fixed assets (NP) and (from the third row of the table) the level of investment (I) of each sector - summed vertically in the *capital* accounts column for each sector. The sum of all of these items is reflected in a net financing requirement for each sector, in the table is called *Net lending*. The sum of all net lending positions in the economy is again necessarily equal to zero, as one sector's surplus is at least one other sector's deficit. The sum of all columns and all rows are thus all equal to zero, and this criterion is respected by the data collected from Eurostat on an annual basis.

Financial and fixed assets in the model are subject to both transactions and revaluations (or capital gains or losses). The accumulation of certain types of assets or liabilities depends in part on the action of the sector in question and in part on the effects of the other sectors. As can be read in the full model description in the appendix, the nominal values that are sourced from the Eurostat database and or AMECO can then be deflated using appropriate price

indices. There are 19 different price indices used in the model, some of which are calculated, but the majority of which are sourced either from Statistics Denmark, AMECO or the OECD. The details of the model structure and the performance of the model relative to the data available can be found in Byrialsen and Raza (2019), and the details of the behavioural equations available in Section 14.10, in the appendix.

What we are most interested in here, however, is the specific channels through which the scenarios proposed below transmit. As mentioned above, the model contains active behaviours and passive behaviours. In each period, in order to ensure closure in the model, there is one variable in each sector that is passive to the budget constraints of each year.

The passive accumulator flows (or residual, buffer variables) for each sector are as follows: transactions in net interest bearing securities for NFC ($NIBTR_t^N$), GOV ($NIBTR_t^G$), and ROW ($NIBTR_t^W$);and, transactions in interest bearing assets for HH ($IBATR_t^H$). While specific behavioural equations determine the holding of all other financial assets, NIB securities act as a catch all category for NFC, GOV and ROW. The sum of those positions is then absorbed by FC. As will be discussed below, the final closure of the model is provided through the indirect provision of equity assets to HH by FC on demand. This is fitting, since HH purchases of mutual funds or unit trusts are likely to be fulfilled by FC, rather than directly by NFC.

14.5 Scenarios

This section briefly explains the four scenarios investigated using the model. Apart from alterations to the structure of household mortgage liabilities, the model operates in the same manner as in Byrialsen and Raza (2019). The shocks presented below are measured as a percentage change from the baseline scenario. This allows for a simpler comparison between scenarios, and the aggregate nominal and real values of stocks and flows are illustrated where relevant.

The first shock (and Scenario 1) is an increase in interest rates in 2020, the second shock (and Scenario 2) is a decline in property prices in 2022. Scenario 3 compounds the first two, in that the first shock is kept in the model before the shock to property prices is imposed. The last scenario, Scenario 4, is a reduction in the level of ARMs in 2017. Effectively, the last scenario changes the pre-conditions for the first two shocks, but applies them in exactly the same manner. It is therefore possible to make a direct comparison between Scenario 3 and Scenario 4, given two different starting points.

This ordering allows the answer to a counter-factual question: What if HH had not taken on as much flexible rate mortgage debt? How would this shift in interest rate exposure affect outcomes, both for HH and the broader economy? In essence, what might have been the case if the innovations leading up to 2003 had not impacted borrowing decisions to the same degree? There are however,

some limitations to the current model that are relevant for this exercise.

14.5.1 Limitations for interpretation of results

Adjustable Rate Mortgages (ARMs) typically do not adjust immediately

As noted above, the bulk of ARMs in Denmark adjust fewer than 5 years into the future. This allows households an extended period of time to observe interest rate fluctuations and make a decision regarding refinancing or property sale. It also means that the effects of an interest rate change will only impact HH cash flows after between one and five years.

A decline in house prices is unlikely to happen in isolation

A fall in house prices is not expected to occur in isolation. Unlike in the model below, a collapse in property prices is unlikely to be an isolated event. It would more likely accompany broader systemic problems or be triggered by some form of financial or economic crisis.

The structure of the economy at end 2017 is integrated with the volume and structure of household debt

For the fourth scenario, it is assumed that we can simply shift the structure of debt and leave the remainder of the economy unchanged. In reality, the total level of debt outstanding would probably be significantly lower if ARM and interest-only products had not been made available. This would have affected a significant array of economic variables, not least of all, domestic demand and house prices. Although this is true, HH have already accumulated significant levels of debt. As such, Scenario 4 is less a question of, what if things had been different, and more a question of how to structure policy in order to best influence future refinancing decisions of HH.

Interest rate changes would change the composition of debt

Refinancing in response to interest rate changes in Denmark is extensive. In a rising interest rate environment, the incentive is to repurchase the previously issued bond at a reduced price, settle the older debt, and then refinance at similar monthly instalments, but with a lower capital value outstanding.

With falling interest rates, the incentive is to refinance at lower monthly instalments, and if possible using a bond with fixed-interest, thus creating the opportunity to refinance if rates rise significantly in the future, and thus reduce the level of debt outstanding. It is therefore unlikely that the structure of debt would remain constant after a shift in rates[23]. Due to the costs involved in

[23]Micro-level contractual data is presently only available from 2009 onwards, thus at an individual level, there is no data that can be used to model household behaviour in response to an increase in interest rates. If the home owner intends to sell their property inside of 5 years, interest rates must fall dramatically for it to be financially beneficial to refinance due to the costs involved. In a rising interest rate environment, a fixed-interest bond holder that sells their property will always be able to benefit from capital losses on their outstanding bond, but might face difficulties in selling their property as demand is expected to be suppressed

refinancing, a change in interest rates is expected impact debt structures gradually, remaining fairly stable for the first year or two, and adjusting to a greater degree in the medium term (approximately up to 5 years).

14.5.2 Scenario 1 - An increase in interest rates

The first shock is a simple interest rate change. The point is to illustrate the expected impact on the level of household disposable income and the household balance sheet.

In this shock we consider a 2 percentage point (2% points) rise in official rates. This is assumed to be passed through perfectly to ARM mortgages (interest rate on flexible-interest-rate mortgage debt, i.e. flexible rate products, with subscript (FL), ($r^H_{L(FL)_t}$). The cost of fixed-interest mortgage debt ($r^H_{L(FI)_t}$) is increased by a proportionally lower adjustment of point five percentage points (0.5% points) to reflect lower sensitivity of adjustments of the overall stock of fixedinterest rate products. This is a strong assumption, and is not likely to hold over longer periods of time, fixed-interest rate debt holders are expected to retain their debt at lower interest rates, while the majority of flexible-interest rate holders are expected to participate fully in the rise in interest rates after a period of three years[24].

In the model baseline, the current rate is calculated as interest payments relative to outstanding debts. This gives a weighted average at the end of 2017 of 1.41% for all debts[25]. After the shock, the adjustment is from this average rate upwards - thus flexible-interest rates are adjusted up to 2.41% and fixed-interest rates up to 1.91%. This constitutes a 141.75 per cent increase in flexible rates, and taking into account changes in the level of outstanding debt in 2021, a 136.29% increase in interest payments. For fixed-interest debt, it constitutes a 35.44 per cent increase in fixed rates, and a 32.38% increase in interest payments.

The interest rates in the model include, interest on fixed ($r^H_{L(FI)}$) and flexible rate ($r^H_{L(FL)}$) mortgages, and the counterpart assets ($r^F_{A(FI)}$, $r^F_{A(FL)}$), the general rate

due to higher borrowing costs. In the same situation, a fixed rate borrower will again need quite significant changes in the level of interest rates for a prepayment or buy-back operation to be profitable in under 5 years.

[24]These time periods are purely for illustrative purposes, since, as mentioned just above, the Danish market is expected to have extensive refinancing as rates shift. This is however expected to be somewhat muted by the expectation that the demand for new debt, and therefore the demand for houses are expected to fall - potentially leading to a fall in house prices, or at the very least, slower capital gains. Selling conditions are generally expected to be worse in a higher interest rate environment, where the rise in the cost of house purchase will naturally exclude a large number of potential buyers.

[25]As noted earlier, interest rates are currently at historically low levels. The actual average rates of interest paid on flexible and fixed-interest mortgage products were 0.29% and 2.29% per annum at the close of 2017. These values, however exclude a variety of debt types such as bank debt, vehicle finance and consumer credit. The use of the average payment on all debt types is a simplification that is made to suit the aggregation of data, and the reader should be aware that this does not take into account the multitude of behavioural incentives that apply to each underlying debt type.

of return on net interest bearing assets (r_N), and the return on interest bearing assets for households (r_A^H). The other rates of return are the domestic and foreign rate of return on equities (χ_t), and pension assets (ψ_t). All rates of return in the model are determined exogenously, which means that any adjustment must be applied manually. As noted above, the change is limited to the cost of borrowing for HH only.

In the case of household debt, it is FC that holds the counter-balance assets. Thus,

$$r^F_{A(FI)_t} = r^H_{L(FI)_t}$$

and,

$$r^F_{A(FL)_t} = r^H_{L(FL)_t}$$

FC receives $r^F_{A(FI)_{t-1}}(IBA^{F\sim H}_{A(FI)_{t-1}})$, and the two interest rates are simply made equivalent. An increase in rates results in an increase in costs for HH and an increase in revenues for FC.

Figure 14.9 illustrates, in part (a) the actual monthly interest rates available for new debt on Danish mortgage markets since 2013 (separated by term of interest fixation). Part (b) shows the progression of official interest rates in Denmark since 2000, where the "Mortgage bond" rate is the dark-red line, and is comparable with *Fixed* mortgage bonds in panel (a), the purple line, from 2013 onwards. Part (c) illustrates the impact of the shock to interest rates in the model in 2020.

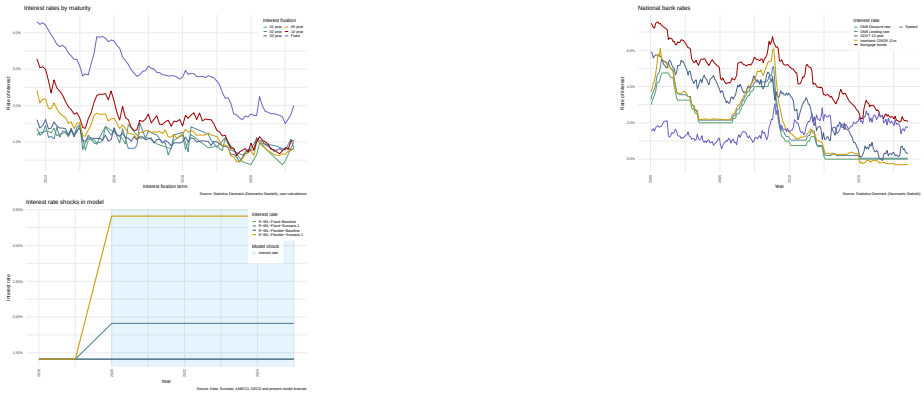


Figure 14.9: Interest rates in Denmark

As can be seen from part (a), the rates available to fixed rate borrowers have followed market rates downwards throughout the period, although this illustrates only those rates available, rather than those paid. Figure 14.7 showing the amounts actually paid in the section above, however, illustrates that the

amount paid has also declined at a similar pace, although with a marginal delay.

The interest rates in the model are split into fixed and flexible rates for the purpose of testing the effects of a shock to interest rate on alternative compositions of mortgage debt. The baseline value of interest rates remains just below 1.5% on average for all debt.

The expected outcome is that where the proportion of fixed-interest outstanding debt is higher, the effects of a shock will be weaker, and vice versa. This of course can only have an impact in the case where mortgage debt is itself split into fixed- and flexible-rate debt.

The total level of outstanding IBL for HH is split into fixed-interest (IBL_{FI}) and flexible-interest bearing liabilities (IBL_{FL}). The proportion of interest bearing assets held as IBL_{FI} is α.

$$IBL^{H}_{FI_t} = \alpha(IBL^{H}_{t}) \tag{14.2}$$

and thus,

$$IBL^{H}_{FL_t} = (1-\alpha)(IBL^{H}_{t}) \tag{14.3}$$

The level of α is calculated from data acquired from multiple data sources at Statistics Denmark, and varies over time. The split was first introduced in 1996, but initial volumes were low. As discussed in Section 14.3, while the composition of this debt is significantly more complex than this, a strong argument can be made for an aggregation up to just these two categories. This split has no effect on the model prior to the shock in 2020, as the rate of interest on each is considered to be equal to the average rate used in the baseline scenario up to that point.

It is also possible to shock all other rates of return to a similar degree. Given the integration of financial markets, this would produce results in the model that are more realistic. Unfortunately, it would also conceal the effects that are purely due to dynamics linked to the interest cost of borrowing for households[26].

14.5.3 Scenario 2 - A fall in house prices

The second scenario is a fall in house prices. This is effected through a negative twenty per cent adjustment to the house price index (-20%). This is a large change to house prices, but is equivalent to the stress test applied by the

[26]Several alternative formulations of the shock were tested, but the inclusion of changes to other rates of return require a number of additional assumptions. For example, an increase in domestic bond rates are only likely in Denmark if European interest rates also rise. Also, the speed and proportion to which rates pass through from official rates to each market are likely to differ across products, but also over time.

IMF (Sheehy, 2014). At a national level, Figure 14.10 illustrates that the average nominal house price index (HPI) for dwellings in Denmark has risen at a relatively steady pace since the GFC.

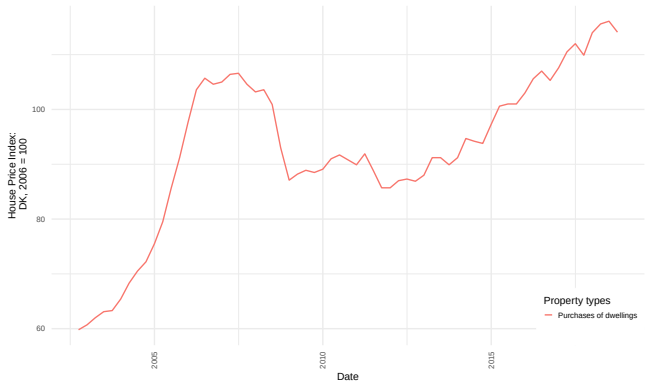


Figure 14.10: National House price index (HPI), 2006 = 100

This follows a collapse of house prices during the GFC, where prices of Danish dwellings fell approximately 20% from the peak in 2006 to the trough in 2011. This average was not uniform across property types or regions. As shown in Figure 14.11, the prices of owner occupied flats in the Capital and North Denmark Regions have risen at roughly the same pace as prior to the GFC. This is not predictive of a correction or price collapse, but does suggest a possible housing price bubble in those markets. All other regions, appear to have only just recovered to pre-crisis prices[27].

[27]The capital region holds a disproportionately large share of real estate assets by value, and thus the impact of property prices there carry a greater weight for an average for the country as a whole.

Figure 14.11: House price index (HPI), 2006 = 100

A more serious concern for potential borrowers is that several markets, particularly those for weekend cottages (otherwise known as summer houses) have not recovered in the period following the GFC. Thus, any property purchased between 2005 and the collapse in 2007 would have a high probability of falling into negative equity[28].

In this model, households are only permitted to make productive investment in housing, which, as in Zezza (2008), Fontana and Godin (2013) and Beckta (2015), is considered only as a primary market. The major difference here is that households are assumed to produce the houses, whereas firms are housing producers for all three of the above-mentioned studies. The secondary market for houses is assumed to affect prices, but not the demand for additional housing investment. Demand for housing investment is determined by by a Tobin's-Q-like function, partially driven by changes in disposable income and previous period housing investment, and partially driven by a relative shift in sales price (P^H_{t-i}) and construction cost (P^i_{t-i}) indices.

Real investment in fixed assets (dwellings), in Equation 14.4, is estimated as a log-linear function that depends on conditions in previous periods. This assumes that the decision to invest in houses occurs based on recent developments, but that actual changes in investment in fixed assets takes some time to materialise. It thus takes one period before the effects of the house price shock can be observed.

[28] Although the risk that the LTV ratio rises above 1 is lower for cottages, since the cap on bond financing has until very recently been significantly lower than for primary residences (60% as opposed to 80%).

$$ln(i_t^H) = \beta_i + \beta_i ln(i_{t-i}^H) + \beta_i ln\left(\frac{P_{t-i}^H}{P_{t-i}^i}\right) + \beta_i ln(yd_{t-i}^H) \tag{14.4}$$

The shock imposed on the model is to the numerator of the Tobin's Q ratio[29]. The imposed decline in house prices affects sales prices negatively, relative to the cost of production, and thus has a contractionary effect on the Tobin's q ratio, $\left(\frac{P_{t-i}^H}{P_{t-i}^i}\right)$, and thus on HH real investment (i_t^H). The shock is implemented as a permanent decline in prices, and thus changes the value of the ratio for all periods following the shock. Growth in house prices continues according to the same trajectory as in the baseline in order to make for a more effective comparison.

The nominal level of investment in housing can be calculated by inflating the real investment in housing series (i_t^H) by the investment price index (P_t^i, which is sourced from Statistics Denmark):

$$I_t^H = i_t^H(P_t^i) \tag{14.5}$$

The nominal stock of housing (K^H), as with other assets to come, follows the simple process of previous stock (K_{t-1}^H), plus acquisition (in this case investment in new houses), less depreciation (D_t^H) plus capital gains ($K_{CG_t}^H$).

$$K_t^H = K_{t-1}^H + I_t^H - D_t^H + K_{CG_t}^H \tag{14.6}$$

Capital gains on houses, in turn, can be calculated in an *ex post* manner as:

$$K_{CG}^H = \Delta P_t^H(K_{t-1}^H) \tag{14.7}$$

Which is simply the change in the price of houses applied to the level of stock at the end of the preceding period.

The change in house prices (ΔP_t^H) leading into the current period is then by definition the same ratio proportion of capital gains to previous housing capital.

$$\Delta P_t^H = \frac{KH_{CG}}{K_{t-1}^H} \tag{14.8}$$

[29] In the present structure of the model, investment is regressed against real investment of the previous period i_{t-1}^H; real disposable income y_d^H, and the same at $t-2$ ($y_{d_{t-2}}^H$); the Tobin's Q ratio at level terms $\left(\frac{P_t^H}{P_t^i}\right)$, and with a one period lag $\left(\frac{P_{t-1}^H}{P_{t-1}^i}\right)$; a constant; and, a trend component.

Nominal housing capital held by HH at the end of the current period can be expressed as the price adjusted stock at the end of the previous period, plus net investment and depreciation. Equation 14.9 is effectively a restatement of Equation 14.6, but with greater emphasis on the variable shocked in the analysis.

$$K_t^H = K_{t-1}^H(1 + \Delta P_t^H) + I_t^H - D_t^H \tag{14.9}$$

The deflated real capital index can then be found, as in Equation (14.10) by dividing the series by the investment (housing) price index, from Equation (14.8).

$$k_t^H = \frac{K_t^H}{P_t^i} \tag{14.10}$$

Housing capital then forms part of HH net wealth, which feeds back into consumption decisions in subsequent periods. A decline in net wealth in period t leads to a decline in consumption in period $t + 1$.

The effects of changes in net wealth (NW), are then felt directly in the level of HH consumption, but with a lag on one period (as can be seen in Equation (14.58) in the appendix). Although a fall in house prices does not affect household disposable income to a substantial degree is contributes to a decline in overall economic activity, and therefore reduces the demand for labour in subsequent periods. This ultimately does affect household income but the effect is not as immediate as was the case for the interest-rate shock.

14.5.4 Scenario 3 - Combination of Scenarios 1 and 2

The third scenario consecutively applies the shocks from Scenarios 1 and 2. First the interest rate increase in 2020, and then the decline in property prices in 2022. This combination sets up the comparison to be introduced in Scenario 4 below.

14.5.5 Scenario 4 - Comparison for Scenario 3, proportion of fixed-interest debt 80%

The final alteration to the model is an increase in the proportion of mortgage debt held as fixed debt (α) from the 2016 level of 33.42% up to 80% in 2017. This shift allows us to test the hypothetical difference of the impact of a shock to interest rates in an artificial scenario, where the proportion of flexible debt amounts to only 20% of outstanding household mortgage liabilities.

14.6 Simulations

This section explains the transmission of the two shocks in the scenarios described above. First, the components of the economy that are most dramatically

affected are identified, and thereafter the key transmission channels that cause these effects are briefly discussed.

The key take-aways from this section are that shock 1 and 2 both propagate through the economy as described above, and that Scenario 3 results in greater volatility in the responses of the economy than Scenario 4. This has implications for the stability of the balance sheets of each sector and for the economy as a whole.

The effects of each shock are summarised in tables in Section 14.9.4 for each of the above-mentioned scenarios[30]. This approach allows a quick summary of the impacts of a shock. It shows all affected variables, and thus provides a snapshot of how broadly the shock propagates. One drawback is that it is a cross section in time, and thus is not able to show the progression of feedback effects over time. These tables are both used as a guide to the most important transmissions, and as a consistency check, to ensure that the model behaves within reason.

The model responds largely as expected to the first shock, with the exception of the rather extreme response of the financial sector. This is because FC transactions in net interest bearing assets ($NIBTR^F$) absorbs all financial transactions of the other sectors - or, stated differently, accumulates all financial imbalances. The second shock, to property prices, has a more interesting result with regard HH savings and will be discussed in more detail in the HH section below.

As noted above, each of the sectors has a buffer flow that summarises the collective effect of each shock, and each of the shocks are quite extreme in nature. It is therefore unsurprising that the effect on the passive elements is somewhat exaggerated. Even though shocks of the same magnitude have occurred in the past, they are not common events and have only been used here to enhance the potential risks associated with the different debt structures.

14.6.1 General economy

The first shock (to interest rates) has a delayed effect that is first visible in the shift from period 2020 to period 2021; as can be seen for Scenarios 1, 3 and 4. The second shock (to property prices) takes effect immediately in 2022, and can therefore be seen to take effect from period 2021 to period 2022 for Scenarios 2, 3 and 4. At a broader economic level, the strongest impact on the major components of GDP from the first shock are a decline in gross fixed capital formation (I) of -1.25% and in imports (M) of -1.22% (and as a result, net exports rise by just over 10.52%). Figure **??** shows how C, I, G, X and M

[30] Those tables are organised, firstly, according to whether the affected variable is a stock, flow, parameter, rate, or index of some kind; and secondly, in order of largest variation from the baseline scenario (as a proportion of the baseline). Transactions in and revaluations in stocks, which occur on an annual basis, are considered flow variables. To capture accumulation effects, tables are provided at the end of period 2021 ($t+1$) for Scenarios 1 and at the end of periods 2022 (t) and 2025 ($t+3$) for Scenarios 2, 3 and 4.

would evolve relative to the baseline, for scenarios 1 and 2, and Figure **??** that shows the same for Scenarios 3 and 4.

The shock to interest rates only impacts the model at $t + 1$ and so there is no change from the baseline in year 2020, whereas the impact of a property price shock takes immediate effect in 2022. Exports remain relatively unchanged under both shocks, only marginally affected due to a shift in domestic prices. Y, or GDP, is more affected by the shock to interest rates in Scenario 1 than by property prices in Scenario 2, largely as a result of the limited impact of the property price shock on C and M. The rapid rise in interest costs clearly result in a decline in all demand components except for G, which is exogenous and therefore remains completely unchanged in all scenarios.

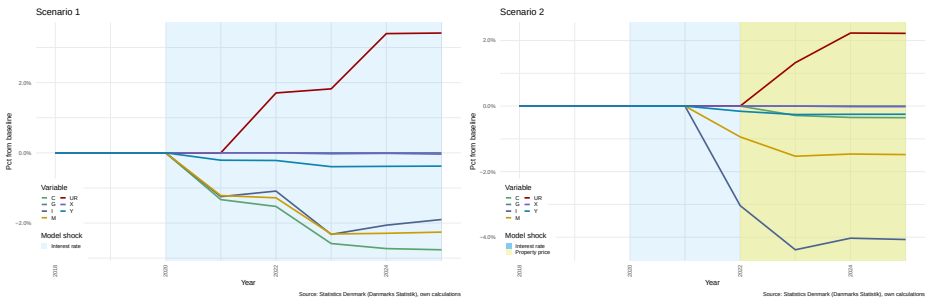


Figure 14.12: National income indicators - Scenarios 1 and 2

As described above, Scenarios 3 and 4 illustrate the compound effect of the two shocks under two different household debt positions. In Scenarios 1 to 3, proportion of fixed-interest debt (α) is 38.91%, in Scenario 4, α is set to 80%. The primary impact of this shift is a reduction in the sensitivity of household disposable income to a dramatic rise in interest rates.

As expected, the effects of the combination of the two shocks are significantly dampened when α is higher. This is clear from the scales in Figure **??**, where on the left for Scenario 3, investment drops just below -6% compared with -5.5% on the right for Scenario 4. This pattern repeats itself throughout this results section.

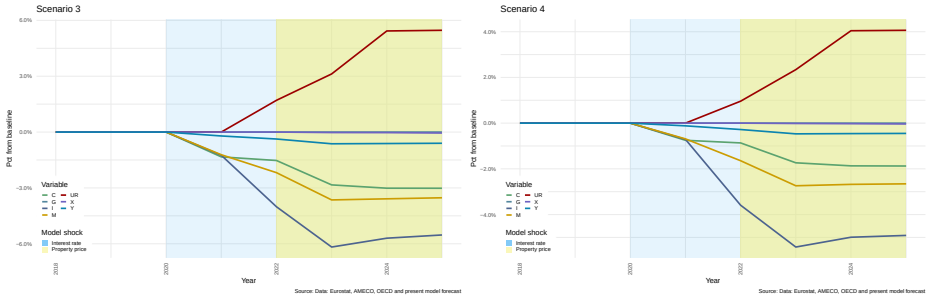


Figure 14.13: National income indicators - Scenarios 3 and 4

GDP is also somewhat better protected from the shock in the latter case. The unemployment rate (UR) increase is a compound effect of the two shocks, and is also significantly higher in Scenario 3 than in Scenario 4. The number of persons employed are determined by the NFC, and is a function of the level of Y in the previous period and changes in the size of the labour force. Exogenous growth in the size of the labour force combined with a decline in economic activity, drive the proportion of unemployed persons upwards. This also results in a rise in the level of social benefits drawn by HH from GOV, but this will be discussed in the sections for each sector below.

In many of the charts that follow, all scenarios are displayed for each of the variables. This allows for a comparison of the impact of the shocks. The baseline scenario is illustrated by a solid black line, Scenario 1 by a light-grey, dashed line. Scenario 2 by a medium-dark-grey, dashed line. Scenario 3 by the dark-grey short-dashed line and Scenario 4 by the red short-dashed line.

For each sector we will highlight the components that move most dramatically for shocks 1 and 2, and thereafter will focus on the comparative difference of these effects in Scenarios 3 and 4. This highlights the major transmissions for each shock in each sector. It also allows us to compare the impact of a hypothetical change in the allocation of debt between fixed- and flexible-interest rate products. Essentially we are able to show the impact of financial innovations, within the bounds of the assumptions discussed above.

A summary of the impact of the shocks, as captured by the net financing requirements (Net lending, NL) of each sector for each year following the shocks, can be seen in Figure 14.14.

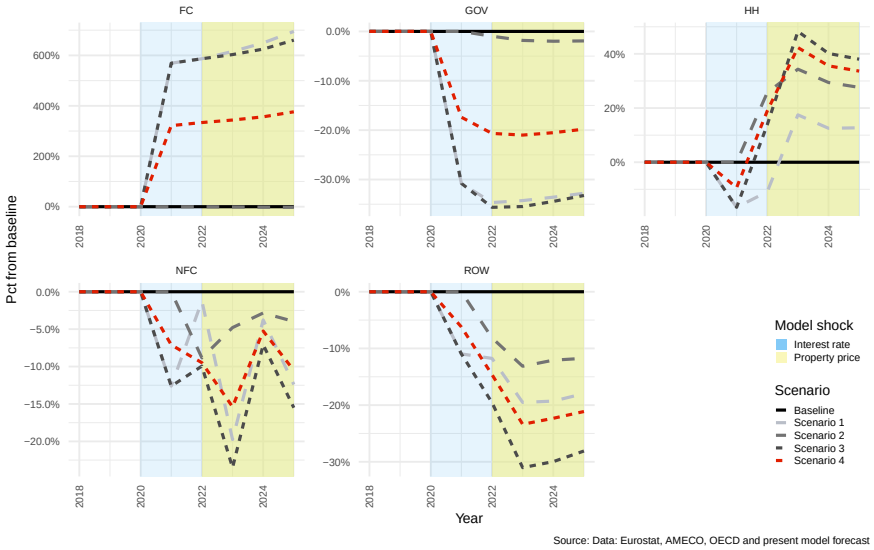


Figure 14.14: Net lending

Base purely on NL, as shown in Figure 14.14, it would appear that HH are net borrowers (have negative NL) as a result of the interest rate rise, as might be expected, but rather counter-intuitively[31] move into a strong net lending position following the property price collapse in 2022. ROW moves into positive NL in all scenarios, as does FC, with the exception of Scenario 2, which leaves FC NL unchanged. The scale of the changes in FC's NL are a cause for concern, and will be addressed in the FC section below. NFC and GOV move into negative NL in all circumstances, but NFC has much more erratic movements.

For all sectors, Scenario 4 is again similar to Scenario 3, but with significantly less dramatic effects. The next section will help to highlight a problem with a focus purely on NL. In summary, such a focus may not be indicative of the actual economic consequences of these shocks for each sector.

For each sector the analysis includes a brief summary the most affected components from each shock, plus a graphical analysis of the most important transmission channels. For Scenario 1, these can be seen in Tables 14.5 to 14.10 for $(t+1)$ 2021, and Tables 14.11 to 14.16 for $(t+3)$, which is 2023.

For Scenario 2, they can be seen in Tables 14.17 to 14.22 for 2022, and Tables 14.23 to 14.28 for $(t+3)$, which is 2025. Similar tables can be seen for Scenarios 3 and 4 from Table 14.29 to Table 14.52, where the effects are summarised for the years 2021, which allows for a comparison of the first shock, and 2025, which captures the difference in the compound effect of both shocks.

[31] This result is perfectly logical in the context of the model, but at first glance appears to be illogical.

14.6.2 Effects for the HH sector

For HH, in 2021, the most obvious effect of the first shock is the increase in interest paid on mortgage debt (or property income paid) of 95.85%. The immediate reduction in transactions for new interest-bearing assets ($\downarrow IBATR^H$) and liabilities ($\downarrow IBLTR^H$) by -78.28% and -73.94% respectively, and transactions in equity assets ($\downarrow EQATR^H$) fall by -68.34%. These are dramatic proportional shifts, largely due to the very low base of the baseline figures. These changes are not only driven by portfolio allocation decisions but also by changes in the real economy, as aggregate demand is reduced due tot he change in interest rates.

HH investment (gross fixed capital formation, $\downarrow I^H$, which is only houses in this model) falls by -6.81% and savings by -10.3% (thus the decline in $\downarrow NL$ of around -16.64%). This follows a decline in disposable income of -2.58% and consequently in consumption of about -1.33%. In terms of stocks, households immediately reduce holdings of IBL by -2.26% and IBA by -3.23%.

The residual financial flow for HH is transactions in interest bearing assets, $IBATR_t^H$, which are assumed to be deposits. It is directly affected by changes in the level of net lending (NL^H), changes in transactions in IBL ($IBLTR_t^H$), transactions in equities ($EQATR_t^H$) and net transactions in pension assets ($PENATR_t^H$). The link between new debt IBL^H and new deposits IBA^H is analogous to the PK theory of endogenous money supply since an increase in debt is associated with an increase in deposits. This is represented in Equation 14.11.

$$IBATR_t^H = NL^H + IBLTR_t^H - EQATR_t^H - PENATR_t^H \tag{14.11}$$

The progression of each of these transaction flows is presented in Figure 14.15 below. The decline in $\downarrow IBATR^H$ of -78.28% is easily discernible. The reader should note that the scale on each plot differs, and the change to $PENATR^H$ is largely irrelevant at less than 1%, and the declines in $IBLTR^H$, $EQATR^H$ and $IBATR^H$ are of far greater interest. This is appropriate, as each item should be read independently.

Following the dark-grey dotted line describes Scenario 1, where, in all but pension asset transactions, the initial decline is dramatic, but in subsequent years there is a fairly rapid recovery. $IBATR^H$ is represented in the top centre panel, and is the sum of the remaining four items. In Scenarios 1,3 and 4, the interest rate shock results in significant negative savings, but with the introduction of the property price collapse in 2022, for Scenarios 2 to 4, NL swings positive. This is explored further below.

Comparing Scenarios 3 (dark-grey short-dashed line) and 4 (red short-dashed line) reveals that the effect of the combination of the two shocks is 50% smaller for Scenario 4 after the interest rate shock (shock 1), and roughly 10% to 20% smaller for the property shock (shock 2).

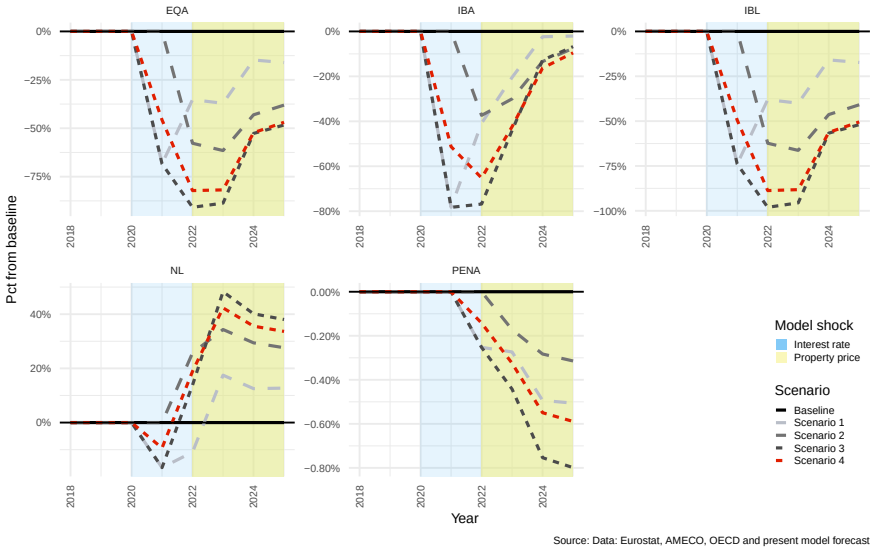


Figure 14.15: Households: Transactions in assets

The level of net lending NL_t^H is essentially driven by changes in savings (S_t^H) and investment levels (I_t^H). The changes in net purchases and sales of fixed assets (NP^H) and net capital transfers (KTR^H) are exogenous, and so do not differ from the baseline (this is repeated for all sectors). The level of net lending for HH is calculated as follows.

$$NL_t^H = S_t^H - I_t^H - NP_t^H + KTR_t^H \tag{14.12}$$

The I^H and S^H components of NL can be seen in Figure 14.16. I^H (INV in the plot) recovers in the second period after the shock but then declines again in the fourth. S^H and NL fall by about around 10% in Scenarios 1 and 3, but only by about half of that for Scenario 4. I^H (which is entirely in houses) declines even more dramatically in Scenarios 2 with the collapse in house prices, and this is compounded with the fall of shock 1 in Scenarios 3 and 4. There is a decline of over 30% from baseline investment by 2023 when the level of ARM (flexible-rate mortgages) is allowed to remain high in Scenario 3.

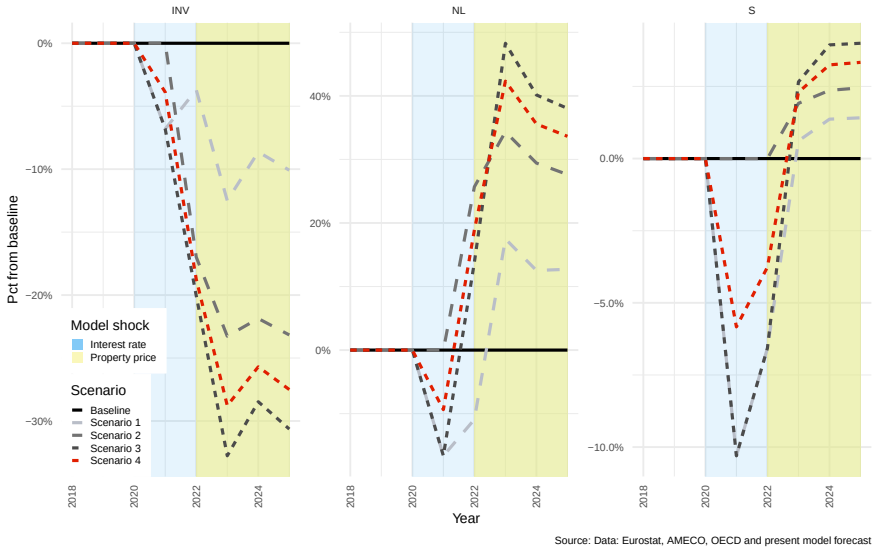


Figure 14.16: Household Net Lending components

Savings (S^H) are almost entirely determined by the level of disposable income of HH, and since the tax proportion is held constant, it is the income portion that drives most of the changes. While savings recover in the periods after the shock, investment activity declines further, which is the main driver behind the correction of NL. Thus, it is unfortunately a decline in economic activity that allows for the financial recovery. The decline in I^H also means that capital formation fails to offset depreciation, and thus, HH capital levels decline.

Equation (14.13) describes the incomes and expenditures of HH that ultimately determine the gross income for the sector (Y_t^H). The primary sources of which are wages (WB^H, W in the plot below), profits ($B2$, which is exogenous), property income (or returns on financial capital, which stems from interest bearing assets, IBA^H, pensions, $PENA^H$, and equities, EQA^H), and social transfers (STR^H, STRA in the plot below).

$$\begin{aligned} Y_t^H =& WB_t^H + B2_t^H + r^H_{A_{t-1}}(IBA^H_{t-1}) \\ & - r^H_{L(FI)_{t-1}}(IBL(FI)^H_{t-1}) \\ & - r^H_{L(FL)_{t-1}}(IBL(FL)^H_{t-1}) \\ & + \chi_t(EQA^H_{t-1}) + \psi_t(PENA^H_{t-1}) + STR_t^H + \epsilon^H \end{aligned} \tag{14.13}$$

Interest rates are represented by r^H, and the "A" ("L") subscript referring to the assets (liabilities), and (χ_t) and (ψ_t) are the rates of return on equities and pensions. As part of the key change in this model, the level of

interest paid on IBL in this model is split between fixed and flexible rate mortgages into $r^H_{L(FI)_{t-1}}(IBL(FI)^H_{t-1})$ (PIP-IBL-Fixed, in the plot below) and $r^H_{L(FL)_{t-1}}(IBL(FL)^H_{t-1})$ (PIP-IBL-Flexible, in the plot below). A similar split is present in the financial corporate sector (FC) below.

The ϵ^H refers to adjustments made to ensure stock and flow consistency in the level of property income received or paid during the periods where data was available[32].

Figure 14.17 displays the endogenous components of HH income. Property income received on financial assets, are labelled PIR-EQA for EQA^H, PIR-IBA for IBA^H, PIR-PENA for $PENA^H$. PIP-IBL is the sum of interest paid on $IBL(FI)^H$ and $IBL(FL)^H$, which is all interest paid on mortgage debt. Also included in the figure are consumption (C^H) and income tax (T^H, TAX in the plot below).

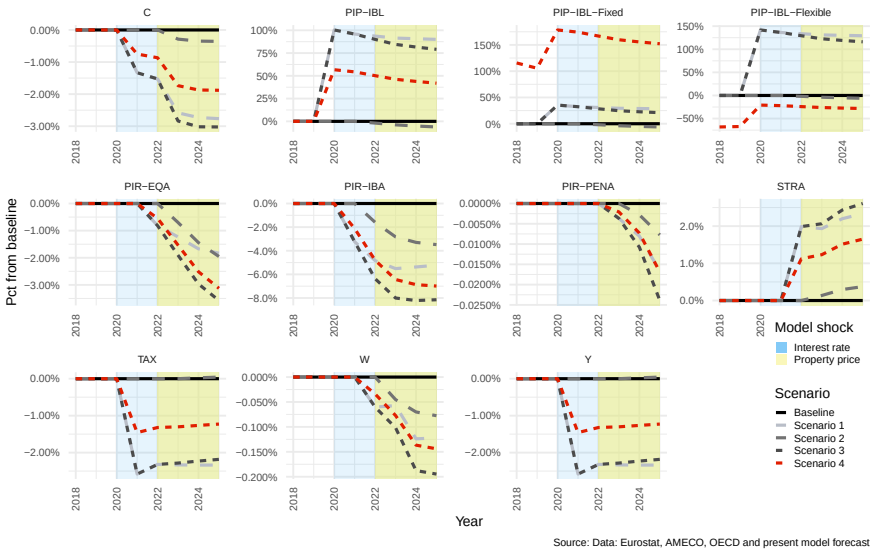


Figure 14.17: Household income components

The sum of all changes in the model accumulate in the level of Y^H in the bottom right hand panel of Figure 14.17, Scenario 2 has almost zero impact on Y^H, while Scenarios 1, 3 and 4, which include the interest rate change, all result in a significant net decline. PIP-IBL, in the panel to the right of consumption (C) in the top left corner, is the total interest paid on debt by HH, and highlights

[32]This convention is used for all sectors. The returns on financial assets are estimated with varying degrees of accuracy for each of the sectors. In order to ensure that the model is consistent in all periods, any difference between the estimated returns and actual returns (on a net basis for each asset class) are added to the adjustment term. These errors in estimation are minimised in the estimation specification for each asset class individually.

the most dramatic change. It also illustrates the key difference introduced in Scenario 4, which is a reduction in the sensitivity of HH income to changes in interest rates relative to Scenario 3.

The largest contributors to HH income are wages (W^H) and social transfers (STR^H, STRA in the plot above). Since 2007, approximately 35% to 37% of social transfers represent a tax funded pension income, and most of the remainder covers medical and disability support[33]. To give a sense of scale, Figure 14.18 shows the actual values of the major contributors, where NPIR is a net sum of all property income received and paid, and remains positive, but falls by roughly 50% due to the rise in interest costs on mortgages[34].

Wages (W), taxes (T^H, TAX) and consumption (C) all decline with Y^H.

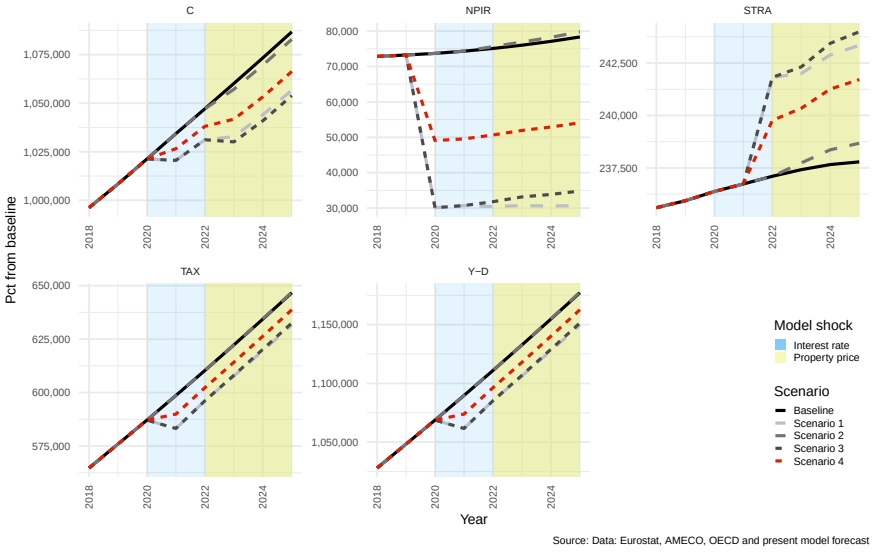


Figure 14.18: Household savings components

From this it is possible to see that the rise in STR^H is not sufficient to offset the fall in property income. Scenario 2 is the obvious exception, where income rises

[33]Based on data from Statistics Denmark, since 2007, approximately 35% - 37% of all social benefits were for old age payments. A further 20% - 22.3% are attributed to medical benefits, an almost constant 14.4% to disability and 10% - 13.2% to family and child benefits. Unemployment (app. 5%), social exclusion (app. 5%), housing (app. 2%) and survivorship (app. 1%) benefits making up the balance. The bulk of these transfers can be thought of as supplementary income, rather than unemployment support.

[34]The impact of the shift in α can be seen in the two panels to the top right. PIP-IBL-Fixed, and PIP-IBL-Flexible are drastically different in Scenario 4 to all other Scenarios. This is because Scenarios 1 to 3 all keep the baseline allocations of debt between fixed and flexible. The difference from baseline illustrated in Figure 14.17 above are predominantly due to the change in α in 2017 - hence the separation prior to the first shock in 2020.

marginally. Disposable income (Y_d, shown as Y-D above) declines in Scenarios 1 and 3, but in Scenario 4 only stagnates before trending upwards again. The trend in consumption follows the shift in Y_d. The effects of the shocks on the HH financial balance sheet can be seen in Figure 14.19.

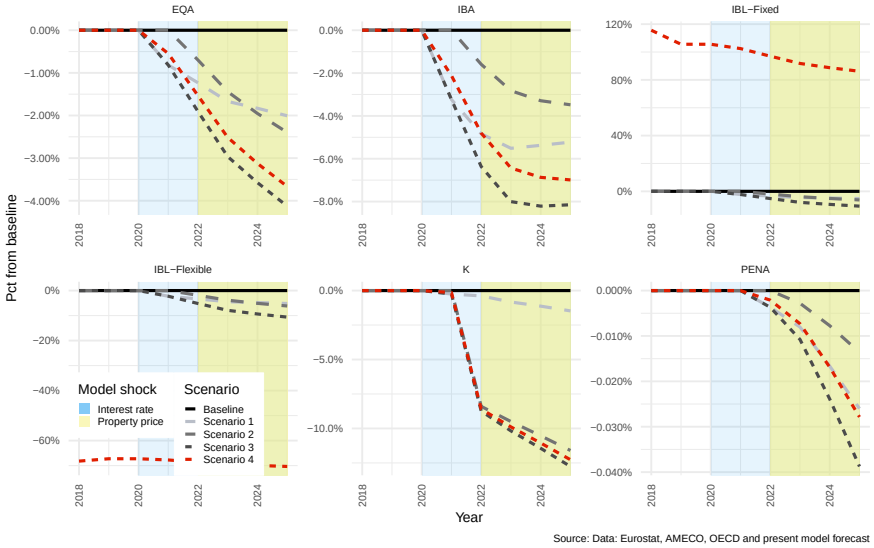


Figure 14.19: Household balance sheet

The decline in $PENA$ are negligible relative to the baseline, but the decline in capital (K^H) that occurs due to the shock to housing prices, has a significant impact on both consumption and investment in subsequent periods. The consequence of the rise in interest rates, and decline in housing investment can be seen in the panel for K above, where Scenario 1 shows a gradual decline relative to the baseline. The impact of a shock to housing prices, however, has a far more dramatic impact in 2022.

In the scenario three, three years after the compounding of the property price decline, net HH wealth falls by 3.34%, but this understates the impact on the HH, since, as mentioned in the introduction, net measurements fail to take into account the impact on gross balances. In gross terms, stock of interest bearing liabilities falls by 10.6%, HH wealth in financial assets falls by 3.55% while stock of capital held in houses falls by 12.76%. These are substantial declines in the total level of wealth, but probably overstates the effect on property, since although property prices are allowed rise gradually, the recovery is more gradual that was observed for the Danish economy. The contraction in liabilites is also substantially higher than the modest effect observed over the GFC. One major difference, however, is that HH benefitted from global suppression of interest rates, which would be quite the opposite if interest rates were to rise.

In summary, on the basis of the model, an interest rate hike and a collapse in property prices would both force the HH balance sheet to contract. The main transmission channel that this would occur through is a direct reduction in disposable income due to debt costs, or the credit channel. It also shows that if it were possible to instigate a change in the composition of debt from flexible- towards fixed-interest products, the lower sensitivity of fixed-rate debt products might protect HH from the majority of these impacts.

14.6.3 Effects for the NFC sector

The changes in Scenario 1 for NFC are rather limited at first, as can be seen in Table 14.7, but by 2023, as shown in Table 14.13, the effects of the shocks have spread far enough that changes in real economic activity have an impact on the level of employment and output.

In 2021 $NIBTR^N$ falls by -12.62%, which is equal to the fall in NL. S^N falls by -1.1%, T^N by -0.2% and profits ($B2^N$) by -0.19%.

By 2023 the real economy effects feed into NFC, and $NIBTR^N$ has fallen by -19.75%, which is equal to the fall in NL. I^N has fallen by -0.22%, and S^N by -1.61%. T^N by -0.33% and profits ($B2^N$) by -0.31%. The net flow of all property income is -0.17% lower and the stock of NIB^N is -1.48% lower than baseline. There is also a -0.08% fall in total capital of NFC.

NFC's residual financial flow is $NIBTR^N$, and the contributors to it are net lending (NL^N) and net equity transactions ($NEQTR^N$). Unlike the household sector, the financial activity of the NFC is not modelled directly, and $NEQTR^N$ are therefore exogenously determined for periods where data is available, and revert exogenously to zero for all periods of estimation. $NIBTR^N$ therefore depend only on NL.

$$NIBTR_t^N = NL_t^N - NEQTR_t^N \tag{14.14}$$

Net lending again depends on Savings and investment,

$$NL_t^N = S_t^N - I_t^N - NP_t^N + KTR^N \tag{14.15}$$

Investment is estimated in real terms, and is positively dependent on real gross income (y_{t-i}), and negatively dependent on the real level of capital (k_{t-i}^N), each with a variable number of lags in the estimate[35]. In this context, the proportion, $\left(\frac{y_{t-i}}{k_{t-i}^N}\right)$, represents capacity utilisation.

[35]In this versions of the model, k_{t-i}^N and y_{t-i} are both estimated at $t-1$, together with a significant dummy variable for 2009.

$$ln(i_t^N) = \beta_i + ln\beta_i \left(\frac{y_{t-i}}{k_{t-i}^N} \right) \tag{14.16}$$

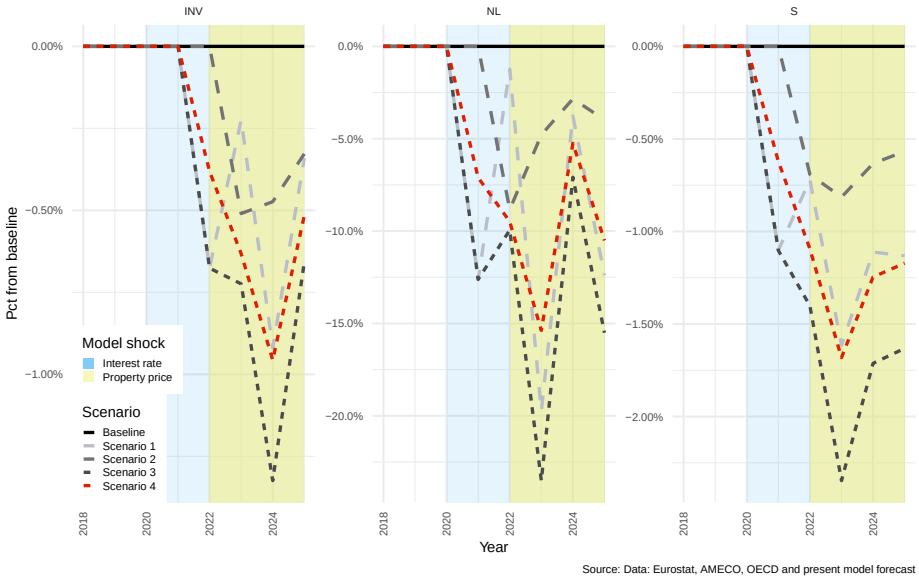


Figure 14.20: NFC Net Lending components

The major determinants of investment are therefore the major determinants of GDP, together with previous capital accumulation in NFC (previous capital, plus investment less depreciation). As can be seen in Figure 14.20, I^N (INV in the plot) is fist affected by Scenario 1 (interest rates) in 2022, this the change in NL observable is 2021 is purely due to the decline in savings. Although the shapes of the panels in Figure 14.20 are very similar, the scales are quite different. The actual underlying values of each category are also significantly different. Plotted as actual values in Figure 14.21, the changes would be almost indiscernible from the baseline.

NFC savings (S_t^N), can be calculated as the net sum primary and secondary income and expenditures.

$$\begin{aligned} S_t^N =& Y_t - WB_t^N + (B2_t^N - B2_t) + r_{t-1}^N (NIB_{t-1}^N) \\ &+ \chi_t (NEQ_{t-1}^N) - T_t^N + STR_t^N + \epsilon^N \end{aligned} \tag{14.17}$$

$NPIR - NEQ$ and $STRA$ are exogenous, and revert to zero values after the last period of available data, 2017.

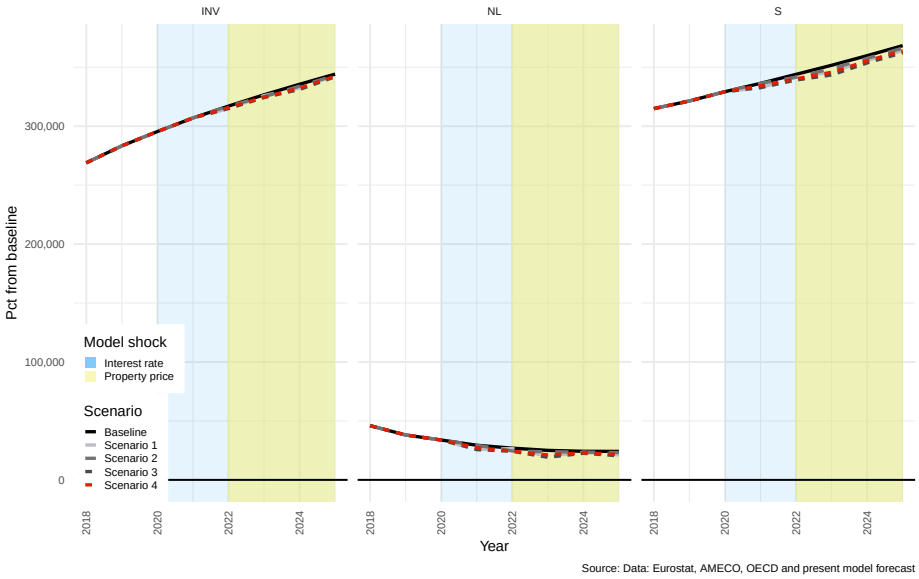


Figure 14.21: NFC Net Lending components

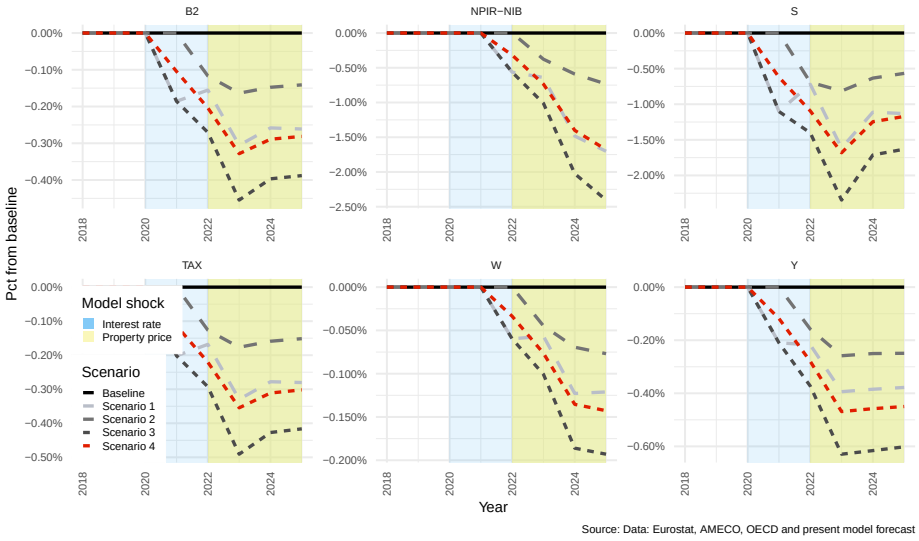


Figure 14.22: NFC Savings components

14.6.4 Effects for the GOV sector

For Scenario 1, in 2021 $NIBTR^G$ is -30.78 % lower than the baseline. The source of this decline can be traced through the plots below. Figure 14.23 shows the decline in net lending and savings.

Contributing to the decline in NL^G is a decline of -11.85% in S^G. The main contributor to which is a fall in T^G of -1.56%. The net issue of IBL results in a fall in NIB^G of -9.16% and for net wealth to decline by -1.3%.

By 2023 the first shock has spread through the economy and NL is -34.27% below the baseline levels. The delayed effect of the change in interest rates is by that stage in effect, and results in a decline in net property income of -15.36%. This contributes to a reduced level of S^G of -14.07% below. The major contributor is a -1.47% lower level of tax revenue.

Social transfers for each sector, $STRA^G$ in the case of GOV, are a net value of receipts less payments. $STRA^G$ declines by -1.21%, indicating that the level of payments has increased relative to receipts. This contributes further to the negative balance in GOV. The decline in $NIBTR^G$ above accumulates in NIB^G that is -19.27% lower than the baseline, and net wealth, NW^G, that is -4.02% lower.

Shock 2 in 2022, the property price decline, has very little impact on GOV, with only a marginal decline in S^G, flowing from limited impacts to the underlying components. NL^G falls by only -0.97%. This since tax revenues are only marginally affected when HH disposable income remains fairly constant, and the ultimate effect on NIB^G is only -0.24%. In reality this could have been substantially worse if the property price collapse resulted in non-performing loans and GOV was required to step in, as was the case for the banking crisis in Sweden in 1993. (Englund, 1999)

By 2025, the effects remain modest, with NL^G only -1.93% down from the baseline level, and NW^G only -0.27% lower.

The largest changes in Scenario 1 for GOV in 2021 are in the residual financial flow for GOV, transactions in net interest bearing assets ($NIBTR^G$). These changes come almost entirely from changes in NL, another term for which would be a government deficit or surplus, for negative and positive NL respectively. GOV issues debt ($NIBTR^G$) to cover the deficit. These assets are accumulated by FC (below), together with property income flows according to the return on these assets (r_N). As can be seen from Equation (14.18) below,

$$NIBTR_t^G = NL_t^G \tag{14.18}$$

Government investment (I^G), (and, as with NFC) NP^G and KTR^G are exogenous, so in Equation (14.19) below, it is only changes in savings (S^G) that are influential after the shocks in each scenario.

$$NL_t^G = S_t^G - I_t^G - NP_t^G + KTR_t^G \tag{14.19}$$

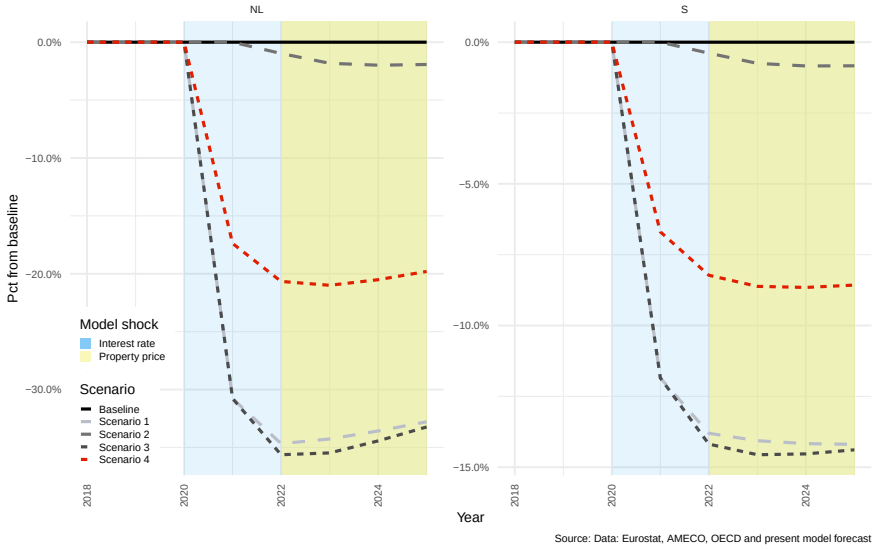


Figure 14.23: GOV Net Lending components

Equation (14.20) highlights the core components of GOV income. Of these $B2^G+$ net property income received, ($r_{N_{t-1}}(NIB_{t-1}^G)$, and NPIR in the plot below) and tax T^G are the incomes received by GOV. Social transfers (STR^G, STRA in the plot below) and GOV expenditure (G). The exogenous component from the incomes is $B2$, and from expenditure G.

$$S_t^G = B2_t^G + r_{N_{t-1}}(NIB_{t-1}^G) + T_t^G + STR_t^G - G_t + \epsilon^G \tag{14.20}$$

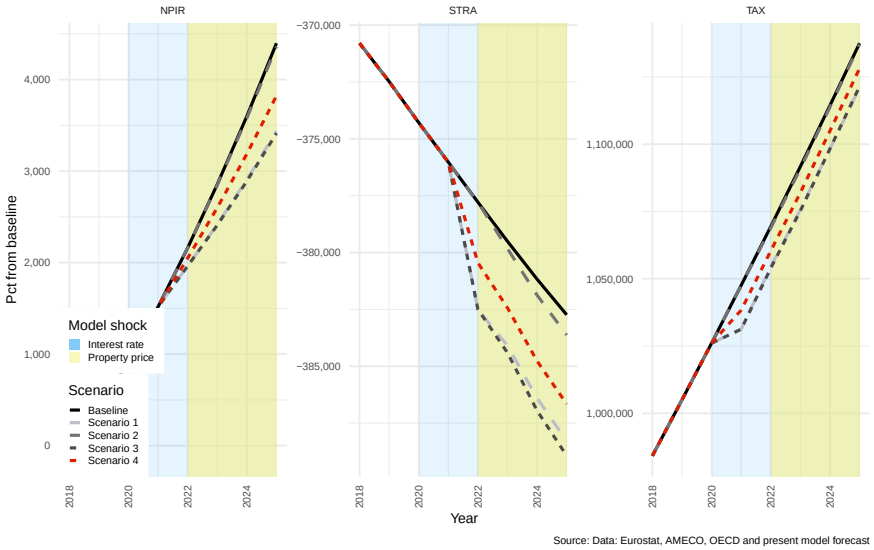


Figure 14.24: GOV Savings components

Considering Scenarios 3 and 4, the difference in the impact of shocks is about half as strong for Scenario 4, where α is at 80%. Scenarios 1 and 3 however result in stronger effects. The impacts to GOV are directly a result of the deterioration in HH cash flows and needs for social support. While STR^G is the expenditure of GOV that flows to HH, based on total net benefit and contribution flows. Rising STR^G expenses are exacerbated by a fall in revenues in the form of both net property income received (NPIR) and taxation T^G (TAX in the plot above.)

14.6.5 Effects for the ROW sector

The ROW sector is primarily driven by exports, which are exogenous, and imports, which are endogenous to changes in the level of household income. The sharp decline in household income causes an immediate improvement in the current account balance, which is reflected as a negative NL balance for ROW[36].

For shock 1, in 2021, ROW is driven into a further deficit to Denmark, with a decline of -10.97% in $NIBTR^W$, which captures the -10.97% decline in NL^W and S^W. This has a negative effect of -0.7% on the level of net wealth (NW^W) held by ROW in Denmark.

The deficit in NL^W continues to grow, and by 2023 is -10.97% lower than the baseline value. The net flow of property income on all financial assets is lower

[36]The flows for ROW are recorded from the perspective of ROW. Thus, if ROW net-lends, it is the same as to say that Denmark net borrows. A positive current account for Denmark is therefore the equivalent of a net borrowing (or, negative net lending) position for ROW.

by %, which reflects a -1.21% fall in the stock of NIB^W. From a balance sheet perspective, there is a decline of -0.7% in net wealth (NW^W).

The second shock, to property prices has less of an impact on ROW, with $NIBTR^W$ still lower, but in 2022, this is only by -8.14%. This is again driven by an equal decline in S^W, which leads to an equal decline in NL^W. The fall in $NIBTR^W$ is reflected as a decline in NIB^W by -0.87%.

By 2025, the shock has spread through the economy, and the impact on S^W, NL^W and $NIBTR^W$ is lower again at -11.74% less than the baseline value. The changes in interest earning assets reduce the level of property income from NIB^W by -3.14%, and from all financial assets by -1.71%. The level of NIB^W continues to fall further into deficit by -3.98% relative to the baseline. After the three year period of accumulative effects, NW^W would be -2.69% lower.

The transmission of these shocks, working backwards from the accumulative effect on transactions in NIB^W, begins with Equation (14.21).

$$NIBTR_t^W = NL_t^W - NEQTR_t^W - NPENTR_t^W \tag{14.21}$$

Equation (14.21) describes the source of changes in $NIBTR^W$, where $NEQTR^W$ and $NPENTR^W$ are exogenous in the model. This leaves only NL as a possible source of change. Unlike the domestic sectors, ROW is assumed not invest in the domestic economy, which means that the net lending function is somewhat simpler, with only savings as the possible source of change.

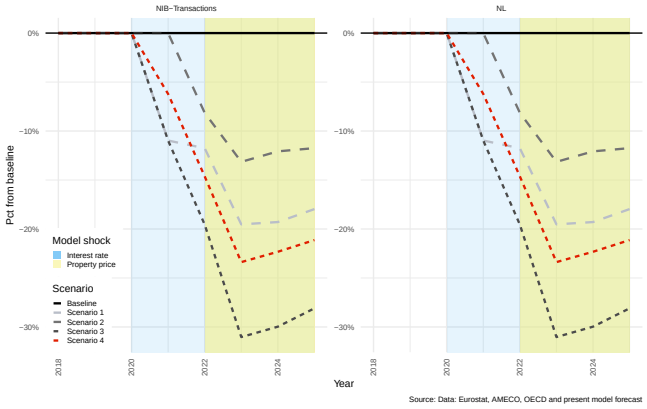


Figure 14.25: ROW: NIBTR: Transactions in assets and net lending

Equation (14.22) highlights the components of NL, and much like the previous sectors, only S^W is endogenous in the model.

$$NL_t^W = S_t^W - NP_t^W + KTR^W \tag{14.22}$$

It is therefore only savings that drives changes in NL. The total level of NL is then, as mentioned earlier, equivalent to the current account balances - although what is positive in the current account must be negative in the ROW NL account.

$$CAB_t = -NL_t^W \tag{14.23}$$

Savings are described by Equation (14.24).

$$\begin{aligned} S_t^W =& M_t - X_t + \chi_t(NEQ_{t-1}^W) + \psi_t(NPEN^W t-1) + r_{N_{t-1}}(NIB_{t-1}^W) \\ &+ WB_t^W - T_t^W + STR_t^W + \epsilon^W \end{aligned} \tag{14.24}$$

ROW is assumed to be largely independent of developments in the domestic economy, and thus WB^W, $\chi_t(NEQ_{t-1}^W)$, $\psi_t(NPEN^W t-1)$, STR^W, and T^W are considered to be exogenous. This is with the exception that the rates of return on each of the asset classes is assumed to be the same as those available domestically. The reason for this is that Denmark is a AAA rated country and maintains a fixed exchange rate regime with the EU, and arbitrage keeps rates of return very close to those available in neighbouring Europe.

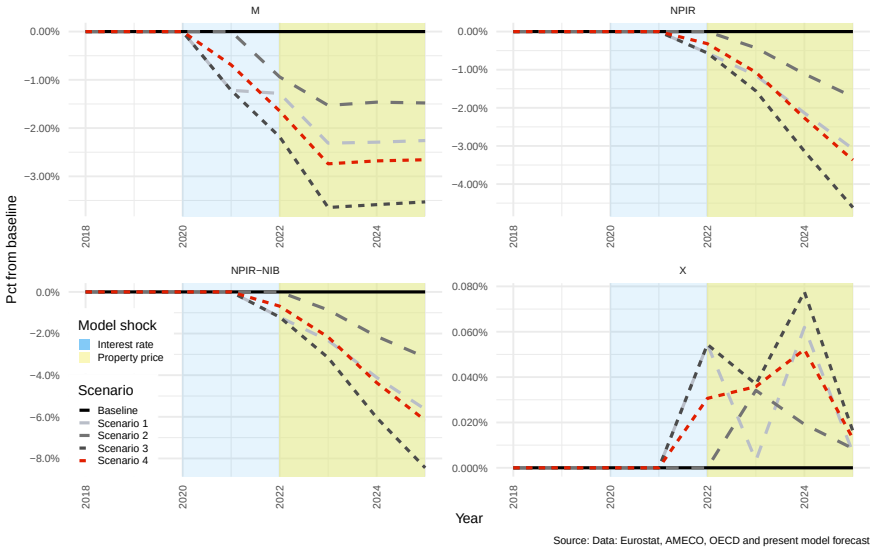


Figure 14.26: ROW Savings components

Imports (M) from the model are a revenue for ROW and exports (X) an expenditure. The return on net interest bearing stocks, $r_{N_{t-1}}(NIB_{t-1}^W)$, (NPIR-NIB in the plot above) depends on whether NIB^W is positive or negative.

Imports are estimated in real terms in the log-linear form in Equation (14.25), and depend on the level of domestic demand in the previous period, and a relative price index between domestic and foreign goods from the previous period $\left(\frac{P^y_{t-1}}{P^m_{t-1}}\right)$.

$$ln(m_t) = \beta_i + \beta_i ln\left(\frac{P^y_{t-1}}{P^m_{t-1}}\right) + \beta_i ln(c_{t-1} + i_{t-1} + x_{t-1}) \tag{14.25}$$

As noted by Byrialsen and Raza (2019), the "export function is based on the Armington (1969) model where the market share of the Danish exports is explained by relative prices."

This relation is captured below as annual Danish exports relative to a weighted index of all trading partners (m^W_t), which should be determined by domestic prices (the export price index, P^x_t) relative to foreign prices (the import price index, P^m_t), but moderated by price elasticity (β).

$$\frac{x_t}{m^W_t} = \left(\frac{P^x_t}{P^m_t}\right)^{\beta} \tag{14.26}$$

Exports thus stay relatively stable in the model, and are only affected by minor changes in the relative price ratio. The lower right panel in Figure 14.26 above is a little deceptive, as the scale is very small. The most important change for ROW is a strong decline in Danish imports, which is primarily driven by the fall in HH disposable income

14.6.6 Effects for the FC sector

FC absorbs all of the imbalances in the other four sectors, and the relatively extreme shock to interest rates culminates in large changes to each. Transactions in net interest bearing assets, $NIBTR^F$, are simply an inversion of the accumulation of $NIBTR$ in three of the four sectors (GOV, NFC and ROW), and $IBLTR^{F\sim H}$ is a reflection of household accumulation of deposits, $IBATR^H$.

$$NIBTR^F_t = -(NIBTR^N_t + NIBTR^G_t + NIBTR^W_t) \tag{14.27}$$

The second, and rather indirect accumulation is that of equities to offset any equity investment by HH. The full explanation is available in the appendix, in Section 14.10.3. An abbreviated summary is that all other components of Equation (14.28) are accounted for by accounting identities between FC and the other sectors, and the value of $EQATR^H$ is carried into FC via $IBLTR^{F\sim H}$. Once all other terms are netted out, the $NEQTR^F$ value is equivalent to $EQATR^H$.

This equivalence is the redundant equation in the model, and is not specified in order to avoid over-identification.

$$NEQTR_t^F = NL_t^F + IBLTR_t^{F\sim H} + PENLTR_t^F - IBATR_t^{F\sim H} - NIBTR_t^F \tag{14.28}$$

Because $NIBTR^F$ captures the net flows of all other sectors, it also represents any excess or shortfall (i.e. net lending) experienced by FC. This is because all flows of all other sectors with each other will already be captured and netted out by the sum of their $NIBTR$ in Equation (14.27) above. The only unaccounted for flow is the net value of FC flows, which is captured in NL^F. Again, NP^F, I^F[37] and KTR^F are exogenous.

$$NL_t^F = S_t^F - I_t^F - NP_t^F + KTR_t^F \tag{14.29}$$

Rather than show the percentage changes, Figure 14.27 shows the actual increase in FC NL and savings as a result of the shocks in each scenario. As can be seen, the impact of the second shock is almost negligible. Scenarios 1 and 3 are almost identical, and Scenario 2 remains very close to the baseline level. It is thus the interest rate change that has the dominating effect on FC's flows and thus balance sheet. It should be unsurprising therefore that there is a substantial difference between Scenarios 3 and 4. In Scenario 4, where a greater portion of HH debt is *less* sensitive to changes in interest rates, the transfer of wealth from HH to FC is substantially reduced.

[37] FC investment is assumed to grow at a constant 2% per annum.

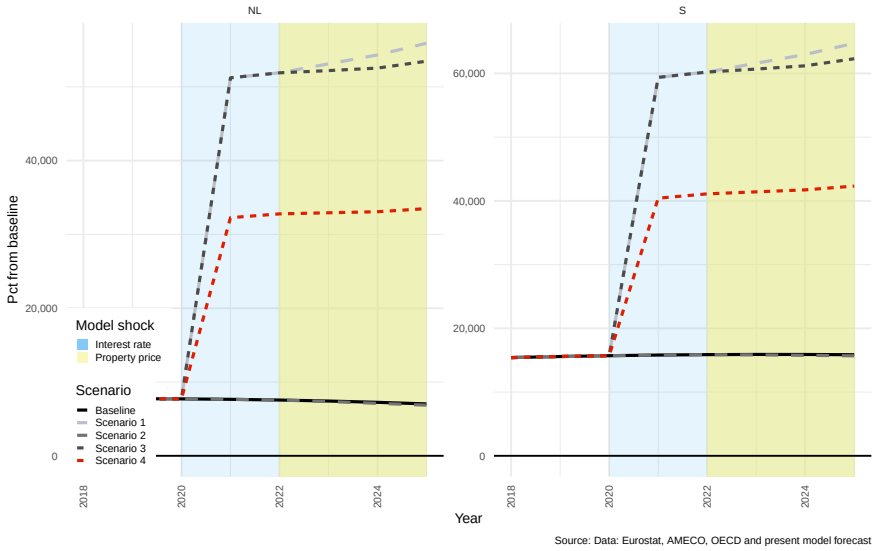


Figure 14.27: FC Net Lending components

From a very low base, NL^F rises by 569.17%, or is roughly five and a half times larger. The shifts in the values of the underlying FC components are sensibly also substantial. Transactions in most assets are net positive, and in liabilities negative - both relative to the baseline and in absolute terms.

The exception is a decline in loan assets as HH deleverage in 2021 by -3.23%. Apart from this single entry, HH borrowing is positive in all periods. Relative to the baseline after the first shock, $IBLTR^{F\sim H}$ is down by -78.28%, and $IBATR^{F\sim H}$ is down by -73.94%. FC is a net issuer of equity and interest bearing assets, with transactions in equity, $NEQTR^F$, up 68.34%, and in NIB up 61.82%. FC thus begins to accumulate assets rapidly.

In terms of property income flows, the rise in interest rates in this example is only allowed to affect the asset returns of FC, and thus the net increase is more extreme than if we adjusted all rates of return. The total net property income received by FC, $NPIR^F$, is 323.58% higher. This comes from the increase in fixed and flexible rate interest receipts, which rise by 32.38%, and 136.29% respectively.

As noted above, FC accumulates assets rapidly. NEQ^F rises by 46.26% and NIB^F by 2.02%. The fall in $IBA^{F\sim H}$ by -2.26% and in $IBL^{F\sim H}$ by -3.23% almost offset each other entirely, and the final impact on net wealth of FC is an increase of 42.82%.

Equation (14.30) highlights the income and expenditure components that contribute to FC savings, and Figure 14.28 illustrates these components in nominal values.

$$
\begin{aligned}
S_t^F =& B2_t^F \\
&+ r^F_{A(FI)_{t-1}}(IBA^{F\sim H}_{A(FI)_{t-1}}) + r^F_{A(FL)_{t-1}}(IBA^{F\sim H}_{A(FL)_{t-1}}) \\
&- r^F_{L_{t-1}}(IBL^{F\sim H}_{L_{t-1}}) + r_{N_{t-1}}(NIB^F_{t-1}) \\
&+ \chi_t(NEQ^F_{t-1}) - \psi_t(PENL^F_{t-1}) - T^F_t + STR^F_t - CPEN^F_t + \epsilon^F
\end{aligned}
\tag{14.30}
$$

From Equation (14.30), $B2^F$ and T^F are exogenous, and the change in FC output, Y^F, is less than -1%. Nominal values are illustrated here in order to give better context to the changes implied by the shocks. The percentage changes that are discussed above for Scenario 1 do not appear to be as unrealistic when viewed in these terms.

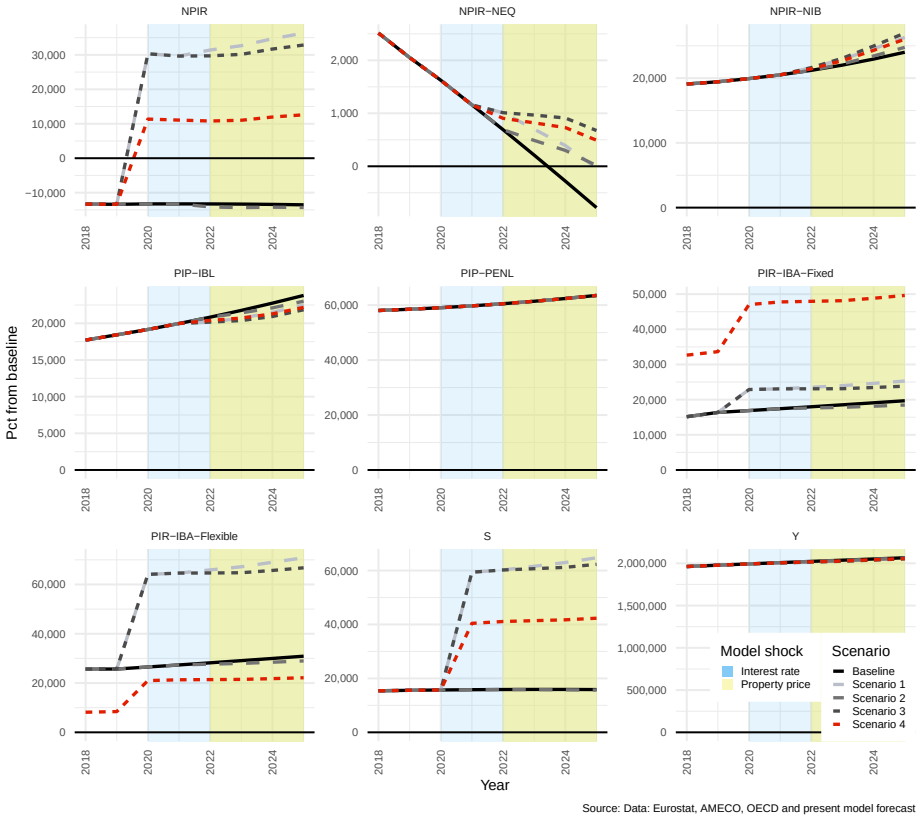


Figure 14.28: FC Savings components

The panel titled net property income (NPIR) in the plot above is a sum of all property income flows, and is similar to Equation (14.30) above for S^F, but

with all other terms removed. The total impact on property income helps to identify the source of changes in FC savings. NPIR is calculated as follows.

$$\begin{aligned} NPIR_t^F = &+ r^F_{A(FI)_{t-1}}(IBA^{F\sim H}_{A(FI)_{t-1}}) + r^F_{A(FL)_{t-1}}(IBA^{F\sim H}_{A(FL)_{t-1}}) \\ &+ r_{N_{t-1}}(NIB^F_{t-1}) + \chi_t(NEQ^F_{t-1}) \\ &- \psi_t(PENL^F_{t-1}) - r^F_{L_{t-1}}(IBL^{F\sim H}_{L_{t-1}}) \end{aligned} \tag{14.31}$$

The bulk of FC flows are property income paid (PIP), property income received (PIR), or NPIR. The representations in Figure 14.28 above are categories of these property income flows. NPIR-NEQ for $\chi_t(NEQ^F_{t-1})$ (on equities), NPIR-NIB for $r_{N_{t-1}}(NIB^F_{t-1})$ (on net interest bearing assets with all sectors other than HH), PIR-IBA-Fixed for $r^F_{A(FI)_{t-1}}(IBA^{F\sim H}_{A(FI)_{t-1}})$ (on fixed-rate HH debt), PIR-IBA-Flexible for $r^F_{A(FL)_{t-1}}(IBA^{F\sim H}_{A(FL)_{t-1}})$ (on flexible-rate HH debt), PIP-IBL for $r^F_{L_{t-1}}(IBL^{F\sim H}_{L_{t-1}})$ (on deposit liabilities).

The shock to interest rates in Scenarios 1, 3 and 4 all result in positive NPIR for FC. The substantially lower level of NPIR in Scenario 4 (the red line) can be traced back to PIR-IBA-Fixed and PIR-IBA-Flexible. The sum of the total revenue generated by the rise in interest rates is the summarised in NPIR. The steady decline of net return on equities, NPIR-NEQ, is due to the systematic issuance of equity to HH as HH demands equity. This demand is retarded slightly in all scenarios. Equity investment by HH is dependent on previous returns, previous returns on house investment and previous changes in the quantity of loans acquired. For both shock 1 and 2, it is due to the reduction in $IBLTR^H$ and for shock 2 it is also driven by a fall in returns on houses.

The effect on FC savings, S^F, is to triple the value in Scenarios 1 and 3, and double the value in Scenario 4.

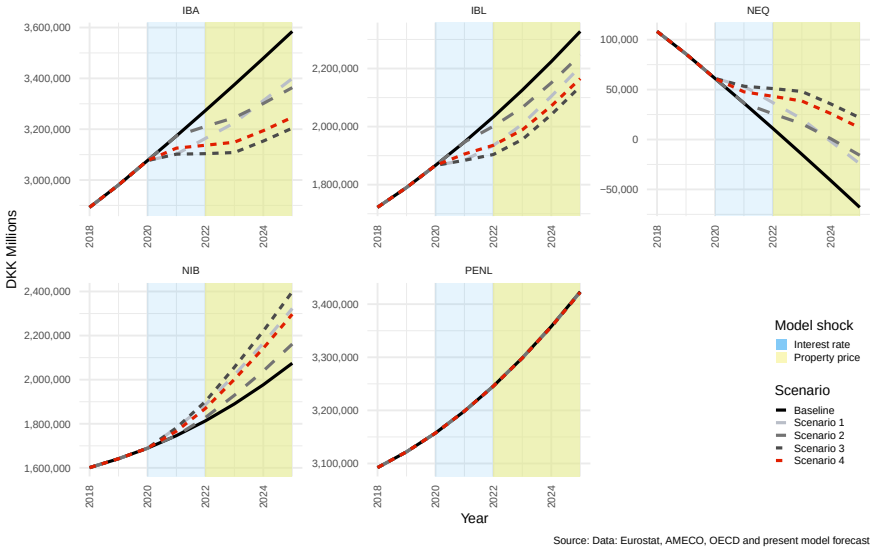


Figure 14.29: FC balance sheet

14.7 Discussion

As noted in Section 14.3, many of the innovations that occurred around the world during the past decades also occurred in the Danish mortgage lending system. In addition, since the GFC, interest rates have reduced to and remained at historically low levels. These conditions provided the platform for rapid expansion of household mortgage debt leading up to the crisis, and to continued expansion of that debt in more recent years. This has coincided with the rapid recovery and inflation of asset prices. Property prices are discussed in Section 14.5.3 above, and as can be seen from panel (a) in Figure 14.30, Danish equity prices (the yellow line) have risen over 230% from 2010 to 2018, with only one other European country (Latvia, the blue line) with a higher increase in its equity price index.

The main effects of the innovations that occurred were a reduction in initial payments for borrowers, a decline in the level of payments towards the outstanding principal debt (and thus a decline in the level of equity accumulation) and a significant shift of risk from investors to lenders. Danish HH responded rapidly to the innovations, and the composition of debt changed from 100% fixed interest debt, in 2000 to less than 30% by 2012, as can be seen in panel (b) of Figure 14.30[38].

[38]The gradual shift out of fixed interest bonds prior to 2003 is due to the introduction of index-linked bonds, which made up a relatively small share of less than 10% the market, and this share reduced rapidly after 2003. There has also been a gradual move back towards more fixed-interest rate products since 2012.

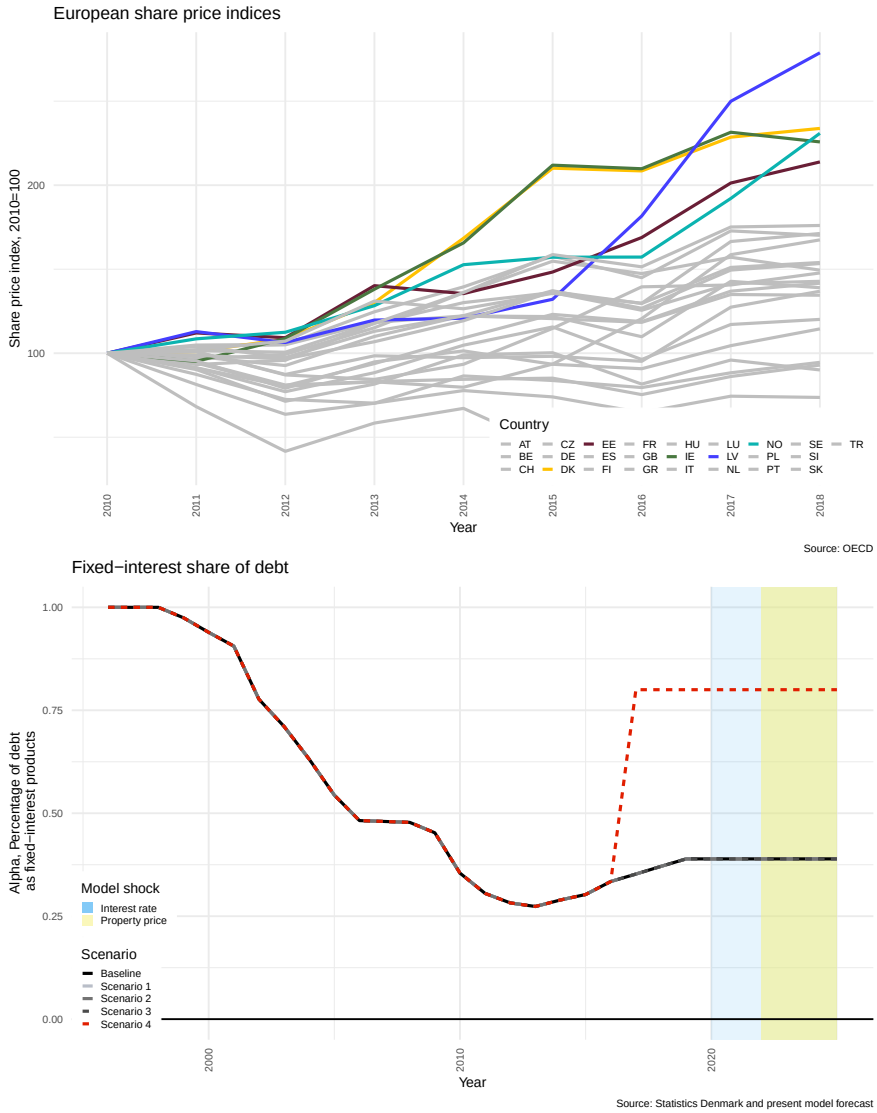


Figure 14.30: Share prices and mortgage composition

The major benefits of fixed interest products include stability of expenditures, insulation against unforseen interest rate hikes, and the possibility to refinance at various favourable instances (stemming from the buy-back, and prepayment rights assigned to borrowers (Skinhøj et al., 2019)). Flexible interest rate products on the other hand, provide low initial cost of borrowing, but transfer interest rate risk to the borrower. Revisions to the coupon rate on the counterbalancing bonds also create a significant opportunity cost for ARM borrowers if

rates rise. This is opportunity cost is enhanced if it is a distressed borrower, or the borrower faces negative shocks, such as a loss of income or an injury. A fixed rate borrower (even without amortization) would be able to accept a lower sale value for their property, since the bond that represents the outstanding debt would reprice downwards as interest rates rise. In the case of an interest rate increase, flexible rate borrowers face the same possibility of unfavourable property market conditions, but the price of bonds outstanding will remain relatively constant, due to the re-setting of the short-term fixation of coupon payments. Flexible rate borrowers, and borrowers with interest-only periods thus face a much higher risk of falling into negative equity if house prices fall.

Many of these dynamics are captured in the model presented in this article, as are several economic relationships between the real and financial sides of the economy. These connections make it possible to show some of the expected "real" economic feedback effects of each shock. Although it is a highly simplified version of the Danish mortgage market, it is still able to provide a realistic scale for the core transmission channels for each of the shocks, and due to the simple structure of the model, it was relatively easy to incorporate a split in the composition of debt of HH.

One of the goals at the outset was to test the sensitivity of HH balance sheets for different compositions of debt. Two shocks were introduced across four scenarios. The primary effect of the first shock, an increase in interest rates by 2% in 2020, was an immediate reduction in HH income. The primary effect of the second shock, a decline in property prices by 20% in 2022, was to reduce the level of HH capital and the attractiveness of housing as an investment alternative. These two shocks were then compounded in Scenarios 3 and 4, but in Scenario 4 the level of debt held in fixed-interest products (α) was increased from around 37% to 80%, as shown in panel (b) of Figure 14.30 above.

The model behaved as expected, and in Scenario 3, with the higher proportion of ARMs, HH are exposed to significantly greater income volatility than in Scenario 4, a result that is corroborated by Danmarks Nationalbank (2016) and Skinhøj et al. (2019). This transmits to both the real and financial sides of the economy, with lower economic output and higher unemployment as a result of the increased sensitivity. The results in Section 14.6 above suggest that for a significant rise in interest rates, or a collapse in property prices, HH would be in a more favourable financial position as a sector if the proportion of mortgage debt held in fixed-interest products (α) was higher. This suggests that policies with a focus on increasing the coverage of fixed-interest-rate products in the mortgage financing system would result in a more resilient HH, and economy as a whole.

The specific movements of variables, however, should be interpreted with caution, as the shocks in this model are not designed to provide a comprehensive economic response within the model structure. Especially since it is only the rates that affect the cost of borrowing that are adjusted in shock 1.

In terms of the transmission channels in the model, HH is a key driver. The primary transmission channel in the interest rate shock is the credit channel, and it is clearly more impactful where interest rates are more sensitive. In a more realistic setting, the rise in interest rates would also affect HH incomes positively. In Denmark, pension funds hold a large portion of the outstanding covered covered bonds on behalf of households, and fees of the mortgage lending companies are generally a fixed rate. This would mean that increased mortgage costs should translate directly to increased pension incomes. HH pension assets are also substantially larger than HH debt, which means that if an interest rate hike resulted in a rise of the rates of return on most asset classes, then HH could experience a net gain. One argument against this is that pension assets are not directly accessible, and therefore would not contribute to short term disposable income of HH. HH in this case do not have discretion over the consumption of all wealth, and therefore those parts that are inaccessible should be excluded.

The current form of the model is also important to consider. Presently, HH consume out of wealth, and there is a positive return on IBA, which are assumed to be deposits. If we adjust the rate of return on IBA (r_N^H) upwards, it would change relative rates of return available for HH investment allocation, and would lead to a rapid accumulation of IBA. It would also drive a large positive effect on HH income, which would conceal the negative effects to disposable income that are displayed in the current form. This would, at least in the short run, not be in line with realistic expectations regarding accessible disposable income of HH.

Even if other asset class returns are adjusted to mitigate the fall in HH disposable income, investment will necessarily be lower as the cost of borrowing rises. In the case of an interest rate rise, aggregate demand and output would still decline, pushing unemployment upwards and providing downward pressure on the wage rate. after several years, the relative improvement in competitiveness in export prices would have a positive influence on exports and negative on imports. Ultimately this would strengthen the current account balance, but at the expense of higher unemployment in the domestic economy. The positive feedback of rising imports on wage income and output would depend on the elasticities of wages to changes in output, and imports and exports to relative price changes. The effect of a fall in house prices on housing investment would also remain in the short-term, as it is dependent on previous returns.

Another transmission channel that would be concealed is the negative pressure that a fall in demand has on the tax base, and therefore on GOV revenues. In the analysis above, it is clear that the fall in overall demand would lead to a fall in employment, a fall in tax revenues and therefore a large negative shift in the GOV net financing requirement. If the Danish GOV enforces a balanced budget, there would need to be a reduction in GOV spending, and the vast majority of this spending is split between a tax funded pension scheme, healthcare, disability support, family and child support. A reduction in any of these categories would result in a further reduction of output and ultimately in HH income.

Even with the simplifications, it should be safe to conclude that larger portions of debt in fixed-interest products would result in much lower volatility of HH disposable income. The use of a more comprehensive model, rather than a simple test of income volatility, allows us to observe the expected accumulation effects of the two shocks for different levels of α. The exogeneity of asset prices and rates of return are potential drawbacks, however, it is not obvious that creating endogenous links between financial markets, assets and rates of return (i.e. a more integrated financial sector) would be an improvement on the current model structure. At present, the most immediate transmission channels for each of the shocks are transparent, and because of the empirical nature of the model, it is possible to get an accurate scale of the initial effects of the shocks, without the complication of complex interdependencies between markets. There is a clear trade-off between complexity with greater accuracy, and better interpretability with greater transparency.

The more complete macroeconomic SFC model presented above requires attention to the gross levels of economic stocks and flows, and thus makes it possible to identify that the rise in HH NL following the second shock (the fall in property prices) was not due to positive changes in HH. Contrarily, HH experienced a decline in investment demand, together with rising unemployment. The model presented here helps to prevent such misinterpretations, and to provide a more complete picture of the possible impact of shocks[39].

The model unfortunately does not presently incorporate some key issues from the mortgage system, including the effect of changes in loan-to-value (LTV) ratios, or second round credit risk effects that might occur due to loss of income due to unemployment. The inclusion of a measure of non-performing loans or some other measure of credit risk might be able to capture these effects. Perhaps the most relevant omission, for the present discussion, is the effect of refinancing behaviour on the composition of debt, although this is not a simple matter to include, as noted by Skinhøj et al. (2019, pp. 19), "The stochastic modelling of prepayment behaviour is a complex task and is outside the scope for most international investors."

The possibility to explore a variety of modifications and alterations is also one of the major benefits that the baseline version of the model offers. It has made it possible to explore some of the complex economic feedback mechanisms described above. This version is also under continuous development by the MaMTEP group[40], and as additional economic components are explored in

[39] In addition to the alterations made, the output of the model is presented in an alternative format. The tables in the appendix provide an exhaustive list of all elements applicable to each sector that are affected by each shock. This cross-section provides at least two things to the modeller. Firstly it identifies the components applicable to each sector that are most dramatically impacted. Secondly, the comprehensive list of affected components expand as a shock propagates through the economy and assists in the identification of timing errors in the model structure.

[40] The Macroeconomic Methodology, Theory and Economic Policy Research Group, Aalborg University.

greater detail it will be possible to include any alterations that strengthen the core structure.

14.8 Conclusion

The Danish mortgage financing system has experienced several innovations in recent decades. Collectively these innovations have had a variety of benefits for borrowers, but these come with a transfer of responsibility and risk to the borrower. One of the most prominent innovations was the introduction of adjustable rate mortgages (ARMs) with periods of interest fixation of a variety of lengths.

Access to individual level administrative data-sets allowed for the construction of aggregate outstanding mortgage data from 2009 to 2017, and highlights the increased concentration of flexible-rate mortgage debt. By the end of 2017, after the introduction of ARM products, approximately 63% of all mortgage debt outstanding was subject to an interest rate adjustment within 5 years. These products were collectively considered to be flexible-interest rate products in the analysis above, and the remaining debt considered to be fixed rate.

The model in this article was adapted from Byrialsen and Raza (2019) to explore the effects of this shift on the stability of incomes and balance sheets of the Danish economy. The primary innovation in the model was to introduce the split in debt, and to test the effect of the changes on the overall sensitivity of incomes and balance sheets, with a particular focus on HH. There are some additional changes that could be incorporated in future versions of the model that might strengthen the outputs of the model. Firstly, additional data could be sourced to provide a further split in HH debt between mortgage institute, bank and consumer debt. Secondly, it might be possible to actively model the refinancing behaviour of Danish property buyers[41]. It might also be possible to include some measure of credit supply constraints, and or borrower risk, for example, non-performing loans. Further developments of the model could make this possible.

The core aim of the analysis was to test the sensitivity of HH and economic conditions of a potential shift in the composition of debt from ARM type products to fixed-interest products. This is an intuitively simple proposition, but the accurately scaled empirical model presented in this article provides a clear indication of the potential scale of these impacts. For a shift in the fixed proportion from 37% up to 80%, in the case of a 2% point increase in interest rates and a 20% decline in property prices, the difference in aggregate unemployment effects could be as much as 2%. The effects discussed for each sector mirror this increase in sensitivity. Both in the initial effects and in terms of volatility in subsequent periods.

[41] There is unfortunately no data available at an individual level that would be representative of a rising interest rate environment.

The results thus provide evidence to support reports made by the IMF (Sheehy, 2014), the Danish national bank (Danmarks Nationalbank, 2016) and the leading mortgage credit institution in Denmark, Nykredit Realkredit (Skinhøj et al., 2019), that the increased concentration of household debt in ARM (flexible-rate) products has resulted in greater sensitivity (and thus less stability) of both HH and the Danish economy in general. This does not imply that the level of outstanding debt poses a systemic economic risk. Again in support of reports presented by the above institutions, it should be noted that simultaneous and sizable shocks to both the cost of borrowing and to property prices only resulted in modest effects on overall output, even where the shock is restricted to borrowing costs.

In contrast to suggestions regarding the systemic risk of household debt in itself, the analysis suggests that the potential risks related to the present high ratio of HH debt to disposable income in Denmark can be dramatically reduced through a migration of HH mortgage debt away from ARM type products towards fixed interest rate products. The all-time low levels of interest rates that are currently available also present an excellent opportunity to support this transition.

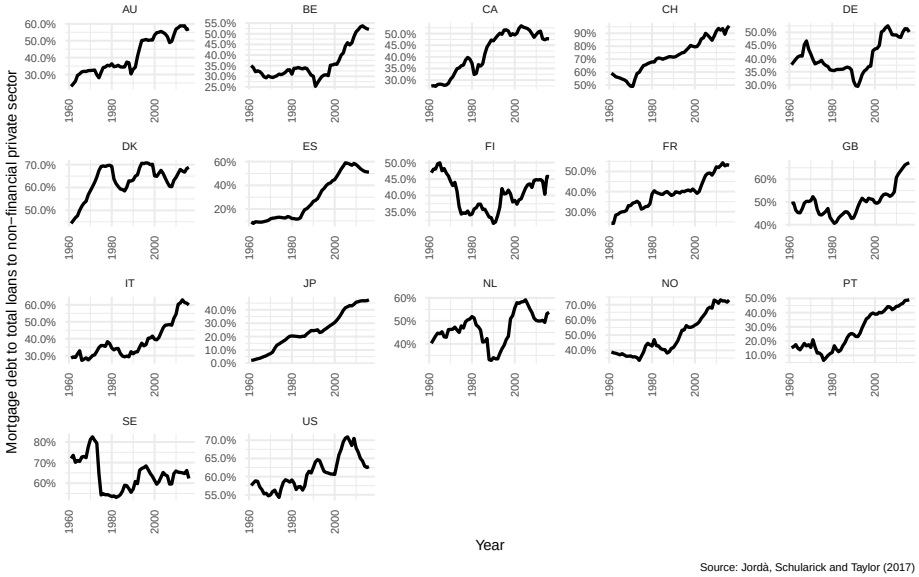


Figure 14.31: Mortgage debt as percentage of total loans

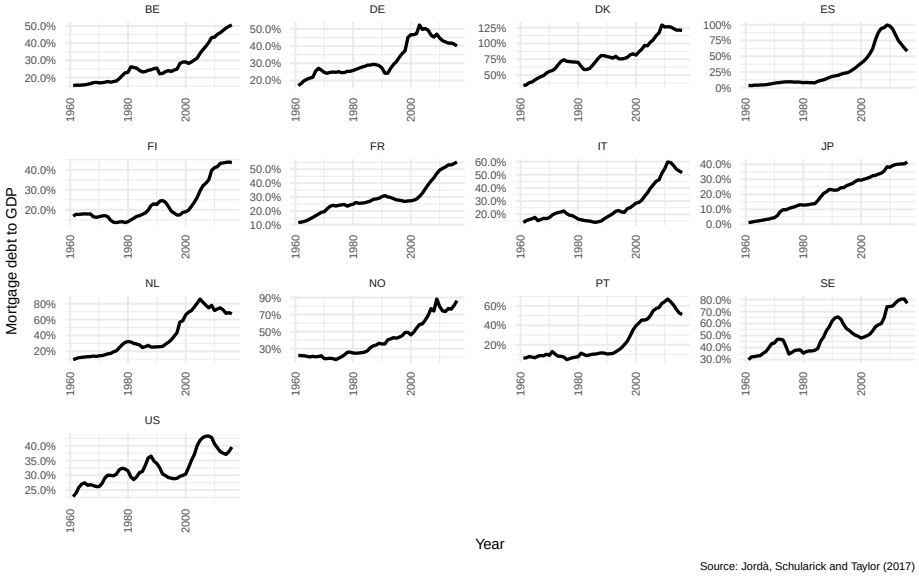


Figure 14.32: Mortgage debt to GDP

Table 14.4: OECD House price index changes, Year on year

Country	2000 to 2007	2007 to 2009	2009 to 2018
Estonia	15.89\%	-17.06\%	11.33\%
Costa Rica	08.94\%	06.07\%	04.11\%
Austria	03.63\%	03.01\%	03.97\%
Colombia	04.58\%	04.79\%	03.85\%
Hungary	13.52\%	08.14\%	03.01\%
Czech Republic	05.25\%	16.46\%	02.83\%
United States	04.10\%	01.82\%	02.78\%
Netherlands	03.35\%	02.03\%	02.62\%
Ireland	16.65\%	-12.57\%	02.50\%
Finland	02.96\%	00.33\%	02.43\%
Israel	00.55\%	05.02\%	02.40\%
Korea, Republic of	03.01\%	01.93\%	02.39\%
Norway	03.72\%	03.27\%	02.35\%
Poland	08.40\%	05.06\%	02.23\%
Mexico	06.03\%	03.23\%	02.15\%
New Zealand	00.97\%	02.29\%	02.07\%
Denmark	03.11\%	02.95\%	01.98\%
United Kingdom	03.52\%	02.65\%	01.95\%
Portugal	03.37\%	02.90\%	01.76\%
Sweden	02.56\%	02.92\%	01.56\%
Latvia	11.22\%	03.58\%	01.39\%
Luxembourg	02.87\%	02.79\%	01.31\%
Germany	01.30\%	01.17\%	01.23\%
Canada	01.64\%	01.63\%	01.09\%
Slovenia	12.31\%	02.53\%	01.00\%
France	03.36\%	02.15\%	00.82\%
Italy	03.07\%	02.95\%	00.80\%
Switzerland	01.87\%	02.46\%	00.75\%
Slovakia	22.41\%	04.09\%	00.42\%
Spain	05.69\%	03.72\%	00.29\%
Greece	06.25\%	03.82\%	-2.33\%
Japan	-0.27\%	-0.22\%	-0.31\%

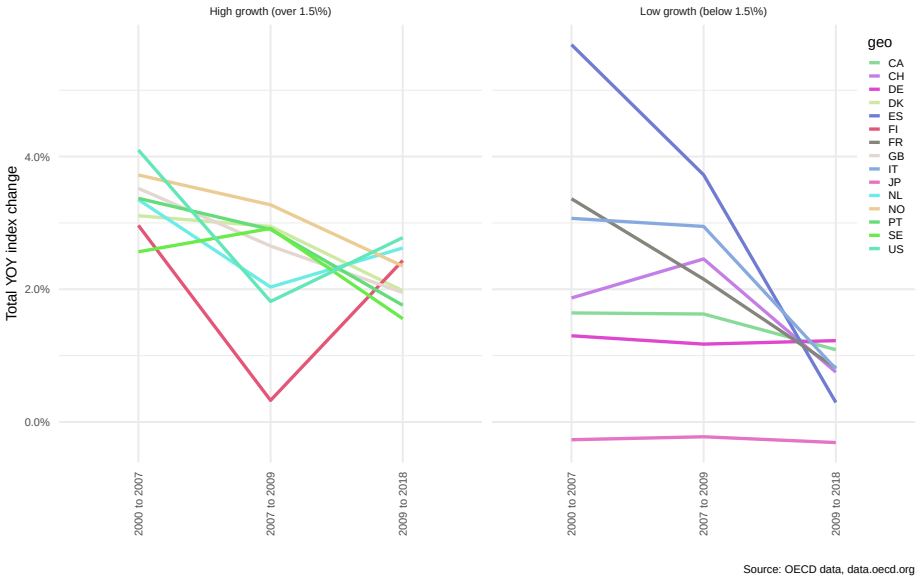


Figure 14.33: OECD house prices: Year-on-year changes

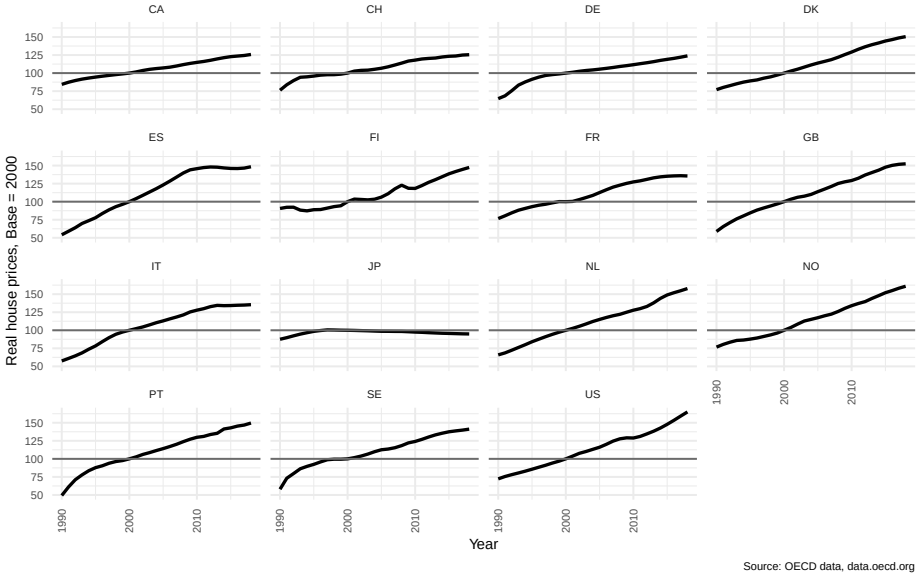


Figure 14.34: OECD house prices: Real price index

Table 14.5: Most affected variables: Perc change from baseline: Scenario 1, 2021: Economy wide

Variables	Type	Description
PY	Deflation index	Price deflator: GDP
CAB	Flow	Current account balance
FAB	Flow	Financial account balance
NX	Flow	Net Exports
I-Real prices	Flow	Gross fixed capital formation
I	Flow	Gross fixed capital formation
M	Flow	Imports
M-Real prices	Flow	Imports
PRIVATE	Flow	Gross income
S-Real prices	Flow	Savings
S	Flow	Savings
Y-Real prices	Flow	Total income
Y	Flow	Total income
B2	Flow	Gross operating surplus
ULC	Rate	Labour force: Unit labour cost: Price index: Index for the price deflator with re
UL-COST	Rate	Labour force: Unit labour cost
CU	Ratio	Capacity Utilisation (Real GNI / real capital stock)
WS	Ratio	Wage share

Table 14.6: Most affected variables: Perc change from baseline: Scenario 1, 2021: HH

Variables	Type	Description	Change
PIP-IBL-HH-Flexible	Flow	Property income paid: IBL	136.2914\%
PIP-IBL-HH	Flow	Property income paid: IBL	95.8530\%
IBA-HH-Transactions	Flow	Financial Assets: Interest bearing assets	-78.2793\%
FL-HH-Transactions	Flow	Financial liabilities	-73.9372\%
IBL-HH-Transactions	Flow	Financial Liabilities: Interest bearing liabilities	-73.9372\%
EQA-HH-Transactions	Flow	Financial Assets: Equity assets	-68.3376\%
NPIR-HH	Flow	Net property income received: Total	-58.6600\%
FA-HH-Transactions	Flow	Financial Assets	-54.5574\%
PIP-IBL-HH-Fixed	Flow	Property income paid: IBL	32.3802\%
FNL-HH	Flow	Financial Net Lending (Balance)	-16.6354\%
NL-HH	Flow	Sector Balance	-16.6354\%
S-HH	Flow	Savings	-10.3028\%
INV-HH-Real prices	Flow	Gross fixed capital formation	-6.8066\%
INV-HH	Flow	Gross fixed capital formation	-6.8066\%
PIR-IBA-HH	Flow	Property income received: IBA	-3.2347\%
Y-D-HH	Flow	Disposable Income	-2.5806\%
Y-HH	Flow	Total income	-2.5806\%
TAX-HH	Flow	Tax	-2.5806\%
Y-D-HH-Real prices	Flow	Disposable Income	-2.5806\%
C-HH-Real prices	Flow	Consumption	-1.3327\%
C-HH	Flow	Consumption	-1.3326\%
R-IBL-HH-Flexible	Rate	Rate of interest: Interest bearing liabilities	141.7474\%
R-IBL-HH-Fixed	Rate	Rate of interest: Interest bearing liabilities	35.4369\%
IBA-HH	Stock	Financial Assets: Interest bearing assets	-3.2347\%
IBL-HH	Stock	Financial Liabilities: Interest bearing liabilities	-2.2569\%
IBL-HH-Fixed	Stock	Financial Liabilities: Interest bearing liabilities	-2.2569\%
IBL-HH-Flexible	Stock	Financial Liabilities: Interest bearing liabilities	-2.2569\%
FA-HH	Stock	Financial Assets	-1.1087\%
EQA-HH	Stock	Financial Assets: Equity assets	-0.8157\%
K-HH	Stock	Stock of Capital	-0.2520\%
K-HH-Real prices	Stock	Stock of Capital	-0.2520\%
NW-HH	Stock	Net Wealth	-0.2223\%
NW-HH-Real prices	Stock	Net Wealth	-0.2222\%
FNW-HH-Real prices	Stock	Financial net wealth	-0.2044\%
FNW-HH	Stock	Financial net wealth	-0.2044\%

Table 14.7: Most affected variables: Perc change from baseline: Scenario 1, 2021: NFC

Variables	Type	Description	Change
FNL-NFC	Flow	Financial Net Lending (Balance)	-12.6166\%
NIB-NFC-Transactions	Flow	Net financial stock: Interest bearing	-12.6166\%
NL-NFC	Flow	Sector Balance	-12.6166\%
S-NFC	Flow	Savings	-1.1026\%
TAX-NFC	Flow	Tax	-0.2016\%
B2-NFC	Flow	Gross operating surplus	-0.1858\%
NIB-NFC	Stock	Net financial stock: Interest bearing	-0.5636\%
NW-NFC	Stock	Net Wealth	-0.2341\%
FNW-NFC	Stock	Financial net wealth	-0.2042\%

Table 14.8: Most affected variables: Perc change from baseline: Scenario 1, 2021: FC

Variables	Type	Description	Change
FNL-FC	Flow	Financial Net Lending (Balance)	569.1674\%
NL-FC	Flow	Sector Balance	569.1674\%
NPIR-FC	Flow	Net property income received: Total	323.5769\%
S-FC	Flow	Savings	275.5754\%
PIR-IBA-FC-HH-Flexible	Flow	Property income received: IBA	136.2914\%
IBL-FC-HH-Transactions	Flow	Financial Liabilities: Interest bearing liabilities	-78.2793\%
IBA-FC-HH-Transactions	Flow	Financial Assets: Interest bearing assets	-73.9372\%
NEQ-FC-Transactions	Flow	Net financial stock: Equity	68.3376\%
NIB-FC-Transactions	Flow	Net financial stock: Interest bearing	61.8225\%
PIR-IBA-FC-HH-Fixed	Flow	Property income received: IBA	32.3802\%
Y-FC	Flow	Total income	-0.0442\%
NEQ-FC	Stock	Net financial stock: Equity	46.2640\%
NW-FC	Stock	Net Wealth	42.8191\%
FNW-FC	Stock	Financial net wealth	23.0242\%
IBL-FC-HH	Stock	Financial Liabilities: Interest bearing liabilities	-3.2347\%
IBA-FC-HH	Stock	Financial Assets: Interest bearing assets	-2.2569\%
NIB-FC	Stock	Net financial stock: Interest bearing	02.0236\%

Table 14.9: Most affected variables: Perc change from baseline: Scenario 1, 2021: GOV

Variables	Type	Description	Change
FNL-GOV	Flow	Financial Net Lending (Balance)	-30.7775\%
NIB-GOV-Transactions	Flow	Net financial stock: Interest bearing	-30.7775\%
NL-GOV	Flow	Sector Balance	-30.7775\%
S-GOV	Flow	Savings	-11.8501\%
TAX-GOV	Flow	Tax	-1.5577\%
FNW-GOV	Stock	Financial net wealth	-9.1649\%
NIB-GOV	Stock	Net financial stock: Interest bearing	-9.1649\%
NW-GOV	Stock	Net Wealth	-1.2954\%

Table 14.10: Most affected variables: Perc change from baseline: Scenario 1, 2021: ROW

Variables	Type	Description	Change
FNL-ROW	Flow	Financial Net Lending (Balance)	-10.9700\%
NIB-ROW-Transactions	Flow	Net financial stock: Interest bearing	-10.9700\%
NL-ROW	Flow	Sector Balance	-10.9700\%
S-ROW	Flow	Savings	-10.9700\%
NIB-ROW	Stock	Net financial stock: Interest bearing	-1.2091\%
FNW-ROW	Stock	Financial net wealth	-0.6953\%
NW-ROW	Stock	Net Wealth	-0.6953\%

Table 14.11: Most affected variables: Perc change from baseline: Scenario 1: Economy wide, 2023

Variables	Type	Description
PY	Deflation index	Price deflator: GDP
PX	Deflation index	Price deflator: Exports
CAB	Flow	Current account balance
FAB	Flow	Financial account balance
NX	Flow	Net Exports
I-Real prices	Flow	Gross fixed capital formation
I	Flow	Gross fixed capital formation
M-Real prices	Flow	Imports
M	Flow	Imports
PRIVATE	Flow	Gross income
S-Real prices	Flow	Savings
S	Flow	Savings
Y-Real prices	Flow	Total income
Y	Flow	Total income
B2	Flow	Gross operating surplus
X-Real prices	Flow	Exports
X	Flow	Exports
UL-COST	Rate	Labour force: Unit labour cost
ULC	Rate	Labour force: Unit labour cost: Price index: Index for the price deflator with re
WAGE	Rate	Labour force: Wage rate
UR	Ratio	Labour force: Unemployment rate
CU	Ratio	Capacity Utilisation (Real GNI / real capital stock)
WS	Ratio	Wage share
UN	Stock	Labour force: Unemployed persons
N	Stock	Labour force: Denmark for workers in production
NF	Stock	Labour force: Employed persons: Danish waged
NU	Stock	Labour force: Employed persons: Danish nationals: Employed abroad

Table 14.12: Most affected variables: Perc change from baseline: Scenario 1: HH, 2023

Variables	Type	Description	Change
PIP-IBL-HH-Flexible	Flow	Property income paid: IBL	130.9800\%
PIP-IBL-HH	Flow	Property income paid: IBL	91.4505\%
NPIR-HH	Flow	Net property income received: Total	-59.5976\%
FL-HH-Transactions	Flow	Financial liabilities	-40.0111\%
IBL-HH-Transactions	Flow	Financial Liabilities: Interest bearing liabilities	-40.0111\%
EQA-HH-Transactions	Flow	Financial Assets: Equity assets	-37.1202\%
PIP-IBL-HH-Fixed	Flow	Property income paid: IBL	29.4045\%
IBA-HH-Transactions	Flow	Financial Assets: Interest bearing assets	-20.4450\%
FNL-HH	Flow	Financial Net Lending (Balance)	17.4954\%
NL-HH	Flow	Sector Balance	17.4954\%
FA-HH-Transactions	Flow	Financial Assets	-16.7101\%
INV-HH	Flow	Gross fixed capital formation	-12.4945\%
INV-HH-Real prices	Flow	Gross fixed capital formation	-12.4945\%
PIR-IBA-HH	Flow	Property income received: IBA	-5.5128\%
C-HH-Real prices	Flow	Consumption	-2.5833\%
C-HH	Flow	Consumption	-2.5833\%
TAX-HH	Flow	Tax	-2.3318\%
Y-D-HH-Real prices	Flow	Disposable Income	-2.3318\%
Y-D-HH	Flow	Disposable Income	-2.3318\%
Y-HH	Flow	Total income	-2.3317\%
SCO-HH	Flow	Social benefit contributions	-2.3195\%
STRA-HH	Flow	Social transfers	01.9329\%
PIR-EQA-HH	Flow	Property income received: EQA	-1.2325\%
S-HH	Flow	Savings	00.6134\%
PENA-HH-Transactions	Flow	Financial Assets: Pension assets	-0.2734\%
SBE-HH	Flow	Social benefit transfers	00.1583\%
W-HH	Flow	Wages	-0.0572\%
PIR-PENA-HH	Flow	Property income received: PENA	-0.0037\%
R-IBL-HH-Flexible	Rate	Rate of interest: Interest bearing liabilities	141.7474\%
R-IBL-HH-Fixed	Rate	Rate of interest: Interest bearing liabilities	35.4369\%
IBA-HH	Stock	Financial Assets: Interest bearing assets	-5.5128\%
IBL-HH-Fixed	Stock	Financial Liabilities: Interest bearing liabilities	-4.4541\%
IBL-HH	Stock	Financial Liabilities: Interest bearing liabilities	-4.4540\%
IBL-HH-Flexible	Stock	Financial Liabilities: Interest bearing liabilities	-4.4540\%
FA-HH	Stock	Financial Assets	-2.0294\%
EQA-HH	Stock	Financial Assets: Equity assets	-1.6706\%
K-HH	Stock	Stock of Capital	-0.8297\%
K-HH-Real prices	Stock	Stock of Capital	-0.8297\%
NW-HH	Stock	Net Wealth	-0.3508\%
NW-HH-Real prices	Stock	Net Wealth	-0.3508\%
FNW-HH	Stock	Financial net wealth	-0.0614\%
FNW-HH-Real prices	Stock	Financial net wealth	-0.0614\%
PENA-HH	Stock	Financial Assets: Pension assets	-0.0080\%

Table 14.13: Most affected variables: Perc change from baseline: Scenario 1: NFC, 2023

Variables	Type	Description	Change
FNL-NFC	Flow	Financial Net Lending (Balance)	-19.7550\%
NIB-NFC-Transactions	Flow	Net financial stock: Interest bearing	-19.7550\%
NL-NFC	Flow	Sector Balance	-19.7550\%
S-NFC	Flow	Savings	-1.6144\%
NPIR-NIB-NFC	Flow	Net property income received: NIB	-0.6404\%
TAX-NFC	Flow	Tax	-0.3297\%
B2-NFC	Flow	Gross operating surplus	-0.3054\%
INV-NFC-Real prices	Flow	Gross fixed capital formation	-0.2240\%
INV-NFC	Flow	Gross fixed capital formation	-0.2240\%
NPIR-NFC	Flow	Net property income received: Total	-0.1657\%
W-NFC	Flow	Wages	-0.0567\%
NIB-NFC	Stock	Net financial stock: Interest bearing	-1.4829\%
NW-NFC	Stock	Net Wealth	-0.6495\%
FNW-NFC	Stock	Financial net wealth	-0.5094\%
K-NFC	Stock	Stock of Capital	-0.0801\%
K-NFC-Real prices	Stock	Stock of Capital	-0.0801\%

Table 14.14: Most affected variables: Perc change from baseline: Scenario 1: FC, 2023

Variables	Type	Description	Change
FNL-FC	Flow	Financial Net Lending (Balance)	615.6131\%
NL-FC	Flow	Sector Balance	615.6131\%
NPIR-FC	Flow	Net property income received: Total	345.2026\%
S-FC	Flow	Savings	287.2370\%
NPIR-NEQ-FC	Flow	Net property income received: NEQ	232.6801\%
PIR-IBA-FC-HH-Flexible	Flow	Property income received: IBA	130.9800\%
NIB-FC-Transactions	Flow	Net financial stock: Interest bearing	75.2630\%
IBA-FC-HH-Transactions	Flow	Financial Assets: Interest bearing assets	-40.0111\%
NEQ-FC-Transactions	Flow	Net financial stock: Equity	37.1202\%
PIR-IBA-FC-HH-Fixed	Flow	Property income received: IBA	29.4045\%
IBL-FC-HH-Transactions	Flow	Financial Liabilities: Interest bearing liabilities	-20.4450\%
PIP-IBL-FC	Flow	Property income paid: IBL	-4.8349\%
NPIR-NIB-FC	Flow	Net property income received: NIB	04.0381\%
PENL-FC-Transactions	Flow	Financial Liabilities: Pension liabilities	-0.2734\%
Y-FC	Flow	Total income	-0.1069\%
PIP-PENL-FC	Flow	Property income paid: PENL	-0.0037\%
NEQ-FC	Stock	Net financial stock: Equity	239.4789\%
NW-FC	Stock	Net Wealth	157.9216\%
FNW-FC	Stock	Financial net wealth	76.6691\%
NIB-FC	Stock	Net financial stock: Interest bearing	06.9344\%
IBL-FC-HH	Stock	Financial Liabilities: Interest bearing liabilities	-5.5128\%
IBA-FC-HH	Stock	Financial Assets: Interest bearing assets	-4.4540\%
PENL-FC	Stock	Financial Liabilities: Pension liabilities	-0.0080\%

Table 14.15: Most affected variables: Perc change from baseline: Scenario 1: GOV, 2023

Variables	Type	Description	Change
FNL-GOV	Flow	Financial Net Lending (Balance)	-34.2672\%
NIB-GOV-Transactions	Flow	Net financial stock: Interest bearing	-34.2672\%
NL-GOV	Flow	Sector Balance	-34.2672\%
NPIR-GOV	Flow	Net property income received: Total	-15.3614\%
NPIR-NIB-GOV	Flow	Net property income received: NIB	-15.3614\%
S-GOV	Flow	Savings	-14.0661\%
TAX-GOV	Flow	Tax	-1.4651\%
STRA-GOV	Flow	Social transfers	-1.2092\%
FNW-GOV	Stock	Financial net wealth	-19.2726\%
NIB-GOV	Stock	Net financial stock: Interest bearing	-19.2726\%
NW-GOV	Stock	Net Wealth	-4.0170\%

Table 14.16: Most affected variables: Perc change from baseline: Scenario 1: ROW, 2023

Variables	Type	Description	Change
FNL-ROW	Flow	Financial Net Lending (Balance)	-19.5257\%
NIB-ROW-Transactions	Flow	Net financial stock: Interest bearing	-19.5257\%
NL-ROW	Flow	Sector Balance	-19.5257\%
S-ROW	Flow	Savings	-19.5257\%
NPIR-NIB-ROW	Flow	Net property income received: NIB	-2.3317\%
NPIR-ROW	Flow	Net property income received: Total	-1.1482\%
NIB-ROW	Stock	Net financial stock: Interest bearing	-4.1077\%
FNW-ROW	Stock	Financial net wealth	-2.5799\%
NW-ROW	Stock	Net Wealth	-2.5799\%

Table 14.17: Most affected variables: Perc change from baseline: Scenario 2, 2022: Economy wide

Variables	Type	Description
PY	Deflation index	Price deflator: GDP
CAB	Flow	Current account balance
FAB	Flow	Financial account balance
NX	Flow	Net Exports
I	Flow	Gross fixed capital formation
I-Real prices	Flow	Gross fixed capital formation
M-Real prices	Flow	Imports
M	Flow	Imports
PRIVATE	Flow	Gross income
S-Real prices	Flow	Savings
S	Flow	Savings
Y-Real prices	Flow	Total income
Y	Flow	Total income
B2	Flow	Gross operating surplus
ZZ1	Index	Index: House price: Imported from DST
ZZ-I	Index	Index: House price: Imported from DST
TOBIN-Q	Index	Index: House price index: Tobin's Q = Ratio between the house price index and
ULC	Rate	Labour force: Unit labour cost: Price index: Index for the price deflator with re
UL-COST	Rate	Labour force: Unit labour cost
CU	Ratio	Capacity Utilisation (Real GNI / real capital stock)
WS	Ratio	Wage share

Table 14.18: Most affected variables: Perc change from baseline: Scenario 2, 2022: HH

Variables	Type	Description	Change
FL-HH-Transactions	Flow	Financial liabilities	-62.3432\%
IBL-HH-Transactions	Flow	Financial Liabilities: Interest bearing liabilities	-62.3432\%
EQA-HH-Transactions	Flow	Financial Assets: Equity assets	-57.7498\%
IBA-HH-Transactions	Flow	Financial Assets: Interest bearing assets	-37.3670\%
FA-HH-Transactions	Flow	Financial Assets	-29.5485\%
FNL-HH	Flow	Financial Net Lending (Balance)	25.6920\%
NL-HH	Flow	Sector Balance	25.6920\%
INV-HH	Flow	Gross fixed capital formation	-16.9799\%
INV-HH-Real prices	Flow	Gross fixed capital formation	-16.9799\%
PIP-IBL-HH-Fixed	Flow	Property income paid: IBL	-1.9007\%
PIP-IBL-HH	Flow	Property income paid: IBL	-1.9007\%
PIP-IBL-HH-Flexible	Flow	Property income paid: IBL	-1.9006\%
PIR-IBA-HH	Flow	Property income received: IBA	-1.5899\%
NPIR-HH	Flow	Net property income received: Total	00.7082\%
K-HH	Stock	Stock of Capital	-8.3997\%
K-HH-Real prices	Stock	Stock of Capital	-8.3997\%
NW-HH	Stock	Net Wealth	-2.9289\%
NW-HH-Real prices	Stock	Net Wealth	-2.9289\%
IBL-HH-Flexible	Stock	Financial Liabilities: Interest bearing liabilities	-1.9007\%
IBL-HH	Stock	Financial Liabilities: Interest bearing liabilities	-1.9006\%
IBL-HH-Fixed	Stock	Financial Liabilities: Interest bearing liabilities	-1.9006\%
IBA-HH	Stock	Financial Assets: Interest bearing assets	-1.5899\%
EQA-HH	Stock	Financial Assets: Equity assets	-0.6999\%
FA-HH	Stock	Financial Assets	-0.6383\%
FNW-HH-Real prices	Stock	Financial net wealth	00.3723\%
FNW-HH	Stock	Financial net wealth	00.3722\%

Table 14.19: Most affected variables: Perc change from baseline: Scenario 2, 2022: NFC

Variables	Type	Description	Change
FNL-NFC	Flow	Financial Net Lending (Balance)	-8.8374\%
NIB-NFC-Transactions	Flow	Net financial stock: Interest bearing	-8.8374\%
NL-NFC	Flow	Sector Balance	-8.8374\%
S-NFC	Flow	Savings	-0.6918\%
TAX-NFC	Flow	Tax	-0.1265\%
B2-NFC	Flow	Gross operating surplus	-0.1169\%
NIB-NFC	Stock	Net financial stock: Interest bearing	-0.3771\%
NW-NFC	Stock	Net Wealth	-0.1397\%
FNW-NFC	Stock	Financial net wealth	-0.1330\%

Table 14.20: Most affected variables: Perc change from baseline: Scenario 2, 2022: FC

Variables	Type	Description	Change
IBA-FC-HH-Transactions	Flow	Financial Assets: Interest bearing assets	-62.3432\%
NEQ-FC-Transactions	Flow	Net financial stock: Equity	57.7498\%
IBL-FC-HH-Transactions	Flow	Financial Liabilities: Interest bearing liabilities	-37.3670\%
NIB-FC-Transactions	Flow	Net financial stock: Interest bearing	22.7852\%
NPIR-FC	Flow	Net property income received: Total	-6.6143\%
PIR-IBA-FC-HH-Fixed	Flow	Property income received: IBA	-1.9007\%
PIR-IBA-FC-HH-Flexible	Flow	Property income received: IBA	-1.9006\%
Y-FC	Flow	Total income	-0.0278\%
NEQ-FC	Stock	Net financial stock: Equity	132.1362\%
IBA-FC-HH	Stock	Financial Assets: Interest bearing assets	-1.9006\%
IBL-FC-HH	Stock	Financial Liabilities: Interest bearing liabilities	-1.5899\%
NIB-FC	Stock	Net financial stock: Interest bearing	00.8395\%

Table 14.21: Most affected variables: Perc change from baseline: Scenario 2, 2022: GOV

Variables	Type	Description	Change
FNL-GOV	Flow	Financial Net Lending (Balance)	-0.9744\%
NIB-GOV-Transactions	Flow	Net financial stock: Interest bearing	-0.9744\%
NL-GOV	Flow	Sector Balance	-0.9744\%
S-GOV	Flow	Savings	-0.3880\%
TAX-GOV	Flow	Tax	-0.0521\%
FNW-GOV	Stock	Financial net wealth	-0.2368\%
NIB-GOV	Stock	Net financial stock: Interest bearing	-0.2368\%
NW-GOV	Stock	Net Wealth	-0.0415\%

Table 14.22: Most affected variables: Perc change from baseline: Scenario 2, 2022: ROW

Variables	Type	Description	Change
FNL-ROW	Flow	Financial Net Lending (Balance)	-8.1425\%
NIB-ROW-Transactions	Flow	Net financial stock: Interest bearing	-8.1425\%
NL-ROW	Flow	Sector Balance	-8.1425\%
S-ROW	Flow	Savings	-8.1425\%
NIB-ROW	Stock	Net financial stock: Interest bearing	-0.8668\%
FNW-ROW	Stock	Financial net wealth	-0.5220\%
NW-ROW	Stock	Net Wealth	-0.5220\%

Table 14.23: Most affected variables: Perc change from baseline: Scenario 2, 2025: Economy wide

Variables	Type	Description
PY	Deflation index	Price deflator: GDP
PX	Deflation index	Price deflator: Exports
PC	Deflation index	Price deflator: Consumption
CAB	Flow	Current account balance
FAB	Flow	Financial account balance
NX	Flow	Net Exports
I	Flow	Gross fixed capital formation
I-Real prices	Flow	Gross fixed capital formation
M	Flow	Imports
M-Real prices	Flow	Imports
PRIVATE	Flow	Gross income
S-Real prices	Flow	Savings
S	Flow	Savings
Y-Real prices	Flow	Total income
Y	Flow	Total income
B2	Flow	Gross operating surplus
X-Real prices	Flow	Exports
X	Flow	Exports
TOBIN-Q	Index	Index: House price index: Tobin's Q = Ratio between the house pr
ZZ1	Index	Index: House price: Imported from DST
ZZ-I	Index	Index: House price: Imported from DST
UL-COST	Rate	Labour force: Unit labour cost
ULC	Rate	Labour force: Unit labour cost: Price index: Index for the price def
WAGE	Rate	Labour force: Wage rate
UR	Ratio	Labour force: Unemployment rate
CU	Ratio	Capacity Utilisation (Real GNI / real capital stock)
WS	Ratio	Wage share
UN	Stock	Labour force: Unemployed persons
N	Stock	Labour force: Denmark for workers in production
NF	Stock	Labour force: Employed persons: Danish waged
NU	Stock	Labour force: Employed persons: Danish nationals: Employed abro

Table 14.24: Most affected variables: Perc change from baseline: Scenario 2, 2025: HH

Variables	Type	Description	Change
FL-HH-Transactions	Flow	Financial liabilities	-40.8998\%
IBL-HH-Transactions	Flow	Financial Liabilities: Interest bearing liabilities	-40.8998\%
EQA-HH-Transactions	Flow	Financial Assets: Equity assets	-38.0412\%
FNL-HH	Flow	Financial Net Lending (Balance)	27.6257\%
NL-HH	Flow	Sector Balance	27.6257\%
INV-HH-Real prices	Flow	Gross fixed capital formation	-23.1670\%
INV-HH	Flow	Gross fixed capital formation	-23.1670\%
FA-HH-Transactions	Flow	Financial Assets	-9.2935\%
IBA-HH-Transactions	Flow	Financial Assets: Interest bearing assets	-7.5369\%
PIP-IBL-HH-Flexible	Flow	Property income paid: IBL	-6.1696\%
PIP-IBL-HH	Flow	Property income paid: IBL	-6.1696\%
PIP-IBL-HH-Fixed	Flow	Property income paid: IBL	-6.1696\%
PIR-IBA-HH	Flow	Property income received: IBA	-3.4809\%
S-HH	Flow	Savings	02.4518\%
PIR-EQA-HH	Flow	Property income received: EQA	-1.9534\%
NPIR-HH	Flow	Net property income received: Total	01.8554\%
STRA-HH	Flow	Social transfers	00.3734\%
C-HH	Flow	Consumption	-0.3563\%
C-HH-Real prices	Flow	Consumption	-0.3540\%
PENA-HH-Transactions	Flow	Financial Assets: Pension assets	-0.3143\%
SBE-HH	Flow	Social benefit transfers	00.2243\%
W-HH	Flow	Wages	-0.0775\%
Y-D-HH-Real prices	Flow	Disposable Income	00.0467\%
Y-HH	Flow	Total income	00.0445\%
TAX-HH	Flow	Tax	00.0444\%
Y-D-HH	Flow	Disposable Income	00.0444\%
SCO-HH	Flow	Social benefit contributions	00.0236\%
PIR-PENA-HH	Flow	Property income received: PENA	-0.0077\%
K-HH-Real prices	Stock	Stock of Capital	-11.5971\%
K-HH	Stock	Stock of Capital	-11.5971\%
IBL-HH-Fixed	Stock	Financial Liabilities: Interest bearing liabilities	-6.1696\%
IBL-HH	Stock	Financial Liabilities: Interest bearing liabilities	-6.1696\%
IBL-HH-Flexible	Stock	Financial Liabilities: Interest bearing liabilities	-6.1695\%
IBA-HH	Stock	Financial Assets: Interest bearing assets	-3.4809\%
NW-HH	Stock	Net Wealth	-3.0871\%
NW-HH-Real prices	Stock	Net Wealth	-3.0849\%
EQA-HH	Stock	Financial Assets: Equity assets	-2.3977\%
FNW-HH-Real prices	Stock	Financial net wealth	02.0247\%
FNW-HH	Stock	Financial net wealth	02.0224\%
FA-HH	Stock	Financial Assets	-1.6886\%
PENA-HH	Stock	Financial Assets: Pension assets	-0.0136\%

Table 14.25: Most affected variables: Perc change from baseline: Scenario 2, 2025: NFC

Variables	Type	Description	Change
FNL-NFC	Flow	Financial Net Lending (Balance)	-3.9717\%
NIB-NFC-Transactions	Flow	Net financial stock: Interest bearing	-3.9717\%
NL-NFC	Flow	Sector Balance	-3.9717\%
NPIR-NIB-NFC	Flow	Net property income received: NIB	-0.7335\%
S-NFC	Flow	Savings	-0.5667\%
INV-NFC-Real prices	Flow	Gross fixed capital formation	-0.3277\%
INV-NFC	Flow	Gross fixed capital formation	-0.3277\%
NPIR-NFC	Flow	Net property income received: Total	-0.1786\%
TAX-NFC	Flow	Tax	-0.1514\%
B2-NFC	Flow	Gross operating surplus	-0.1411\%
W-NFC	Flow	Wages	-0.0769\%
NIB-NFC	Stock	Net financial stock: Interest bearing	-0.9374\%
NW-NFC	Stock	Net Wealth	-0.4605\%
FNW-NFC	Stock	Financial net wealth	-0.3047\%
K-NFC-Real prices	Stock	Stock of Capital	-0.1153\%
K-NFC	Stock	Stock of Capital	-0.1153\%

14.9 Appendix

14.9.1 Mortgage debt as a percentage of total loans to non-financial private sector (nominal, local currency)

14.9.2 Mortgage debt to GDP

14.9.3 House Prices

14.9.4 Simulation most affected variables in each shock

14.9.4.1 Scenario 1: Percentage from baseline: An increase in 2020 interest rates, measured in 2021

14.9.4.2 Scenario 1: Percentage from baseline: An increase in 2020 interest rates, measured in 2023

14.9.4.3 Scenario 2: Percentage from baseline: Fall in 2022 property prices, measured in 2022

14.9.4.4 Scenario 2: Percentage from baseline: Fall in 2022 property prices, measured in 2025

14.9.4.5 Scenario 3: Percentage from baseline: Combined scenario 1 and 2, measured in 2021

14.9.4.6 Scenario 3: Percentage from baseline: Combined scenario 1 and 2, measured in 2025

14.9.4.7 Scenario 4: Percentage from baseline: Scenario 3, plus α increased to 80% in 2017, measured in 2021

14.9.4.8 Scenario 4: Percentage from baseline: Scenario 3, plus α increased to 80% in 2017, measured in 2025

Table 14.26: Most affected variables: Perc change from baseline: Scenario 2, 2025: FC

Variables	Type	Description	Change
NPIR-NEQ-FC	Flow	Net property income received: NEQ	101.8950\%
IBA-FC-HH-Transactions	Flow	Financial Assets: Interest bearing assets	-40.8998\%
NEQ-FC-Transactions	Flow	Net financial stock: Equity	38.0412\%
NIB-FC-Transactions	Flow	Net financial stock: Interest bearing	25.4575\%
IBL-FC-HH-Transactions	Flow	Financial Liabilities: Interest bearing liabilities	-7.5369\%
PIR-IBA-FC-HH-Flexible	Flow	Property income received: IBA	-6.1696\%
PIR-IBA-FC-HH-Fixed	Flow	Property income received: IBA	-6.1696\%
NPIR-FC	Flow	Net property income received: Total	-5.7659\%
PIP-IBL-FC	Flow	Property income paid: IBL	-3.2914\%
NPIR-NIB-FC	Flow	Net property income received: NIB	03.1540\%
FNL-FC	Flow	Financial Net Lending (Balance)	-2.4247\%
NL-FC	Flow	Sector Balance	-2.4247\%
S-FC	Flow	Savings	-1.0750\%
PENL-FC-Transactions	Flow	Financial Liabilities: Pension liabilities	-0.3143\%
Y-FC	Flow	Total income	-0.0801\%
PIP-PENL-FC	Flow	Property income paid: PENL	-0.0077\%
NEQ-FC	Stock	Net financial stock: Equity	76.7352\%
IBA-FC-HH	Stock	Financial Assets: Interest bearing assets	-6.1696\%
NIB-FC	Stock	Net financial stock: Interest bearing	04.2019\%
IBL-FC-HH	Stock	Financial Liabilities: Interest bearing liabilities	-3.4809\%
NW-FC	Stock	Net Wealth	-0.5494\%
FNW-FC	Stock	Financial net wealth	-0.2333\%
PENL-FC	Stock	Financial Liabilities: Pension liabilities	-0.0136\%

Table 14.27: Most affected variables: Perc change from baseline: Scenario 2, 2025: GOV

Variables	Type	Description	Change
FNL-GOV	Flow	Financial Net Lending (Balance)	-1.9261\%
NIB-GOV-Transactions	Flow	Net financial stock: Interest bearing	-1.9261\%
NL-GOV	Flow	Sector Balance	-1.9261\%
S-GOV	Flow	Savings	-0.8339\%
NPIR-GOV	Flow	Net property income received: Total	-0.8226\%
NPIR-NIB-GOV	Flow	Net property income received: NIB	-0.8226\%
STRA-GOV	Flow	Social transfers	-0.2320\%
TAX-GOV	Flow	Tax	-0.0374\%
FNW-GOV	Stock	Financial net wealth	-1.0013\%
NIB-GOV	Stock	Net financial stock: Interest bearing	-1.0013\%
NW-GOV	Stock	Net Wealth	-0.2694\%

Table 14.28: Most affected variables: Perc change from baseline: Scenario 2, 2025: ROW

Variables	Type	Description	Change
FNL-ROW	Flow	Financial Net Lending (Balance)	-11.7439\%
NIB-ROW-Transactions	Flow	Net financial stock: Interest bearing	-11.7439\%
NL-ROW	Flow	Sector Balance	-11.7439\%
S-ROW	Flow	Savings	-11.7439\%
NPIR-NIB-ROW	Flow	Net property income received: NIB	-3.1359\%
NPIR-ROW	Flow	Net property income received: Total	-1.7125\%
NIB-ROW	Stock	Net financial stock: Interest bearing	-3.9822\%
FNW-ROW	Stock	Financial net wealth	-2.6903\%
NW-ROW	Stock	Net Wealth	-2.6903\%

Table 14.29: Most affected variables: Perc change from baseline: Scenario 3, 2021: Economy wide

Variables	Type	Description
PY	Deflation index	Price deflator: GDP
CAB	Flow	Current account balance
FAB	Flow	Financial account balance
NX	Flow	Net Exports
I-Real prices	Flow	Gross fixed capital formation
I	Flow	Gross fixed capital formation
M	Flow	Imports
M-Real prices	Flow	Imports
PRIVATE	Flow	Gross income
S-Real prices	Flow	Savings
S	Flow	Savings
Y-Real prices	Flow	Total income
Y	Flow	Total income
B2	Flow	Gross operating surplus
ULC	Rate	Labour force: Unit labour cost: Price index: Index for the price def
UL-COST	Rate	Labour force: Unit labour cost
CU	Ratio	Capacity Utilisation (Real GNI / real capital stock)
WS	Ratio	Wage share

Table 14.30: Most affected variables: Perc change from baseline: Scenario 3, 2021: HH

Variables	Type	Description	Change
PIP-IBL-HH-Flexible	Flow	Property income paid: IBL	136.2914\%
PIP-IBL-HH	Flow	Property income paid: IBL	95.8530\%
IBA-HH-Transactions	Flow	Financial Assets: Interest bearing assets	-78.2793\%
FL-HH-Transactions	Flow	Financial liabilities	-73.9372\%
IBL-HH-Transactions	Flow	Financial Liabilities: Interest bearing liabilities	-73.9372\%
EQA-HH-Transactions	Flow	Financial Assets: Equity assets	-68.3376\%
NPIR-HH	Flow	Net property income received: Total	-58.6600\%
FA-HH-Transactions	Flow	Financial Assets	-54.5574\%
PIP-IBL-HH-Fixed	Flow	Property income paid: IBL	32.3802\%
FNL-HH	Flow	Financial Net Lending (Balance)	-16.6354\%
NL-HH	Flow	Sector Balance	-16.6354\%
S-HH	Flow	Savings	-10.3028\%
INV-HH-Real prices	Flow	Gross fixed capital formation	-6.8066\%
INV-HH	Flow	Gross fixed capital formation	-6.8066\%
PIR-IBA-HH	Flow	Property income received: IBA	-3.2347\%
Y-D-HH	Flow	Disposable Income	-2.5806\%
Y-HH	Flow	Total income	-2.5806\%
TAX-HH	Flow	Tax	-2.5806\%
Y-D-HH-Real prices	Flow	Disposable Income	-2.5806\%
C-HH-Real prices	Flow	Consumption	-1.3327\%
C-HH	Flow	Consumption	-1.3326\%
R-IBL-HH-Flexible	Rate	Rate of interest: Interest bearing liabilities	141.7474\%
R-IBL-HH-Fixed	Rate	Rate of interest: Interest bearing liabilities	35.4369\%
IBA-HH	Stock	Financial Assets: Interest bearing assets	-3.2347\%
IBL-HH	Stock	Financial Liabilities: Interest bearing liabilities	-2.2569\%
IBL-HH-Fixed	Stock	Financial Liabilities: Interest bearing liabilities	-2.2569\%
IBL-HH-Flexible	Stock	Financial Liabilities: Interest bearing liabilities	-2.2569\%
FA-HH	Stock	Financial Assets	-1.1087\%
EQA-HH	Stock	Financial Assets: Equity assets	-0.8157\%
K-HH	Stock	Stock of Capital	-0.2520\%
K-HH-Real prices	Stock	Stock of Capital	-0.2520\%
NW-HH	Stock	Net Wealth	-0.2223\%
NW-HH-Real prices	Stock	Net Wealth	-0.2222\%
FNW-HH-Real prices	Stock	Financial net wealth	-0.2044\%
FNW-HH	Stock	Financial net wealth	-0.2044\%

Table 14.31: Most affected variables: Perc change from baseline: Scenario 3, 2021: NFC

Variables	Type	Description	Change
FNL-NFC	Flow	Financial Net Lending (Balance)	-12.6166\%
NIB-NFC-Transactions	Flow	Net financial stock: Interest bearing	-12.6166\%
NL-NFC	Flow	Sector Balance	-12.6166\%
S-NFC	Flow	Savings	-1.1026\%
TAX-NFC	Flow	Tax	-0.2016\%
B2-NFC	Flow	Gross operating surplus	-0.1858\%
NIB-NFC	Stock	Net financial stock: Interest bearing	-0.5636\%
NW-NFC	Stock	Net Wealth	-0.2341\%
FNW-NFC	Stock	Financial net wealth	-0.2042\%

Table 14.32: Most affected variables: Perc change from baseline: Scenario 3, 2021: FC

Variables	Type	Description	Change
FNL-FC	Flow	Financial Net Lending (Balance)	569.1674\%
NL-FC	Flow	Sector Balance	569.1674\%
NPIR-FC	Flow	Net property income received: Total	323.5769\%
S-FC	Flow	Savings	275.5754\%
PIR-IBA-FC-HH-Flexible	Flow	Property income received: IBA	136.2914\%
IBL-FC-HH-Transactions	Flow	Financial Liabilities: Interest bearing liabilities	-78.2793\%
IBA-FC-HH-Transactions	Flow	Financial Assets: Interest bearing assets	-73.9372\%
NEQ-FC-Transactions	Flow	Net financial stock: Equity	68.3376\%
NIB-FC-Transactions	Flow	Net financial stock: Interest bearing	61.8225\%
PIR-IBA-FC-HH-Fixed	Flow	Property income received: IBA	32.3802\%
Y-FC	Flow	Total income	-0.0442\%
NEQ-FC	Stock	Net financial stock: Equity	46.2640\%
NW-FC	Stock	Net Wealth	42.8191\%
FNW-FC	Stock	Financial net wealth	23.0242\%
IBL-FC-HH	Stock	Financial Liabilities: Interest bearing liabilities	-3.2347\%
IBA-FC-HH	Stock	Financial Assets: Interest bearing assets	-2.2569\%
NIB-FC	Stock	Net financial stock: Interest bearing	02.0236\%

Table 14.33: Most affected variables: Perc change from baseline: Scenario 3, 2021: GOV

Variables	Type	Description	Change
FNL-GOV	Flow	Financial Net Lending (Balance)	-30.7775\%
NIB-GOV-Transactions	Flow	Net financial stock: Interest bearing	-30.7775\%
NL-GOV	Flow	Sector Balance	-30.7775\%
S-GOV	Flow	Savings	-11.8501\%
TAX-GOV	Flow	Tax	-1.5577\%
FNW-GOV	Stock	Financial net wealth	-9.1649\%
NIB-GOV	Stock	Net financial stock: Interest bearing	-9.1649\%
NW-GOV	Stock	Net Wealth	-1.2954\%

Table 14.34: Most affected variables: Perc change from baseline: Scenario 3, 2021: ROW

Variables	Type	Description	Change
FNL-ROW	Flow	Financial Net Lending (Balance)	-10.9700\%
NIB-ROW-Transactions	Flow	Net financial stock: Interest bearing	-10.9700\%
NL-ROW	Flow	Sector Balance	-10.9700\%
S-ROW	Flow	Savings	-10.9700\%
NIB-ROW	Stock	Net financial stock: Interest bearing	-1.2091\%
FNW-ROW	Stock	Financial net wealth	-0.6953\%
NW-ROW	Stock	Net Wealth	-0.6953\%

Table 14.35: Most affected variables: Perc change from baseline: Scenario 3, 2025: Economy wide

Variables	Type	Description
PY	Deflation index	Price deflator: GDP
PX	Deflation index	Price deflator: Exports
PC	Deflation index	Price deflator: Consumption
CAB	Flow	Current account balance
FAB	Flow	Financial account balance
NX	Flow	Net Exports
I	Flow	Gross fixed capital formation
I-Real prices	Flow	Gross fixed capital formation
M	Flow	Imports
M-Real prices	Flow	Imports
PRIVATE	Flow	Gross income
S-Real prices	Flow	Savings
S	Flow	Savings
Y-Real prices	Flow	Total income
Y	Flow	Total income
B2	Flow	Gross operating surplus
X-Real prices	Flow	Exports
X	Flow	Exports
TOBIN-Q	Index	Index: House price index: Tobin's Q = Ratio between the house pr
ZZ1	Index	Index: House price: Imported from DST
ZZ-I	Index	Index: House price: Imported from DST
UL-COST	Rate	Labour force: Unit labour cost
ULC	Rate	Labour force: Unit labour cost: Price index: Index for the price def
WAGE	Rate	Labour force: Wage rate
UR	Ratio	Labour force: Unemployment rate
CU	Ratio	Capacity Utilisation (Real GNI / real capital stock)
WS	Ratio	Wage share
UN	Stock	Labour force: Unemployed persons
N	Stock	Labour force: Denmark for workers in production
NF	Stock	Labour force: Employed persons: Danish waged
NU	Stock	Labour force: Employed persons: Danish nationals: Employed abro

Table 14.36: Most affected variables: Perc change from baseline: Scenario 3, 2025: HH

Variables	Type	Description	Change
PIP-IBL-HH-Flexible	Flow	Property income paid: IBL	116.0762\%
PIP-IBL-HH	Flow	Property income paid: IBL	79.0974\%
NPIR-HH	Flow	Net property income received: Total	-55.5466\%
FL-HH-Transactions	Flow	Financial liabilities	-51.9626\%
IBL-HH-Transactions	Flow	Financial Liabilities: Interest bearing liabilities	-51.9626\%
EQA-HH-Transactions	Flow	Financial Assets: Equity assets	-48.3308\%
FNL-HH	Flow	Financial Net Lending (Balance)	38.0367\%
NL-HH	Flow	Sector Balance	38.0367\%
INV-HH	Flow	Gross fixed capital formation	-30.6438\%
INV-HH-Real prices	Flow	Gross fixed capital formation	-30.6438\%
PIP-IBL-HH-Fixed	Flow	Property income paid: IBL	21.0548\%
FA-HH-Transactions	Flow	Financial Assets	-10.4517\%
PIR-IBA-HH	Flow	Property income received: IBA	-8.1491\%
IBA-HH-Transactions	Flow	Financial Assets: Interest bearing assets	-6.7667\%
S-HH	Flow	Savings	03.9972\%
PIR-EQA-HH	Flow	Property income received: EQA	-3.5759\%
C-HH	Flow	Consumption	-3.0237\%
C-HH-Real prices	Flow	Consumption	-3.0184\%
STRA-HH	Flow	Social transfers	02.6078\%
SCO-HH	Flow	Social benefit contributions	-2.2286\%
Y-D-HH	Flow	Disposable Income	-2.1827\%
TAX-HH	Flow	Tax	-2.1827\%
Y-HH	Flow	Total income	-2.1827\%
Y-D-HH-Real prices	Flow	Disposable Income	-2.1774\%
PENA-HH-Transactions	Flow	Financial Assets: Pension assets	-0.7989\%
SBE-HH	Flow	Social benefit transfers	00.5458\%
W-HH	Flow	Wages	-0.1946\%
PIR-PENA-HH	Flow	Property income received: PENA	-0.0239\%
R-IBL-HH-Flexible	Rate	Rate of interest: Interest bearing liabilities	141.7474\%
R-IBL-HH-Fixed	Rate	Rate of interest: Interest bearing liabilities	35.4369\%
K-HH	Stock	Stock of Capital	-12.7563\%
K-HH-Real prices	Stock	Stock of Capital	-12.7562\%
IBL-HH-Flexible	Stock	Financial Liabilities: Interest bearing liabilities	-10.6191\%
IBL-HH	Stock	Financial Liabilities: Interest bearing liabilities	-10.6190\%
IBL-HH-Fixed	Stock	Financial Liabilities: Interest bearing liabilities	-10.6190\%
IBA-HH	Stock	Financial Assets: Interest bearing assets	-8.1491\%
EQA-HH	Stock	Financial Assets: Equity assets	-4.1269\%
FA-HH	Stock	Financial Assets	-3.5478\%
NW-HH	Stock	Net Wealth	-3.3432\%
NW-HH-Real prices	Stock	Net Wealth	-3.3380\%
FNW-HH-Real prices	Stock	Financial net wealth	02.3140\%
FNW-HH	Stock	Financial net wealth	02.3084\%
PENA-HH	Stock	Financial Assets: Pension assets	-0.0388\%

Table 14.37: Most affected variables: Perc change from baseline: Scenario 3, 2025: NFC

Variables	Type	Description	Change
FNL-NFC	Flow	Financial Net Lending (Balance)	-15.5018\%
NIB-NFC-Transactions	Flow	Net financial stock: Interest bearing	-15.5018\%
NL-NFC	Flow	Sector Balance	-15.5018\%
NPIR-NIB-NFC	Flow	Net property income received: NIB	-2.4045\%
S-NFC	Flow	Savings	-1.6316\%
INV-NFC	Flow	Gross fixed capital formation	-0.6578\%
INV-NFC-Real prices	Flow	Gross fixed capital formation	-0.6578\%
NPIR-NFC	Flow	Net property income received: Total	-0.5855\%
TAX-NFC	Flow	Tax	-0.4163\%
B2-NFC	Flow	Gross operating surplus	-0.3880\%
W-NFC	Flow	Wages	-0.1930\%
NIB-NFC	Stock	Net financial stock: Interest bearing	-3.1805\%
NW-NFC	Stock	Net Wealth	-1.3873\%
FNW-NFC	Stock	Financial net wealth	-1.0337\%
K-NFC-Real prices	Stock	Stock of Capital	-0.2950\%
K-NFC	Stock	Stock of Capital	-0.2950\%

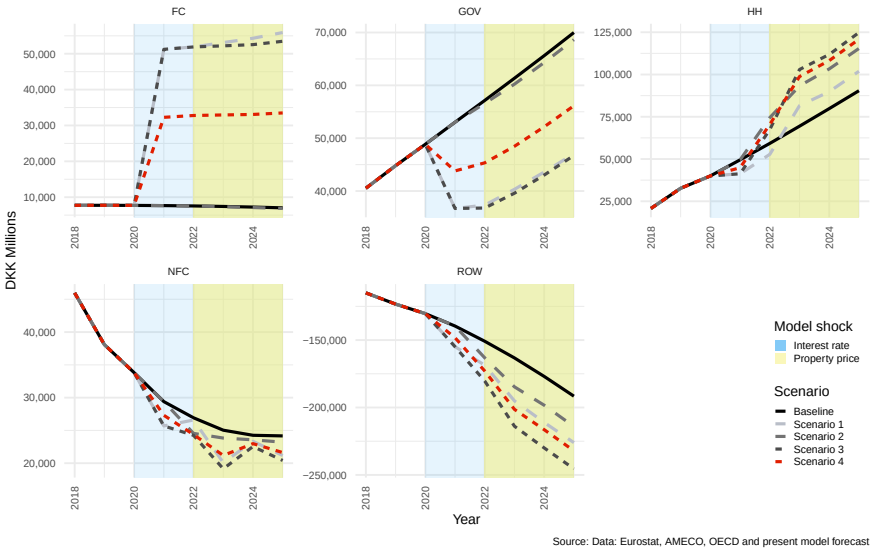


Figure 14.36: Net Lending

Table 14.38: Most affected variables: Perc change from baseline: Scenario 3, 2025: FC

Variables	Type	Description	Change
FNL-FC	Flow	Financial Net Lending (Balance)	660.5146\%
NL-FC	Flow	Sector Balance	660.5146\%
NPIR-FC	Flow	Net property income received: Total	342.8977\%
S-FC	Flow	Savings	292.8453\%
NPIR-NEQ-FC	Flow	Net property income received: NEQ	186.5300\%
PIR-IBA-FC-HH-Flexible	Flow	Property income received: IBA	116.0762\%
NIB-FC-Transactions	Flow	Net financial stock: Interest bearing	82.9489\%
IBA-FC-HH-Transactions	Flow	Financial Assets: Interest bearing assets	-51.9626\%
NEQ-FC-Transactions	Flow	Net financial stock: Equity	48.3308\%
PIR-IBA-FC-HH-Fixed	Flow	Property income received: IBA	21.0548\%
NPIR-NIB-FC	Flow	Net property income received: NIB	12.3172\%
PIP-IBL-FC	Flow	Property income paid: IBL	-8.2137\%
IBL-FC-HH-Transactions	Flow	Financial Liabilities: Interest bearing liabilities	-6.7667\%
PENL-FC-Transactions	Flow	Financial Liabilities: Pension liabilities	-0.7989\%
Y-FC	Flow	Total income	-0.2090\%
PIP-PENL-FC	Flow	Property income paid: PENL	-0.0238\%
NW-FC	Stock	Net Wealth	330.4677\%
FNW-FC	Stock	Financial net wealth	140.2816\%
NEQ-FC	Stock	Net financial stock: Equity	132.0764\%
NIB-FC	Stock	Net financial stock: Interest bearing	15.6355\%
IBA-FC-HH	Stock	Financial Assets: Interest bearing assets	-10.6190\%
IBL-FC-HH	Stock	Financial Liabilities: Interest bearing liabilities	-8.1491\%
PENL-FC	Stock	Financial Liabilities: Pension liabilities	-0.0386\%

Table 14.39: Most affected variables: Perc change from baseline: Scenario 3, 2025: GOV

Variables	Type	Description	Change
FNL-GOV	Flow	Financial Net Lending (Balance)	-33.2304\%
NIB-GOV-Transactions	Flow	Net financial stock: Interest bearing	-33.2304\%
NL-GOV	Flow	Sector Balance	-33.2304\%
NPIR-GOV	Flow	Net property income received: Total	-22.3750\%
NPIR-NIB-GOV	Flow	Net property income received: NIB	-22.3750\%
S-GOV	Flow	Savings	-14.3875\%
STRA-GOV	Flow	Social transfers	-1.6202\%
TAX-GOV	Flow	Tax	-1.4130\%
FNW-GOV	Stock	Financial net wealth	-24.1332\%
NIB-GOV	Stock	Net financial stock: Interest bearing	-24.1332\%
NW-GOV	Stock	Net Wealth	-6.4939\%

Table 14.40: Most affected variables: Perc change from baseline: Scenario 3, 2025: ROW

Variables	Type	Description	Change
FNL-ROW	Flow	Financial Net Lending (Balance)	-28.0969\%
NIB-ROW-Transactions	Flow	Net financial stock: Interest bearing	-28.0969\%
NL-ROW	Flow	Sector Balance	-28.0969\%
S-ROW	Flow	Savings	-28.0969\%
NPIR-NIB-ROW	Flow	Net property income received: NIB	-8.4498\%
NPIR-ROW	Flow	Net property income received: Total	-4.6143\%
NIB-ROW	Stock	Net financial stock: Interest bearing	-10.3814\%
FNW-ROW	Stock	Financial net wealth	-7.0134\%
NW-ROW	Stock	Net Wealth	-7.0134\%

Table 14.41: Most affected variables: Perc change from baseline: Scenario 4, 2021: Economy wide

Variables	Type	Description
PY	Deflation index	Price deflator: GDP
CAB	Flow	Current account balance
FAB	Flow	Financial account balance
NX	Flow	Net Exports
I	Flow	Gross fixed capital formation
I-Real prices	Flow	Gross fixed capital formation
M	Flow	Imports
M-Real prices	Flow	Imports
PRIVATE	Flow	Gross income
S-Real prices	Flow	Savings
S	Flow	Savings
Y-Real prices	Flow	Total income
Y	Flow	Total income
B2	Flow	Gross operating surplus
ULC	Rate	Labour force: Unit labour cost: Price index: Index for the price def
UL-COST	Rate	Labour force: Unit labour cost
ALPHA	Ratio	Ratio of fixed interest mortgage debt
CU	Ratio	Capacity Utilisation (Real GNI / real capital stock)
WS	Ratio	Wage share

Table 14.42: Most affected variables: Perc change from baseline: Scenario 4, 2021: HH

Variables	Type	Description	C
PIP-IBL-HH-Fixed	Flow	Property income paid: IBL	1
PIP-IBL-HH	Flow	Property income paid: IBL	5
IBA-HH-Transactions	Flow	Financial Assets: Interest bearing assets	-5
FL-HH-Transactions	Flow	Financial liabilities	-4
IBL-HH-Transactions	Flow	Financial Liabilities: Interest bearing liabilities	-4
EQA-HH-Transactions	Flow	Financial Assets: Equity assets	-4
FA-HH-Transactions	Flow	Financial Assets	-3
NPIR-HH	Flow	Net property income received: Total	-3
PIP-IBL-HH-Flexible	Flow	Property income paid: IBL	-2
FNL-HH	Flow	Financial Net Lending (Balance)	-9
NL-HH	Flow	Sector Balance	-9
S-HH	Flow	Savings	-5
INV-HH	Flow	Gross fixed capital formation	-3
INV-HH-Real prices	Flow	Gross fixed capital formation	-3
PIR-IBA-HH	Flow	Property income received: IBA	-2
Y-D-HH	Flow	Disposable Income	-1
TAX-HH	Flow	Tax	-1
Y-D-HH-Real prices	Flow	Disposable Income	-1
Y-HH	Flow	Total income	-1
C-HH	Flow	Consumption	-0
C-HH-Real prices	Flow	Consumption	-0
R-IBL-SENS-HH	Rate	Rate of interest: Interest bearing liabilities: Weighted mortgage interest rate	1
R-IBL-HH-Flexible	Rate	Rate of interest: Interest bearing liabilities	1
R-IBL-HH-Fixed	Rate	Rate of interest: Interest bearing liabilities	3
IBL-HH-Fixed	Stock	Financial Liabilities: Interest bearing liabilities	1
IBL-HH-Flexible	Stock	Financial Liabilities: Interest bearing liabilities	-0
IBA-HH	Stock	Financial Assets: Interest bearing assets	-2
IBL-HH	Stock	Financial Liabilities: Interest bearing liabilities	-1
FA-HH	Stock	Financial Assets	-0
EQA-HH	Stock	Financial Assets: Equity assets	-0
K-HH	Stock	Stock of Capital	-0
K-HH-Real prices	Stock	Stock of Capital	-0
NW-HH-Real prices	Stock	Net Wealth	-0
NW-HH	Stock	Net Wealth	-0
FNW-HH-Real prices	Stock	Financial net wealth	-0
FNW-HH	Stock	Financial net wealth	-0

Table 14.43: Most affected variables: Perc change from baseline: Scenario 4, 2021: NFC

Variables	Type	Description	Change
FNL-NFC	Flow	Financial Net Lending (Balance)	-7.1043\%
NIB-NFC-Transactions	Flow	Net financial stock: Interest bearing	-7.1043\%
NL-NFC	Flow	Sector Balance	-7.1043\%
S-NFC	Flow	Savings	-0.6208\%
TAX-NFC	Flow	Tax	-0.1135\%
B2-NFC	Flow	Gross operating surplus	-0.1046\%
NIB-NFC	Stock	Net financial stock: Interest bearing	-0.3174\%
NW-NFC	Stock	Net Wealth	-0.1318\%
FNW-NFC	Stock	Financial net wealth	-0.1150\%

Table 14.44: Most affected variables: Perc change from baseline: Scenario 4, 2021: FC

Variables	Type	Description	Change
FNL-FC	Flow	Financial Net Lending (Balance)	321.5055\%
NL-FC	Flow	Sector Balance	321.5055\%
NPIR-FC	Flow	Net property income received: Total	183.4174\%
PIR-IBA-FC-HH-Fixed	Flow	Property income received: IBA	174.2141\%
S-FC	Flow	Savings	155.6643\%
IBL-FC-HH-Transactions	Flow	Financial Liabilities: Interest bearing liabilities	-51.2763\%
IBA-FC-HH-Transactions	Flow	Financial Assets: Interest bearing assets	-49.4508\%
NEQ-FC-Transactions	Flow	Net financial stock: Equity	45.7057\%
NIB-FC-Transactions	Flow	Net financial stock: Interest bearing	34.9421\%
PIR-IBA-FC-HH-Flexible	Flow	Property income received: IBA	-22.0419\%
Y-FC	Flow	Total income	-0.0249\%
NEQ-FC	Stock	Net financial stock: Equity	30.9423\%
NW-FC	Stock	Net Wealth	24.1872\%
FNW-FC	Stock	Financial net wealth	13.0057\%
IBL-FC-HH	Stock	Financial Liabilities: Interest bearing liabilities	-2.1188\%
IBA-FC-HH	Stock	Financial Assets: Interest bearing assets	-1.5094\%
NIB-FC	Stock	Net financial stock: Interest bearing	01.1437\%

Table 14.45: Most affected variables: Perc change from baseline: Scenario 4, 2021: GOV

Variables	Type	Description	Change
FNL-GOV	Flow	Financial Net Lending (Balance)	-17.3824\%
NIB-GOV-Transactions	Flow	Net financial stock: Interest bearing	-17.3824\%
NL-GOV	Flow	Sector Balance	-17.3824\%
S-GOV	Flow	Savings	-6.6926\%
TAX-GOV	Flow	Tax	-0.8798\%
FNW-GOV	Stock	Financial net wealth	-5.1761\%
NIB-GOV	Stock	Net financial stock: Interest bearing	-5.1761\%
NW-GOV	Stock	Net Wealth	-0.7316\%

Table 14.46: Most affected variables: Perc change from baseline: Scenario 4, 2021: ROW

Variables	Type	Description	Change
FNL-ROW	Flow	Financial Net Lending (Balance)	-6.2108\%
NIB-ROW-Transactions	Flow	Net financial stock: Interest bearing	-6.2108\%
NL-ROW	Flow	Sector Balance	-6.2108\%
S-ROW	Flow	Savings	-6.2108\%
NIB-ROW	Stock	Net financial stock: Interest bearing	-0.6846\%
FNW-ROW	Stock	Financial net wealth	-0.3937\%
NW-ROW	Stock	Net Wealth	-0.3937\%

Table 14.47: Most affected variables: Perc change from baseline: Scenario 4, 2025: Economy wide

Variables	Type	Description
PY	Deflation index	Price deflator: GDP
PX	Deflation index	Price deflator: Exports
PC	Deflation index	Price deflator: Consumption
CAB	Flow	Current account balance
FAB	Flow	Financial account balance
NX	Flow	Net Exports
I-Real prices	Flow	Gross fixed capital formation
I	Flow	Gross fixed capital formation
M	Flow	Imports
M-Real prices	Flow	Imports
PRIVATE	Flow	Gross income
S-Real prices	Flow	Savings
S	Flow	Savings
Y-Real prices	Flow	Total income
Y	Flow	Total income
B2	Flow	Gross operating surplus
X-Real prices	Flow	Exports
X	Flow	Exports
TOBIN-Q	Index	Index: House price index: Tobin's Q = Ratio between the house pr
ZZ1	Index	Index: House price: Imported from DST
ZZ-I	Index	Index: House price: Imported from DST
UL-COST	Rate	Labour force: Unit labour cost
ULC	Rate	Labour force: Unit labour cost: Price index: Index for the price def
WAGE	Rate	Labour force: Wage rate
ALPHA	Ratio	Ratio of fixed interest mortgage debt
UR	Ratio	Labour force: Unemployment rate
CU	Ratio	Capacity Utilisation (Real GNI / real capital stock)
WS	Ratio	Wage share
UN	Stock	Labour force: Unemployed persons
N	Stock	Labour force: Denmark for workers in production
NF	Stock	Labour force: Employed persons: Danish waged
NU	Stock	Labour force: Employed persons: Danish nationals: Employed abro

Table 14.48: Most affected variables: Perc change from baseline: Scenario 4, 2025: HH

Variables	Type	Description
PIP-IBL-HH-Fixed	Flow	Property income paid: IBL
FL-HH-Transactions	Flow	Financial liabilities
IBL-HH-Transactions	Flow	Financial Liabilities: Interest bearing liabilities
EQA-HH-Transactions	Flow	Financial Assets: Equity assets
PIP-IBL-HH	Flow	Property income paid: IBL
FNL-HH	Flow	Financial Net Lending (Balance)
NL-HH	Flow	Sector Balance
NPIR-HH	Flow	Net property income received: Total
PIP-IBL-HH-Flexible	Flow	Property income paid: IBL
INV-HH	Flow	Gross fixed capital formation
INV-HH-Real prices	Flow	Gross fixed capital formation
FA-HH-Transactions	Flow	Financial Assets
IBA-HH-Transactions	Flow	Financial Assets: Interest bearing assets
PIR-IBA-HH	Flow	Property income received: IBA
S-HH	Flow	Savings
PIR-EQA-HH	Flow	Property income received: EQA
C-HH	Flow	Consumption
C-HH-Real prices	Flow	Consumption
STRA-HH	Flow	Social transfers
SCO-HH	Flow	Social benefit contributions
Y-D-HH	Flow	Disposable Income
TAX-HH	Flow	Tax
Y-HH	Flow	Total income
Y-D-HH-Real prices	Flow	Disposable Income
PENA-HH-Transactions	Flow	Financial Assets: Pension assets
SBE-HH	Flow	Social benefit transfers
W-HH	Flow	Wages
PIR-PENA-HH	Flow	Property income received: PENA
R-IBL-SENS-HH	Rate	Rate of interest: Interest bearing liabilities: Weighted mortgage interest rate
R-IBL-HH-Flexible	Rate	Rate of interest: Interest bearing liabilities
R-IBL-HH-Fixed	Rate	Rate of interest: Interest bearing liabilities
IBL-HH-Fixed	Stock	Financial Liabilities: Interest bearing liabilities
IBL-HH-Flexible	Stock	Financial Liabilities: Interest bearing liabilities
K-HH	Stock	Stock of Capital
K-HH-Real prices	Stock	Stock of Capital
IBL-HH	Stock	Financial Liabilities: Interest bearing liabilities
IBA-HH	Stock	Financial Assets: Interest bearing assets
EQA-HH	Stock	Financial Assets: Equity assets
NW-HH	Stock	Net Wealth
NW-HH-Real prices	Stock	Net Wealth
FA-HH	Stock	Financial Assets
FNW-HH-Real prices	Stock	Financial net wealth
FNW-HH	Stock	Financial net wealth
PENA-HH	Stock	Financial Assets: Pension assets

Table 14.49: Most affected variables: Perc change from baseline: Scenario 4, 2025: NFC

Variables	Type	Description	Change
FNL-NFC	Flow	Financial Net Lending (Balance)	-10.5069\%
NIB-NFC-Transactions	Flow	Net financial stock: Interest bearing	-10.5069\%
NL-NFC	Flow	Sector Balance	-10.5069\%
NPIR-NIB-NFC	Flow	Net property income received: NIB	-1.6785\%
S-NFC	Flow	Savings	-1.1715\%
INV-NFC	Flow	Gross fixed capital formation	-0.5161\%
INV-NFC-Real prices	Flow	Gross fixed capital formation	-0.5160\%
NPIR-NFC	Flow	Net property income received: Total	-0.4088\%
TAX-NFC	Flow	Tax	-0.3018\%
B2-NFC	Flow	Gross operating surplus	-0.2813\%
W-NFC	Flow	Wages	-0.1427\%
NIB-NFC	Stock	Net financial stock: Interest bearing	-2.2066\%
NW-NFC	Stock	Net Wealth	-0.9854\%
FNW-NFC	Stock	Financial net wealth	-0.7171\%
K-NFC-Real prices	Stock	Stock of Capital	-0.2172\%
K-NFC	Stock	Stock of Capital	-0.2172\%

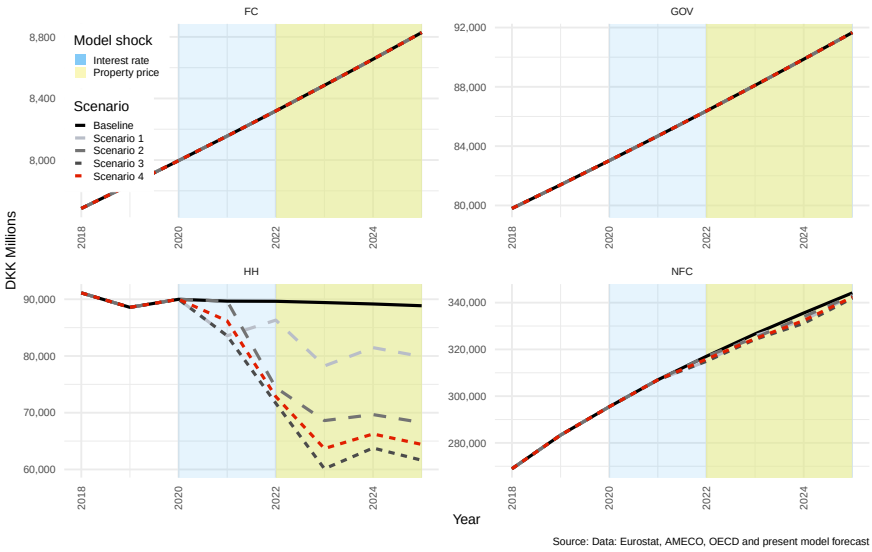


Figure 14.37: Investment

Table 14.50: Most affected variables: Perc change from baseline: Scenario 4, 2025: FC

Variables	Type	Description	Change
FNL-FC	Flow	Financial Net Lending (Balance)	376.3513\%
NL-FC	Flow	Sector Balance	376.3513\%
NPIR-FC	Flow	Net property income received: Total	193.1527\%
S-FC	Flow	Savings	166.8588\%
NPIR-NEQ-FC	Flow	Net property income received: NEQ	163.0814\%
PIR-IBA-FC-HH-Fixed	Flow	Property income received: IBA	152.1575\%
NIB-FC-Transactions	Flow	Net financial stock: Interest bearing	58.3658\%
IBA-FC-HH-Transactions	Flow	Financial Assets: Interest bearing assets	-50.4361\%
NEQ-FC-Transactions	Flow	Net financial stock: Equity	46.9109\%
PIR-IBA-FC-HH-Flexible	Flow	Property income received: IBA	-28.3125\%
IBL-FC-HH-Transactions	Flow	Financial Liabilities: Interest bearing liabilities	-9.5399\%
NPIR-NIB-FC	Flow	Net property income received: NIB	08.3725\%
PIP-IBL-FC	Flow	Property income paid: IBL	-6.8698\%
PENL-FC-Transactions	Flow	Financial Liabilities: Pension liabilities	-0.5891\%
Y-FC	Flow	Total income	-0.1533\%
PIP-PENL-FC	Flow	Property income paid: PENL	-0.0168\%
NW-FC	Stock	Net Wealth	187.9476\%
NEQ-FC	Stock	Net financial stock: Equity	117.3077\%
FNW-FC	Stock	Financial net wealth	79.7827\%
NIB-FC	Stock	Net financial stock: Interest bearing	10.7212\%
IBA-FC-HH	Stock	Financial Assets: Interest bearing assets	-9.4316\%
IBL-FC-HH	Stock	Financial Liabilities: Interest bearing liabilities	-6.9890\%
PENL-FC	Stock	Financial Liabilities: Pension liabilities	-0.0278\%

Table 14.51: Most affected variables: Perc change from baseline: Scenario 4, 2025: GOV

Variables	Type	Description	Change
FNL-GOV	Flow	Financial Net Lending (Balance)	-19.8010\%
NIB-GOV-Transactions	Flow	Net financial stock: Interest bearing	-19.8010\%
NL-GOV	Flow	Sector Balance	-19.8010\%
NPIR-GOV	Flow	Net property income received: Total	-13.0776\%
NPIR-NIB-GOV	Flow	Net property income received: NIB	-13.0776\%
S-GOV	Flow	Savings	-8.5730\%
STRA-GOV	Flow	Social transfers	-1.0251\%
TAX-GOV	Flow	Tax	-0.8229\%
FNW-GOV	Stock	Financial net wealth	-14.1666\%
NIB-GOV	Stock	Net financial stock: Interest bearing	-14.1666\%
NW-GOV	Stock	Net Wealth	-3.8120\%

Table 14.52: Most affected variables: Perc change from baseline: Scenario 4, 2025: ROW

Variables	Type	Description	Change
FNL-ROW	Flow	Financial Net Lending (Balance)	-21.1286\%
NIB-ROW-Transactions	Flow	Net financial stock: Interest bearing	-21.1286\%
NL-ROW	Flow	Sector Balance	-21.1286\%
S-ROW	Flow	Savings	-21.1286\%
NPIR-NIB-ROW	Flow	Net property income received: NIB	-6.1683\%
NPIR-ROW	Flow	Net property income received: Total	-3.3684\%
NIB-ROW	Stock	Net financial stock: Interest bearing	-7.6392\%
FNW-ROW	Stock	Financial net wealth	-5.1608\%
NW-ROW	Stock	Net Wealth	-5.1608\%

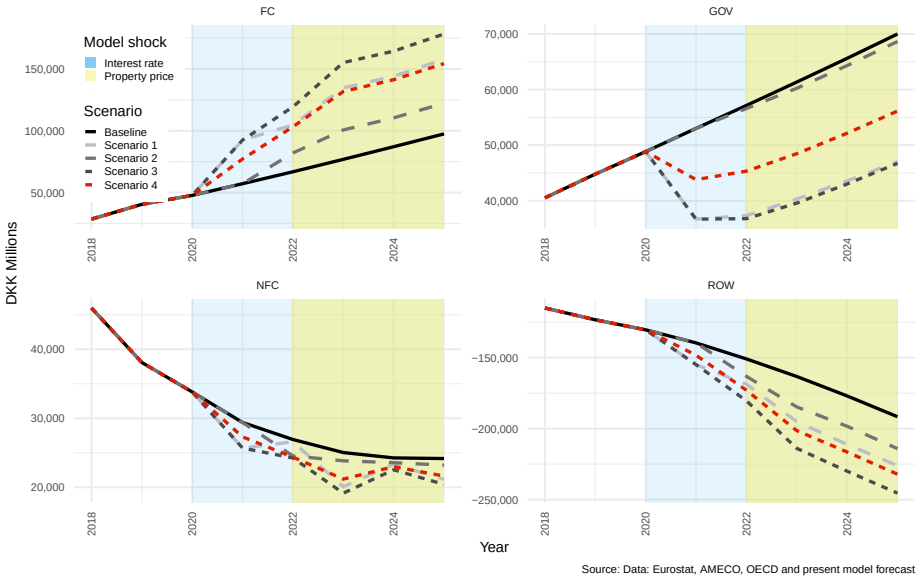


Figure 14.38: Net interest bearing asset transactions

14.9.5.2 Residual sector flows

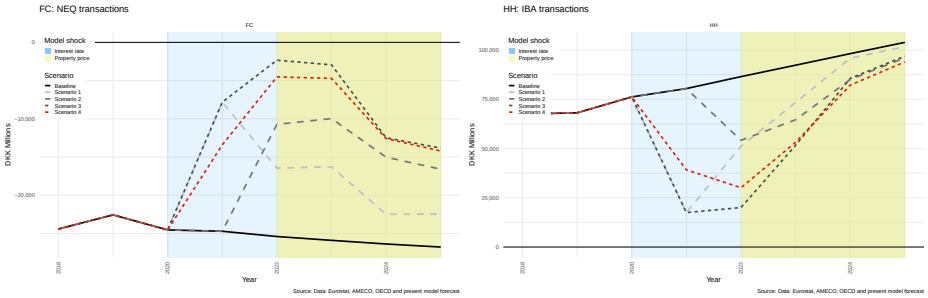


Figure 14.39: Residual flows for FC and HH

14.9.5.3 NW: Nominal prices: All sectors

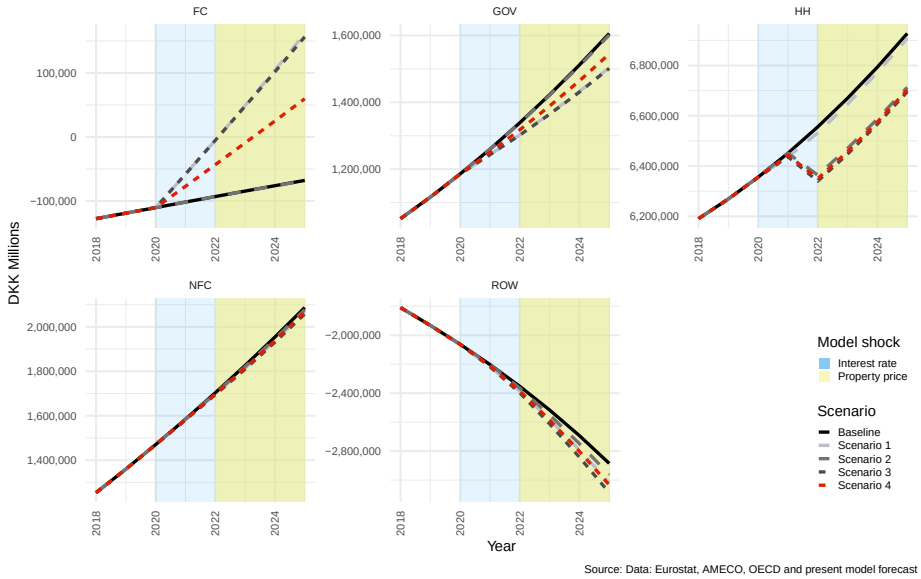


Figure 14.40: NW: Nominal prices: All sectors

14.9.5.4 Capital Stock: Nominal prices: HH, NFC

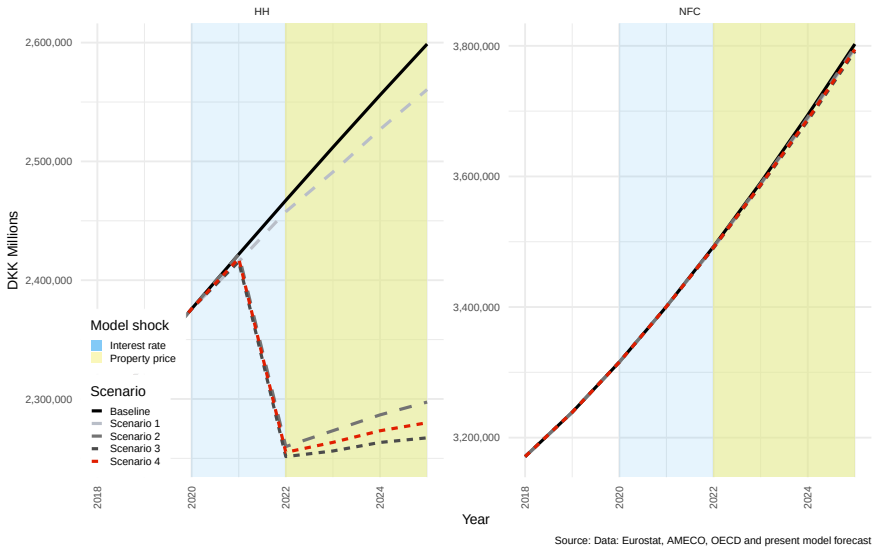


Figure 14.41: Capital Stock: Nominal prices: HH, NFC

14.9.5.5 Financial transactions: Nominal prices: HH

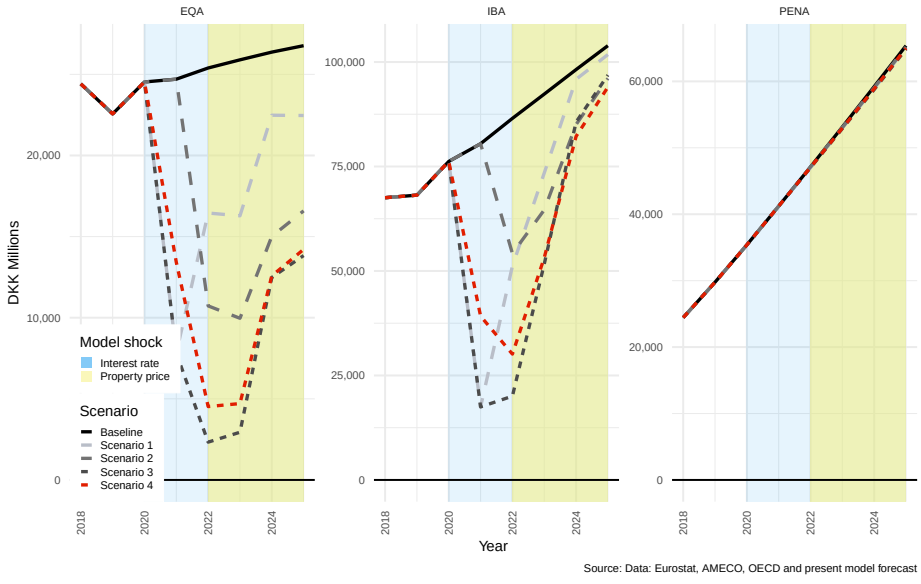


Figure 14.42: Financial transactions: Nominal prices: HH

14.9.5.6 Financial transactions: Nominal prices: NFC

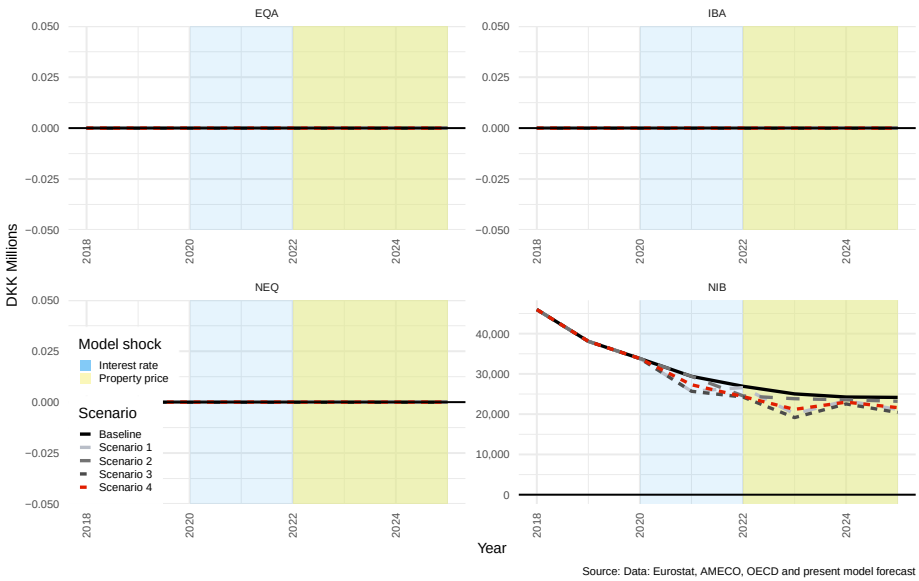


Figure 14.43: Financial transactions: Nominal prices: NFC

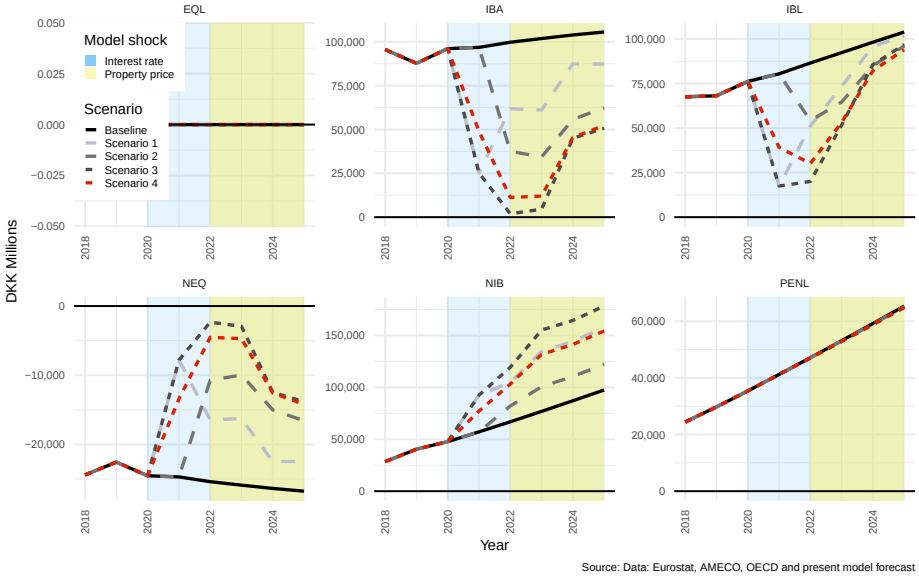


Figure 14.44: Financial transactions: Nominal prices: FC

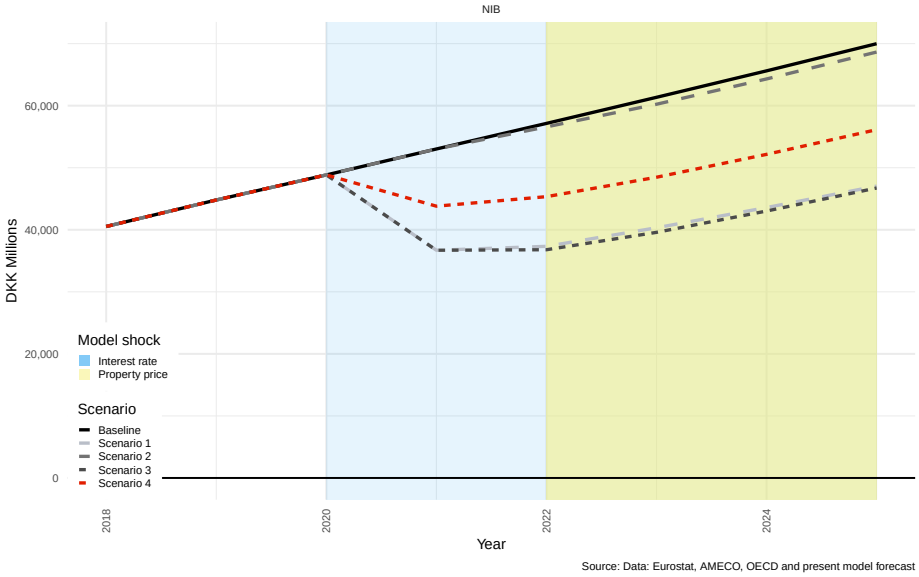


Figure 14.45: Financial transactions: Nominal prices: GOV

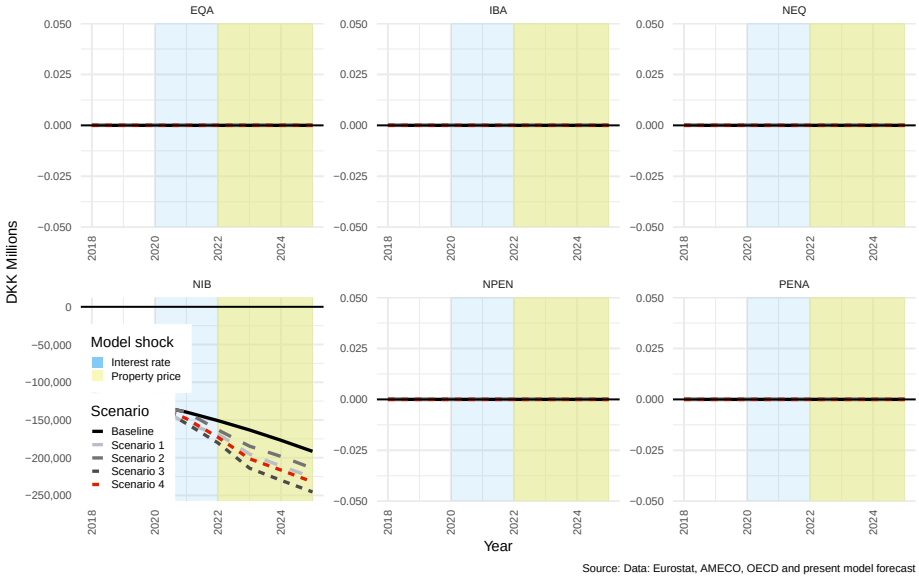


Figure 14.46: Financial transactions: Nominal prices: ROW

14.9.5.7 Financial transactions: Nominal prices: FC

14.9.5.8 Financial transactions: Nominal prices: GOV

14.9.5.9 Financial transactions: Nominal prices: ROW

14.9.5.10 IBA and IBL: Stock: FC

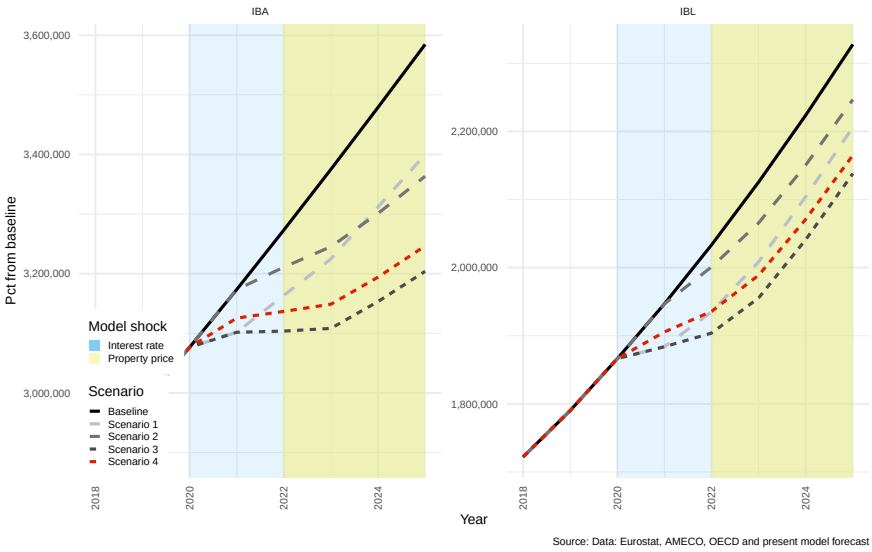


Figure 14.47: IBA and IBL: Stock: FC

14.9.5.11 IBL: Fixed and Flexible: Stocks: HH

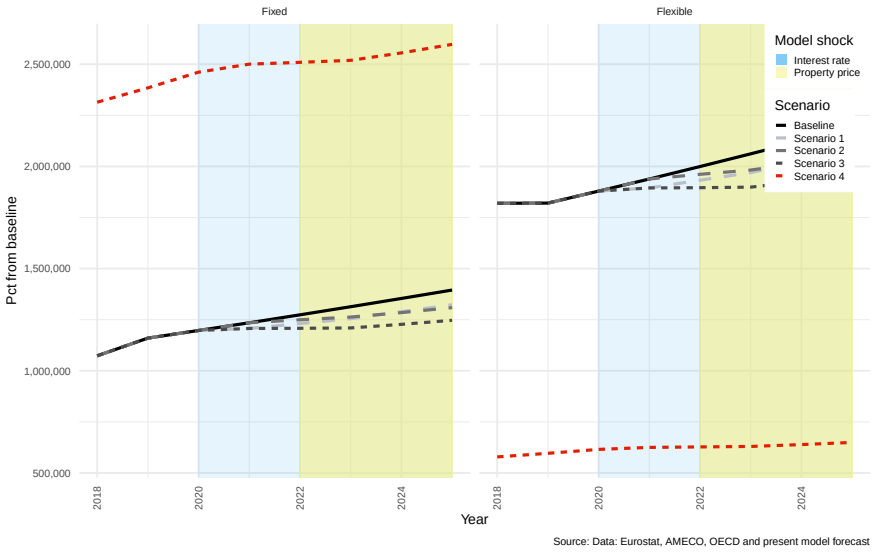


Figure 14.48: IBL: Fixed and Flexible: Stocks: HH

14.9.6 Lists of variables from scenarios

\begin{table}

\caption{(#tab:variable-names-table_shocks)List of variables in scenario tables}

Variable	Type	Description
ALPHA	Ratio	Ratio of fixed interest mortgage debt
B2	Flow	Gross operating surplus
BETA,DATA	Parameter	Parameter
BOP	Flow	Balance of payments
C	Flow	Consumption
CAB	Flow	Current account balance
CGK	Flow	Capital gains
CGS	Flow	Capital gains
CHECK,B2	Check	Consistency check: Gross operating surplus
CHECK,CTR	Check	Consistency check: Capital transactions
CHECK,EQ	Flow	Consistency check: Equity Transactions
CHECK,ERROR1	Check	Consistency check: Error 1
CHECK,ERROR2	Check	Consistency check: Error 2
CHECK,ERROR3	Check	Consistency check: Error 3
CHECK,IB	Flow	Consistency check: Interest bearing transactions
CHECK,IB,TFLOW	Check	Consistency check: Interest bearing: Flows
CHECK,INVEST	Check	Consistency check: Investment
CHECK,NEQ	Flow	Consistency check: Net equity
CHECK,NIB	Check	Consistency check: Net interest bearing
CHECK,NIB	Flow	Consistency check: Net interest bearing
CHECK,NIB,TFLOW	Check	Consistency check: Net interest bearing: Flows
CHECK,NP	Check	Consistency check: Net purchases of non-financial assets (N
CHECK,NPEN	Flow	Consistency check: Net pensions: Revaluations
CHECK,PEN	Flow	Consistency check: Pensions: Transactions
CHECK,STRA	Check	Consistency check: Social transfers
CHECK,TAX	Check	Consistency check: Tax
CHECK,WAGE	Check	Consistency check: Wages
CPEN	Flow	Financial Liabilities: Change in pension entitlements
CTR	Flow	Capital transfers
CU	Ratio	Capacity Utilisation (Real GNI / real capital stock)
D,1998	Dummy	Dummy variable: 1998
D,200	Dummy	Dummy variable: 2000
D,2004	Dummy	Dummy variable: 2004
D,2006	Dummy	Dummy variable: 2006
D,2007	Dummy	Dummy variable: 2007
D,2008	Dummy	Dummy variable: 2008
D,2009	Dummy	Dummy variable: 2009
D,2010	Dummy	Dummy variable: 2010
D,2011	Dummy	Dummy variable: 2011
D,2014	Dummy	Dummy variable: High taxes: 2014
D,2015	Dummy	Dummy variable: 2015
D,2016	Dummy	Dummy variable: 2016
D21	Flow	Taxes on products
D29	Flow	Other taxes on production
D31	Flow	Subsidies D31
D39	Flow	Subsidies D39
D41,P	Flow	Interest: Paid
D41,R	Flow	Interest: Received
D41B	Flow	Interest: Received
D42,P	Flow	Distributed income of corporations: Paid
D42,R	Flow	Distributed income of corporations: Received
D44,P	Flow	Other investment income: Paid

\end{table}

14.10 Complete set of model equations

14.10.1 Non-Financial Corporate Sector

The following appendix is adapted from Byrialsen and Raza (2019), except otherwise indicated. It is included here for completeness in the explanation of the structure of the model. As in their model, the non-financial corporate sector (NFC) is responsible for all production, where total nominal production is represented as:

$$Y_t = C_t + I_t + G_t + X_t - M_t \tag{14.32}$$

This can be rewritten in terms of sales, or rather, from an income perspective:

$$S_t = C_t + I_t + G_t + X_t \tag{14.33}$$

The production equation from Equation (14.32) can be deflated to real prices;

$$y_t = c_t + i_t + g_t + x_t - m_t \tag{14.34}$$

Where the GDP deflator can be represented as:

$$P_t^y = \frac{Y_t}{y_t} \tag{14.35}$$

Outflows for NFC include taxes paid to GOV, wages (WB) paid to domestic and foreign households, and profits ($B2$[42]).

$$WB_t^N = W_t(N_t^N) \tag{14.36}$$

The nominal wage bill is calculated as the wage rate (W_t) times the level of employment (NN_t), where NN_t includes all domestic employment of citizens plus the net employment of foreigners in Denmark and Danish citizens abroad.

[42]Profits here refer to the gross operating surplus for the sector, ESA non financial transactions item $B2$.

Taxes paid by NFC are predominantly production based and are therefore calculated as a proportion of total production in each period (Y_t).

$$T_t^N = \beta_3(Y_t) \tag{14.37}$$

It is assumed that firms target a fairly stable level of mark-up on production, and thus $B2$ is calculated as an estimated proportion of Y_t.

$$B2_t = \beta Y_t \tag{14.38}$$

The stock of NFC fixed capital, (K_t^N), is diverse, and is calculated via the standard accounting method, allowing for capital accumulation via investment (I_t^N), depreciation (D_t^N) and capital gains ($K_{CG_t}^N$).

$$K_t^N = K_{t-1}^N + I_t^N - D_t^N + K_{CG_t}^N \tag{14.39}$$

Depreciation of capital is assumed to apply to stock held at the end of the previous period.

$$D_t^N = \delta(K_{t-1}^N) \tag{14.40}$$

The capital deflator (P_t^i) can then be used to calculate the real value of the stock of capital in each period.

$$k_t^N = \frac{K_t^N}{P_t^i} \tag{14.41}$$

Investment is estimated in real terms as a function of capacity utilisation.

$$ln(i_t^N) = \beta_i + ln\beta_i.\left(\frac{y_{t-i}}{k_{t-i}^N}\right) \tag{14.42}$$

It can then be inflated to current prices using the same capital price deflator as in Equation (14.41), P_t^i.

$$I_t^N = i_t^N(P_t^i) \tag{14.43}$$

NFC savings (S_t^N), not to be confused with sales (S_t) in Equation (14.33), can be calculated as the net sum primary and secondary income and expenditures.

$$\begin{aligned} S_t^N =& Y_t - WB_t^N + (B2_t^N - B2_t) + r_{t-1}^N(NIB_{t-1}^N) \\ &+ \chi_t(NEQ_{t-1}^N) - T_t^N + STR_t^N + \epsilon^N \end{aligned} \tag{14.44}$$

Net lending (NL^N) takes into account the additional sources of change originating from fixed asset adjustments. In particular, NP is the net sale and acquisition of non-financial assets, savings and investment reflect *ex post* portfolio decisions, and finally KTR^N represents any additional capital transfers. [43] NFC is also assumed to receive all income from production in the economy, and thus the level of operating surplus must be adjusted to take into account that of all other sectors, thus NFC retains ($B2_t^N - B2_t$) gross operating surplus. The ϵ^N refers to adjustments made to ensure stock and flow consistency in the level of property income received or paid during the periods where data was available[44].

$$NL_t^N = S_t^N - I_t^N - NP_t^N + KTR^N \tag{14.45}$$

The calculation of stocks for each of the classes held by NFC are in equations (14.46) and (14.47).

Net equities:

$$NEQ_t^N = NEQ_{t-1}^N + NEQTR_t^N + NEQ_{CG_t}^N \tag{14.46}$$

Net interest bearing stocks:

$$NIB_t^N = NIB_{t-1}^N + NIBTR_t^N + NIB_{CG_t}^N \tag{14.47}$$

Net interest bearing assets, like several others in this model, are determined by a combination of previous stocks (NIB_{t-1}^N), transactions ($NIBTR_t^N$) and

[43] This structure follows for each of the sectors, with the exception of the rest of the world sector (ROW), where ownership of fixed assets is not included, and therefore, by definition, neither is investment. NP is determined exogenously, and is for the most part of negligible size.

[44] This convention is used for all sectors. The returns on financial assets are estimated with varying degrees of accuracy for each of the sectors. In order to ensure that the model is consistent in all periods, any difference between the estimated returns and actual returns (on a net basis for each asset class) are added to the adjustment term. These errors in estimation are minimised in the estimation specification for each asset class individually.

capital gains ($NIB^N_{CG_t}$). The transactions component of interest bearing assets for NFC is determined passively. It is calculated as the remainder of Savings, after capital transfers, and after portfolio allocation towards equities. Transactions in equities ($NEQTR^N$) are thus the active component of the composition of the NFC balance sheet portfolio.

$$NIBTR^N_t = NL^N_t - NEQTR^N_t \tag{14.48}$$

Since NFC only holds these two financial assets in the model, the sum constitutes the financial net wealth (FNW^N) of NFC.

$$FNW^N_t = NIB^N_t + NEQ^N_t \tag{14.49}$$

This is different to the total net wealth (NW^N), which also includes the fixed capital (K^N) owned by NFC.

$$NW^N_t = FNW^N_t + K^N \tag{14.50}$$

14.10.2 Household Sector

The household sector (HH) is the primary focus of this model, in particular the interest bearing liabilities of the household sector, and the drivers thereof. It is therefore the sector with most endogenous components. Equation (14.51) describes the incomes and expenditures of HH. The primary sources of which are wages (WB^H), profits ($B2$), property income (or returns on financial capital, which stems from interest bearing assets, IBA^H, pensions, $PENA^H$, and equities, EQA^H), and social transfers(STR^H).

$$\begin{aligned} Y^H_t =& WB^H_t + B2^H_t + r^H_{A_{t-1}}(IBA^H_{t-1}) \\ & - r^H_{L(FI)_{t-1}}(IBL(FI)^H_{t-1}) \\ & - r^H_{L(FL)_{t-1}}(IBL(FL)^H_{t-1}) \\ & + \chi_t(EQA^H_{t-1}) + \psi_t(PENA^H_{t-1}) + STR^H_t + \epsilon^H \end{aligned} \tag{14.51}$$

Interest rates are represented by r^H, and the "A" ("L") subscript referring to the assets (liabilities), and (χ_t) and (ψ_t) are the rates of return on equities and pensions. As part of the key change in this model, the level of interest paid on IBL in this model is split between fixed and flexible rate mortgages into $r^H_{L(FI)_{t-1}}(IBL(FI)^H_{t-1})$ and $r^H_{L(FL)_{t-1}}(IBL(FL)^H_{t-1})$. A similar split is present in the financial corporate sector (FC) below.

Social transfers received by the households in the above equations is the sum of social contribution ($SCON^H$) paid by the households, social benefits ($SBEN_t^H$), and other transfers (OTR^H) received by the households: Social transfers:

$$STR_t^H = SBEN_t^H + OTR_t^H - SCON^H \tag{14.52}$$

Total taxes paid by households are a relatively constant proportion of income over time, and are deducted from total income to give disposable income:

$$YD_t^H = Y_t^H - T_t^H \tag{14.53}$$

The total value of tax payment by households is assumed to be a constant portion (β_i) of household primary and secondary income.

$$T_t^H = \beta_i(Y_t^H) \tag{14.54}$$

The level of social contributions are a proportion of disposable income, adjusted over time.

$$SCON_t^H = \beta_7(YD_{t-i}^H) \tag{14.55}$$

The largest components of $SBEN^H$ are pension and medical payments. Byrialsen and Raza (2019), modelled changes in benefits against changes in the the wage rate and the level of unemployment. Although not directly related to the main components of benefits, they appear to be good proxies for changes in pension distributions, which in some cases may be based on emoluments.

$$ln(SBEN_t^H) = \beta_i + \beta_i ln(U_t^N) + \beta_i ln(W_{t-i}^H) \tag{14.56}$$

Since 2007, approximately 35% - 37% of all social benefits were for old age payments. A further 20% - 22.3% are attributed to medical benefits, an almost constant 14.4% to disability and 10% - 13.2% to family and child benefits. Unemployment (app. 5%), social exclusion (app. 5%), housing (app. 2%) and survivorship (app. 1%) benefits making up the balance.

The old age category, as can be seen from Figure 14.50, is then dominated by tax funded pension payouts (app. 50% in 2017), old age accommodation and

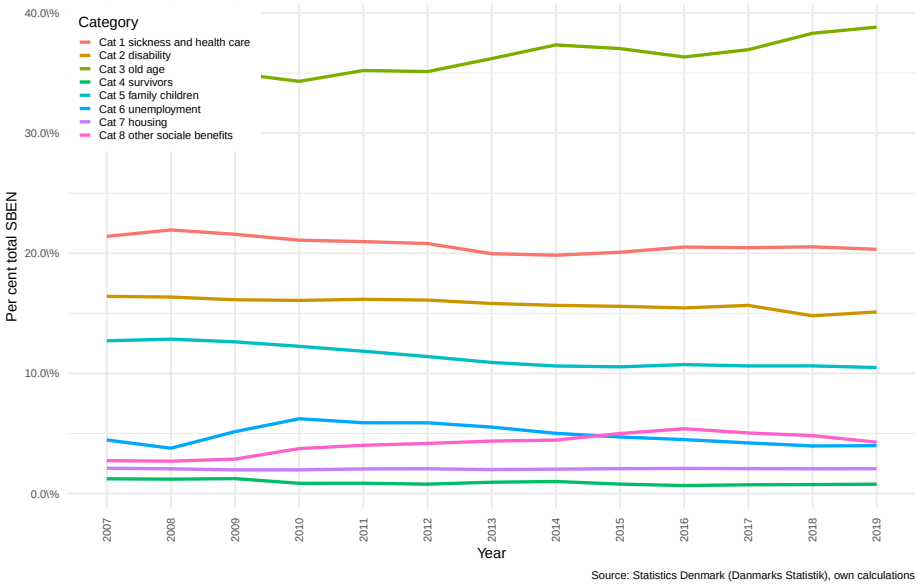


Figure 14.49: Social benefits by category

care (app. 15%) and civil (app. 11%) and other pension schemes (app. 12%), with the declining anticipated pension allocations (app. 5.2% in 2017) and growing labour market supplementary pension benefits (ATP[45]) (app. 5.8%) making up the balance. The full amount therefore could be considered as pension income, but since these pension benefits are funded predominantly by tax, rather than from assets, they are best kept separate from the capital income on pension assets described in Equation (14.51) above. This is perhaps with the exception of labour market supplementary pension benefits, which are payouts from a pooled investment portfolio.

This is not merely a question of semantics, as the old age component is also an element of wage negotiations for the working population. A large part of social contributions ($SCON^H$) are also contributions towards the labour market pension fund.[46] $SBEN^H$ is, perhaps understandably, the second largest

[45] ATP is an anagram for *Arbejdsmarkedets Tillægspension*, which translates directly to *labour market supplementary pension*.

[46] The Danish pension system is beyond the scope of this discussion, but a brief summary may be useful here. As described by Andersen (2016, pp. 2), the system is relatively complex three pillar system, with the most recent comprehensive reform taking place in 1964. The three pillars are: 1.) A state pension (with several minor schemes), 2.) Semi-mandatory occupational pensions (or labour market pensions), and 3.) Personal pension savings. The state pension and other peripheral benefits (such as old age accommodation support, heating support etc) is tax funded and essentially a flat rate benefit for all citizens, while the second and third pillars are savings based, and thus have been slower to mature. There have been a range of relatively minor adjustments to the state pension system over the past few decades, some

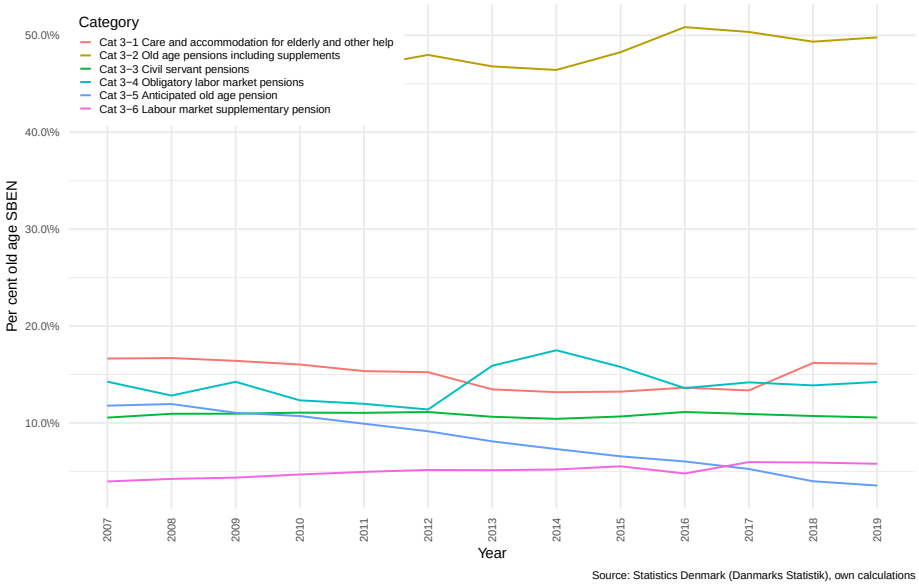


Figure 14.50: Old age social benefits

component of HH disposable income in Denmark. As can be seen in Figure 14.49, this can quickly be understood to be driven primarily by healthcare and pensions, but in a more general sense, by components of the strong Danish welfare system. Labour market pension payouts are expected to fall (rise), as are unemployment benefit payouts, as economic conditions improve (deteriorate). Unemployment, as an indicator of economic distress, appears to be a good proxy for expected changes in benefit payouts relative to total HH disposable income. Equation (14.56) captures this effect, together with the effect of changes in the wage rate. The latter because unemployment benefits and several pension benefits are adjusted according to changes in industry wage rates, as noted by Byrialsen and Raza (2018) and (2019).

Real disposable income, as will be the case for several other variables in this model, can be calculated by dividing household disposable income by a consumption price index (P^c).

of which are adjustments according to what other benefits or income the person has (partially means tested). The conditions of the occupational pension system, much like much of the labour market working conditions agreements, are determined via collective agreement. While there are no legislated wage or pension requirements - for example there is no minimum wage in Denmark - the coverage of collective bargaining agreements is almost universal. (Andersen, 2016)

$$yd_t^H = \frac{YD_t^H}{P_t^c} \tag{14.57}$$

Consumption, like NFC investment, is estimated in real terms in a standard Keynesian form, and log-linearised for stationarity. Consumption is taken to be determined by a combination of real disposable income and household wealth of the preceding period. Although not explicitly modelled, current consumption thus is assumed to be based purely on expectations developed in the previous period.

$$ln(c_t) = \beta_0 + \beta_i ln(yd_{t-i}^H) + \beta_i ln(nw_{t-1}^H) \tag{14.58}$$

Nominal consumption can be calculated using the consumption price index to inflate the series.

$$C_t = c_t(P_t^c) \tag{14.59}$$

P^c, the consumption price index is endogenous to changes in the wage rate and the import price index from the previous period. In some way reflecting a delayed adjustment in (or, sticky) prices, and the importance of international prices for smaller open economies, such as Denmark.

$$ln(P_t^c) = \beta_0 + \beta_i ln(W_{t-i}) + \beta_i ln(P_{t-i}^m) \tag{14.60}$$

The following equations are related to household interactions with capital an investment markets.

In this model, households are only permitted to make productive investment in housing, which, in this model, is considered only as a primary market, following Zezza (2008), Fontana and Godin (2013) and Beckta (2015). The secondary market for houses is assumed to affect prices, but not the demand for additional housing investment. Demand for housing investment is determined by by a Tobin's-Q-like function, partially driven by changes in disposable income and previous period housing investment, and partially driven by a relative shift in sales price (P_{t-i}^H) and construction cost (P_{t-i}^i) indices.

Real investment in fixed assets (dwellings):

$$ln(i_t^H) = \beta_i + \beta_i ln(i_{t-i}^H) + \beta_i ln\left(\frac{P_{t-i}^H}{P_{t-i}^i}\right) + \beta_i ln(yd_{t-i}^H) \tag{14.61}$$

As noted by Byrialsen and Raza (2019, pp. 20), "The intuition behind the above equation is straight forward, i.e., an increase in the house prices motivates the households to invest more in the construction of new houses, while an increase in the construction costs would lower housing investment."

A shift downwards in house prices would conversely reduce overall returns on houses relative to construction costs, and thus result in a decline in the demand for housing investment. This would result, all else equal, in an increase in savings and a consequent rise in the demand for alternative outlets. Limited below to the purchase of financial assets[47].

The nominal level can be calculated by inflating the real investment in housing series (i_t^H) by the investment price index (P_t^i):

$$I_t^H = i_t^H(P_t^i) \tag{14.62}$$

The nominal stock of housing (K^H), as with other assets to come, follows the simple process of previous stock, plus acquisition (in this case investment in new houses), less depreciation (or disposal) plus capital gains.

$$K_t^H = K_{t-1}^H + I_t^H - D_t^H + K_{CG_t}^H \tag{14.63}$$

Capital gains on houses, in turn, are calculated as:

$$KH_{CG} = \Delta P_t^H(K_{t-1}^H) \tag{14.64}$$

Which is simply the change in the price of houses applied to the level of stock at the end of the preceding period. The change in house prices leading into the current period is then by definition the same ratio proportion of capital gains to previous housing capital.

[47] André (2016), in a recent OECD working paper argue that while there is an obvious connection between the availability of credit and house prices, the extent to which house prices are affected by changes in mortgage lending is affected by a wide range of factors, including sentiment, employment conditions, legislative changes, and a range of cyclical economic factors. Kohlscheen et al. (2018) also note the co-movement of residential property prices and credit as a prominent feature of models of financial cycles, although their focus is on commonalities in financial, demographic and real economy factors. Their (Kohlscheen et al., 2018, pp. 2) findings suggest that the primary drivers are "real house prices, nominal interest rates, demographic factors, and the state of housing supply". The present model captures all but demographic factors in the determination of residential (HH) investment. They also find strong asymmetries in the effects of interest rates between boom and bust cycles, and with rising interest rates rather than falling. This is supported by Scanlon et al. (2008)'s findings that household mortgage lending is highly sensitive to short-term budget implications of interest and capital repayment costs.

$$\Delta P_t^H = \frac{KH_{CG}}{K_{t-1}^H} \tag{14.65}$$

Nominal housing capital held by HH at the end of the current period can be expressed as the price adjusted stock at the end of the previous period, plus net investment and depreciation.

$$K_t^H = K_{t-1}^H(1 + \Delta P_t^H) + I_t^H - D_t^H \tag{14.66}$$

The deflated real capital index can then be found by dividing the series by the investment (housing) price index, as in Equation (14.65) above.

$$k_t^H = \frac{K_t^H}{P_t^i} \tag{14.67}$$

The level of savings is then calculated as a residual disposable income after consumption and net pension adjustments - the ESA 2010 (Statistical Office of the European Communities., 2013) definition of which is net of contributions, disbursements and returns of pension funds.

$$S_t^H = YD_t^H - C_t^H + CPEN_t^H \tag{14.68}$$

Net lending can then be calculated savings plus additional consideration for the net acquisition and disposal of fixed assets (NP) and capital transfers (KTR) less investment (assumed here to be solely in houses).

$$NL_t^H = S_t^H - I_t^H - NP_t^H + KTR_t^H \tag{14.69}$$

HH must also fund real activities and allocate any excess funds in the financial markets. As noted above, HH is the sector with most endogenous components in this model. It is also the sector, together with the financial corporate sector (FC) that has the most complex financial accounts. As noted by Byrialsen and Raza (2019), financial market changes in this model are driven primarily by the demand for credit and assets. As they explained, transmission is from flows to stocks. The behaviour is primarily modelled in transaction decisions, and stocks are then calculated as the sum of these together with capital gains.

The net effect of annual changes in the financial position of HH is captured by financial net lending. This is the sum of changes in financial assets less the sum of changes in financial liabilities:

$$FNL_t^H = FATR_t^H - FLTR_t^H \tag{14.70}$$

Household financial assets are held in interest bearing assets (IBA), equities[48] (EQA) and pensions ($PENA$). Transactions in each of these sum to make up the total transactions in financial assets.

$$FATR_t^H = IBATR_t^H + EQATR_t^H + PENATR_t^H \tag{14.71}$$

Transactions in equities are determined by a Tobin allocation matrix, thus enforcing a budget constraint on HH, where the investment decision of the sector is determined at least in part by relative rates of return. One exception is pension allocations, where a fairly constant portion of HH income is allocated to pension investments, irrespective of the rate of return. This leaves equities and interest bearing assets.

Demand for equities is negatively affected by increases in the returns available on interest bearing assets in the previous period (β on $r^H_{A_{t-1}}$), positively related to returns on equities (χ), and positively related to increases in the extension of credit (β on $IBLTR^H$).

$$EQATR_t^H = \beta_i + \beta_i(\chi_t) + \beta_i(r^H_{A_{t-1}}) + \beta_i(IBLTR_t^H) \tag{14.72}$$

The link with IBL is associated with the investment incentive for more sophisticated investors, where low interest rate debt can be used to arbitrage higher returns on equities.

Pension transactions, in addition to the fixed proportion that is reflected as a constant in the equation below, are positively affected by returns on pensions (ψ) and the wage bill (WB). Pensions transactions can thus be affected directly by the wage rate, or the level of employment (and thus negatively by a rise in unemployment).

$$PENATR_t^H = \beta_i + \beta_i(\psi_t) + \beta_i WB_t^H \tag{14.73}$$

The demand for credit by households is where the current model differs most from Byrialsen and Raza (2019). The total demand for new credit is captured in the level of transactions ($IBLTR^H$). This is positively related to the level

[48]The equity component in the balance sheets of the other sectors in this model is limited to a net equity position. It is assumed here that HH do not issue equities.

of demand for (new) housing (I^H), negatively to the level of debt in the previous period, positively to the total level of transactions in equities (for the same investment reason described above), and negatively related to the interest cost on loans ($r^H_{L_{t-1}}$) in the previous period.

$$IBLTR^H_t = \beta_i(I^H_{t-i}) + \beta_i(IBL^H_{t-i}) + \beta_i(FATR^H_t) + \beta_i(r^H_{L_{t-1}}) \tag{14.74}$$

The primary change to the model is the introduction of adjustable rate mortgage products in a fairly generic form, where the total level of outstanding IBL is split into fixed-interest (IBL_{FI}) and flexible-interest bearing liabilities (IBL_{FL}). The proportion of interest bearing assets held as IBL_{FI} is α.

$$IBL^H_{FI_t} = \alpha(IBL^H_t) \tag{14.75}$$

and thus,

$$IBL^H_{FL_t} = (1-\alpha)(IBL^H_t) \tag{14.76}$$

The level of α is taken from Statistics Denmark, and varies over time. The split is introduced in 2003, when the option was made available to HH. The composition of this debt is significantly more complex, as discussed in Section 14.3 above. This complexity can be simplified using a combination of interest rates and sensitivity or adjustment weights. At an aggregate level, the degree to which flexible rate mortgages adjust to changes in official rates can be estimated for each aggregate group of mortgage products. This is done for two broad groups in for this model, fixed[49] and flexible[50]. The effect is calculated as a percentage pass-through of official rate changes. Unfortunately it is not possible to compare rising and falling pass-through rates to existing mortgage holders prior to 2009. For the 2009 to 2017 period, however, fixed and flexible average interest rate payments, relative to outstanding nominal capital (cash) amounts, appears to have followed a very stable spread of approximately 2%. This is fairly easy to explain in a falling rates environment as borrowers take advantage of the option to refinance debt.

The composition of debt and the expected pass-through rate have a combined effect on the sensitivity of HH balance sheets and incomes to a shock to either interest rates or property prices. This simple modification is able to capture the two most dramatics innovations in the Danish mortgage debt system: the introduction of ARMs and of delayed amortization (or interest-only period, IO loans) loans.

[49] Group 1, called "fixed-interest" includes:

[50] Group 2, called "flexible-interest" includes:

The incentive to borrow for the purchase of a house, as in Equation (14.61) above, is partially driven by interest rates. The available interest rate is then adjusted according to the weighted average interest rate observed for each of the two groups (flexible and fixed). The second is the introduction of interest-only periods, as explained in Section 14.2, the effect of which is to reduce the initial cost of borrowing. Thus as the amount paid on mortgages per family falls, the incentive to borrow rises.

An alternative is to calculate the interest rate as the total payments made by the household towards debt, inclusive of amortization payments, as a percentage of total debt remaining. This alternative is not employed here, but is planned for future research. Although this would not normally be captured in the interest rate, it is possible to artificially lower the rate of interest on the flexible rate group in order to capture this incentive. This is similar for debt with longer term structures, where monthly costs would reflect the reduced portion allocated to amortization.

Unfortunately, the additional risks factors related to products with full-term interest-only, or perpetual-interest-only loans would not be possible to capture in this framework.

The only interest bearing asset held by households in the model is deposits, which are calculated as the residual effect of transactions in the other assets. debt and net lending contributing positively, and outflows for equities or pension investment contributing negatively.

$$IBATR_t^H = NL^H + IBLTR_t^H - EQATR_t^H - PENATR_t^H \tag{14.77}$$

The current stock of each asset is then the sum of the stock from the preceding period, plus any transactions (positive or negative), plus any capital gains (or losses). The same is true for all assets and liabilities.

$$IBA_t^H = IBA_{t-1}^H + IBATR_t^H + IBA_{CG_t}^H \tag{14.78}$$

Equities:

$$EQA_t^H = EQA_{t-1}^H + EQATR_t^H + EQA_{CG_t}^H \tag{14.79}$$

Pensions:

$$PENA_t^H = PENA_{t-1}^H + PENATR_t^H + PENA_{CG_t}^H \tag{14.80}$$

Interest bearing liabilities:

$$IBL_t^H = IBL_{t-1}^H + IBLTR_t^H + IBL_{CG_t}^H \tag{14.81}$$

The sum of financial assess (liabilities) provides the total financial assets (liabilities).

$$FA_t^H = IBA_t^H + EQA_t^H + PENA_t^H \tag{14.82}$$

Since the only financial liability for households in this model interest bearing, it makes up the total.

$$FL^H = IBL_t^H \tag{14.83}$$

Net financial wealth is the difference between total assets and liabilities.

$$FNW_t^H = FA_t^H - FL_t^H \tag{14.84}$$

The inclusion of fixed assets provides the total net wealth for each sector, which both in this model and in reality are dominated by dwellings for the household sector.

$$NW_t^H = FNW_t^H + K_t^H \tag{14.85}$$

This can be deflated to provide wealth at constant prices, where real financial net wealth:

$$fnw_t^H = \frac{FNW_t^H}{P_t^c} \tag{14.86}$$

And, where real wealth, are the result of deflation by the consumption prices index P_t^c

$$nw_t^H = \frac{NW_t^H}{P_t^c} \tag{14.87}$$

14.10.3 Financial Corporate Sector

The financial sector acts as the provider, and thus counterpart of newly created credit in this model. The financial corporate sector (FC) is comprised of banks, insurance and pension companies, as well as several services related to the financial markets. Property income made up just below 75% of FC inflows, and approximately the same proportion of outflows in 1995, and falling to just above 50% in 2017 - with positive flows higher than negative flows, reflecting the rental income spread extracted by the sector.

Savings, according to the national accounts can be expressed as the sum of the net capital income, gross operating surplus ($B2_t^F$) (received), social transfers (STR^F) minus taxes paid to the government (T^F), and the changes in pension entitlements ($CPEN^F$) paid to the households.

This model adjusts the inflow to FC to take into account the split in debt in the household sector between flexible and fixed, where the average interest rate on each category is applied to the outstanding level of fixed or flexible debt respectively.

$$\begin{aligned} S_t^F =& B2_t^F \\ &+ r^F_{A(FI)_{t-1}}(IBA^{F\sim H}_{A(FI)_{t-1}}) + r^F_{A(FL)_{t-1}}(IBA^{F\sim H}_{A(FL)_{t-1}}) \\ &- r^F_{L_{t-1}}(IBL^{F\sim H}_{L_{t-1}}) + r_{N_{t-1}}(NIB^F_{t-1}) \\ &+ \chi_t(NEQ^F_{t-1}) - \psi_t(PENL^F_{t-1}) - T^F_t + STR^F_t - CPEN^F_t + \epsilon^F \end{aligned} \tag{14.88}$$

Where, $r^F_{A_{t-1}}$, and $r^F_{L_{t-1}}$ are average interest rates on assets and liabilities where the household sector is the counterpart, this is noted using the superscript on, for example, interest bearing assets, $IBA^{F\sim H}$, to indicate that these assets are held by FC and that the counterpart is HH. $r_{N_{t-1}}$ is a generic rate of return applied toall other interest bearing assets and liabilities in the form of a net interest bearing (NIB) position.

Fixed assets are again determined as the stock of the preceding period, less depreciation, plus additional investment and capital gains.

$$K^F_t = K^F_{t-1} + I^F_t - D^F_t + K^F_{CG_{t-1}} \tag{14.89}$$

Net lending can be then be expressed as the net savings after taking investment net sales and acquisitions of fixed property and any capital transfers into account.

$$NL^F_t = S^F_t - I^F_t - NP^F_t + KTR^F_t \tag{14.90}$$

The financial equivalent, financial net lending, takes into account any transactions in the financial assets and liabilities held by the sector. Again the superscript denotes the sector, and for IBA and IBL, the counterpart sector.

$$FNL_t^F = IBATR_t^{F\sim H} + NIBTR_t^F + NEQTR_t^F - IBLTR_t^{F\sim H} - PENLTR^F \tag{14.91}$$

In the cases of both $IBATR$ and $IBLTR$, the counterpart sector is HH, and the values for these flows are by definition equal

$$IBATR_t^{F\sim H} = IBLTR_t^H \tag{14.92}$$

$$IBLTR_t^{F\sim H} = IBATR_t^H \tag{14.93}$$

FC is thus passive to the demands and capacity of HH to borrow in each of these cases. All other interest bearing transactions are also determined passively from the transactions in other sectors - where again, the net positions determine the adjustment required by FC.

$$NIBTR_t^F = -(NIBTR_t^N + NIBTR_t^G + NIBTR_t^W) \tag{14.94}$$

Again the superscripts on each variable refer to the originating sector, where G refers to government, N to NFC, W to ROW.

As in the household sector, financial stocks are determined as the closing value from the preceding period, plus net transactions, plus (less) any capital gains (losses). This is repeated for the other asset classes.

$$IBA_t^{F\sim H} = IBA_{t-1}^{F\sim H} + IBATR_t^{F\sim H} + IBA_{CG_t}^{F\sim H} \tag{14.95}$$

Although in this model $IBA^{F\sim H}$ is split into fixed $IBA_{FI}^{F\sim H}$ and flexible $IBA_{FL}^{F\sim H}$ rate products, the accumulation of stocks is calculated in advance of the split. This ensures stock-flow consistency in a simple fashion, and still allows the change in property income and expenditure to influence accumulation over time.

IBL on the other hand is simply the counterpart of the accumulation of deposits by households.

$$IBL_t^{F\sim H} = IBL_{t-1}^{F\sim H} + IBLTR_t^{F\sim H} + IBL_{CG_t}^{F\sim H} \tag{14.96}$$

The calculation of the stock at the end of the current period follows the simple standard structure.

$$NIB_t^F = NIB_{t-1}^F + NIBTR_t^F + NIB_{CG_t}^F \tag{14.97}$$

Pension assets include a domestic and relatively small and exogenous international component, which accumulates to offshore denominated assets.

$$PENLTR_t^F = PENATR_t^H + NPENTR^W \tag{14.98}$$

The equity asset transactions for FC are the residual flow, in that equity transactions are not modelled directly, but contributes positively or negatively depending on the relative sizes of NL^F, and the transactions in other assets. FC is fully passive in this regard as all other financial asset and liability components are equally passive to the behaviours generated in other sectors, as discussed above.

To explain the source of the changes in the value of net equity transactions in FC, we need to refer back to HH. Equation (14.99) is a repeat of Equation (14.77) in the HH section, and is shown here to identify the closure of the model.

$$IBATR_t^H = NL^H + IBLTR_t^H - EQATR_t^H - PENATR_t^H \tag{14.99}$$

$IBLTR_t^H$, $EQATR^H$ and $PENATR^H$ are all estimated directly, and NL^H is endogenous to the changes in HH income and expenditures. The only component that is not specified as for closure in any other sector is the level of $EQATR_t^H$

The full effect of $IBATR^H$ is also absorbed directly into FC via $IBLTR^{F\sim H}$, which is specified as equal to $IBATR^H$, which includes the value of $EQATR^H$, as captured by Equation (14.100).

$$IBLTR_t^{F\sim H} = IBATR_t^H \tag{14.100}$$

$IBLTR^H$, $PENATR^H$ and $IBATR^H$ are all directly offset in the FC via identities for $IBLTR$, $PENATR$ and $IBATR$, all of which are captured in

Equation (14.101). The only financial transaction component that is unaccounted for in the equation is $EQATR_t^H$.

$$NEQTR_t^F = NL_t^F + IBLTR_t^{F\sim H} + PENLTR_t^F - IBATR_t^{F\sim H} - NIBTR_t^F \tag{14.101}$$

Since NL^F is equal to $NIBTR^F$, $NEQTR^F$ is necessarily equal to $EQATR^H$. This is the redundant equation, which, if specified, would cause the model to be over-specified.

Calculating the accumulation of net equity by FC, like NIB^F, follows the simple standard method.

$$NEQ_t^F = NEQ_{t-1}^F + NEQTR_t^F + NEQ_{CG_t}^F \tag{14.102}$$

Again, financial net wealth can be calculated as financial assets less liabilities.

$$FNW_t^F = NIB_t^F + NEQ_t^F + IBA_t^{F\sim H} - IBL_t^{F\sim H} - PENL_t^F \tag{14.103}$$

And total net wealth can again be calculated with the inclusion of fixed assets. FC fixed assets are minor relative to financial assets, with a total of 6% of GDP in 1995, and falling to 4% of GDP in 2017.

If desired, these can both be calculated in real terms using the consumption price index, but the repetition is excluded here for brevity.

$$NW_t^F = FNW_t^F + K^F \tag{14.104}$$

14.10.4 Government Sector

Denmark has a strong welfare system and as a result, a relatively large public sector (GOV. Government consumption, made up largely of wages to public sector employees, made up between 25% and 30% of GDP, and social transfers (made up largely of pension and medical expenditures) contributed a further 15% to 20% of GDP between 1995 and 2017. The total expenditure of GOV varied between 58% and 48% of GDP between 1995 and 2017, ending on 50.4%. Thus, roughly half of total GDP can be attributed to government expenditures.

The bulk of these expenditures are financed by taxation, although a relatively small of GOV income is generated from semi-private enterprises (between 2% and 3% of GDP, and roughly 5% of total positive GOV flows).

The taxes of all other sectors are combined to calculate total tax revenues.

$$T_t^G = T_t^N + T_t^H + T_t^F + T_t^W \tag{14.105}$$

Social transfers are also combined for all other sectors. The largest of which are to households via old age and medical categories. Old age transfers predominantly comprise tax funded pension payments, with the exception of ATP, a supplementary labour pension, funded by an investment portfolio.

$$STR_t^G = -(STR_t^H + STR_t^N + STR_t^F + STR_t^W) \tag{14.106}$$

Savings can then be calculated from government spending, which as in Byrialsen and Raza (2019), remains exogenous in this model, gross operating surplus, interest on net interest bearing stocks, taxes and social transfers.

$$S_t^G = B2_t^G + r_{N_{t-1}}(NIB_{t-1}^G) + T_t^G + STR_t^G - G_t + \epsilon^G \tag{14.107}$$

Government (or public) investment was between 2.6% and 3.5% of GDP between 1995 and 2017, and contributes to government capital stock in the same way as for the other sectors. The on-going stock of capital is then calculated as per the sections above.

$$K_t^G = K_{t-1}^G + I_t^G - D_t^G + K_{CG_t}^G \tag{14.108}$$

Net lending is also calculated in the same manner as previously.

$$NL_t^G = S_t^G - I_t^G - NP_t^G + KTR_t^G \tag{14.109}$$

All financial flows in GOV are passively balanced by transactions in the level of net interest bearing stocks. The assumption here is that any deficit or surplus will be reflected in a change in these stocks. A deficit will be financed by the issue of debt and a surplus will finance the redemption thereof. $NIBTR_t^G$ is thus the barometer of public sector finance effects of any shock.

$$FNL_t^G = NIBTR_t^G \tag{14.110}$$

The financing requirements of government are thus fully captured in $NIBTR_t^G$, the trigger for any need to finance a deficit or invest surplus funds is the net financing requirement generated in the real sector, net lending (NL).

$$NIBTR_t^G = NL_t^G \tag{14.111}$$

The change in the stock of NIB follows the same pattern as other financial assets in the previous sectors.

$$NIB_t^G = NIB_{t-1}^G + NIBTR_t^G + NIB_{CG_t} \tag{14.112}$$

This concludes the behavioural equations of GOV.

14.10.5 The rest of the world

The foreign sector, like GOV, remains unchanged from Byrialsen and Raza (2019). The model reflects that the Danish economy is small and open, and thus is exposed to relative price differentials with trading partners. In this model the gap in price differences is reduced to zero after the date at which the first shock is introduced - this is a marginal difference from Byrialsen and Raza (2019), but one worth noting.

Because it affects the levels of import and export growth relative to Byrialsen and Raza (2019)'s baseline model, there is also an impact on the speed of accumulation of foreign assets. This is artificially accelerated in their model in order to capture the growth of foreign sector assets. Although unrealistic in the long run, the mechanism acts as a buffer in that it eliminates the risk that a shock to interest rates will unnecessarily complicate relative prices, and that Denmark continues to maintain a positive trade balance (as appears to be realistic from data).

Imports are estimated in real terms in the log-linear form below.

$$ln(m_t) = \beta_i + \beta_i ln\left(\frac{P_{t-1}^y}{P_{t-1}^m}\right) + \beta_i ln(c_{t-1} + i_{t-1} + x_{t-1}) \tag{14.113}$$

As noted by Byrialsen and Raza (2019, pp. 27), the "export function is based on the Armington (1969) model where the market share of the Danish exports is explained by relative prices."

This relation is captured below as annual Danish exports relative to a weighted index of all trading partners (m_t^W), which should be determined by domestic prices (the export price index, P_t^x) relative to foreign prices (the import price index, P_t^m), but moderated by price elasticity (β).

$$\frac{x_t}{m_t^W} = \left(\frac{P_t^x}{P_t^m} \right)^{\beta} \tag{14.114}$$

Some simple algebra allows this relation to be written in log linear form, with exports as the dependent component.

$$ln(x_t) = \beta_{35} + \beta_{36} ln \left(\frac{P_{t-1}^x}{P_{t-1}^m} \right) + \beta_{38} ln(m_t^W) \tag{14.115}$$

Both imports and exports can be inflated using their relevant price indices to for current prices.

$$M_t = m_t(P_t^m) \tag{14.116}$$

$$X_t = x_t(P_t^x) \tag{14.117}$$

In this model, actual prices of imports are expressed as the number one (1), and export prices are estimated as a function of import prices and unit labour costs. According to Byrialsen and Raza (2019), this is due to the fact that a large portion of imports to Denmark are intermediate goods. Kristoffersen and Spange (2016) investigated the effect of effective nominal exchange rate pass-through, and found that while domestic consumer prices were slow to adjust, the relationship between nominal exchange adjustments and import prices was stronger but weakening over time[51]. The influence on export prices depends more dramatically, however, on the composition of exports in terms of intermediate imports. Bo et al. (2018) discuss the complexities in identifying the ultimate trading partners, and suggest the trade in value added (TiVA) method[52], but also point to the source of value added in Danish exports,

[51] They attribute the decline in pass-through of exchange movements to the growing relative importance of the Euro-zone, with which Denmark maintains a fixed exchange rate, together with increased invoicing in Euros and enhanced global adherence to inflation targeting monetary policy.

[52] They discuss the alternative interpretations of international trade in goods, balance of payments in goods, international trade in services, balance of payments in goods and services, balance of payments in direct exports and trade in value added by final destination. The relative importance of various trading partners shifts according to the choice of measure, but Germany, the USA, the UK, Sweden, China, Norway, France and the Netherlands comprise just over 50% off all export. Germany the largest share at 11.1%.

where approximately 58% of export value is generated outside of the country[53]. As such, the model allows external price adjustments to inform part of export prices.

$$ln(P_t^x) = \beta_{39} + \beta_{40} ln(P_t^m) + \beta_{41} ln(ULC_{t-1}) \tag{14.118}$$

The savings of the foreign sector (rest of the world, ROW) are expressed from the perspective of ROW. Thus imports from the model are a revenue for ROW and exports an expenditure. Net pension flows are either positive or negative, depending on levels of contribution and disbursements. Interest on NIB and returns on NEQ depend on whether the net stock is positive or negative, wages and social transfers received are positive, and taxes paid are an expenditure.

$$\begin{aligned} S_t^W =& M_t - X_t + \chi_t(NEQ_{t-1}^W) + \psi_t(NPEN^W t - 1) + r_{N_{t-1}}(NIB_{t-1}^W) \\ &+ WB_t^W - T_t^W + STR_t^W + \epsilon^W \end{aligned} \tag{14.119}$$

The rates of return on equities (χ_t) and on pension assets (ψ_t) are assumed to be the same as for domestic assets. Danish pension funds invest a large proportion of assets outside of the country, largely as a result of the limited size of the Danish financial markets. As with the previous sectors, net lending can be calculated by taking net acquisitions and disposals of fixed assets, and capital transfers into account. The only difference here being that ROW is assumed not to make investment in Denmark.

$$NL_t^W = S_t^W - NP_t^W + KTR^W \tag{14.120}$$

Net lending is taken to reflect the current account balance for each period.

$$CAB_t = -NL_t^W \tag{14.121}$$

The financial net lending account is again the sum of transactions in net financial stocks.

$$FNL_t^W = NIBTR_t^W + NEQTR_t^W + NPENTR_t^W \tag{14.122}$$

[53]Germany (11.1%), Norway (10.1%), US (9.5%), Russia (8.7%), the United Kingdom (7.9%), Sweden (6.4%) China (4.3%), and all others (42%)

The present stock of each asset class is again determined by the simple method of preceding period stock, plus net transactions and capital gains (or less losses).

$$NIB_t^W = NIB_{t-1}^W + NIBTR_t^W + NIB_{CG_t}^W \tag{14.123}$$

$$NEQ_t^W = NEQ_{t-1}^W + NEQTR_t^W + NEQ_{CG_t}^W \tag{14.124}$$

$$NPEN_t^W = NPEN_{t-1}^W + NPENTR_t^W + NPEN_{CG_t}^W \tag{14.125}$$

The residual asset class for ROW is net interest bearing assets, largely because national liability positions are predominantly held as international debt.

$$NIBTR_t^W = NL_t^W - NEQTR_t^W - NPENTR_t^W \tag{14.126}$$

Net financial wealth can then be calculated as in the previous sectors, as the sum of net assets.

$$FNW_t^W = NIB_t^W + NEQ_t^W + NPEN^W \tag{14.127}$$

Since ROW does not own fixed assets, as per the system of national accounts, net wealth would be identical to financial net wealth, and is therefore excluded here.

14.10.6 The labour market

The final market that must clear in the model is the labour market. The size of the labour market is determined by the level of demand in the model, reflecting the Post Keynesian structure. GDP at factor costs (taken to be total labour costs plus gross operating surplus - profit - for the nation) is then used to calculate the adjusted wage share, from which the unit labour cost (ULC) is calculated.

$$Y_t^F = WB_t^N + B2_t \tag{14.128}$$

The adjusted wage share can then be calculated as the wage bill relative to Y_t^F.

$$WS_t = \frac{WB_t^N}{Y_t^F} \tag{14.129}$$

Finally, ULC is calculated as the ratio between the wage component and total factor costs.

$$ULC_t = \frac{WS_t(Y_t)}{Y_t^F} \tag{14.130}$$

Employment is then determined by the number of persons that are part of the labour force, but are not employed. Or, the difference between the total labour force (LF) and the number of persons that are employed (N).

$$UN_t = LF_t - N_t \tag{14.131}$$

UN as a proportion of LF provides the rate of unemployment.

$$UR_t = \frac{UN_t}{LF_t} \tag{14.132}$$

Employment (N) is estimated using actual population data and lagged real GDP.

$$ln(N_t) = \beta_i + \beta_i ln(y_{t-1}) + \beta_i ln(LF_t) \tag{14.133}$$

A combination of domestically and foreign employed persons provides the total level of employment (N_t^N)

$$N_t^N = N_t + N_t^W \tag{14.134}$$

Returning to the income of HH, wages (WB^H) for domestic employees are a product of locally employed persons and the local wage rate, which is in-turn estimated as a negative relation with the rate of unemployment.

$$WB_t^H = W_t(N_t) \tag{14.135}$$

$$W_t = \beta_0 + \beta_i UR_{t-i} \tag{14.136}$$

This reflects falling bargaining power in unions as unemployment rises, but also the relative over-supply of labour.

The number of foreign employed persons is then calculated as the average wage rate into the total foreign wage bill.

$$N_t^W = \frac{WB_t^W}{W_t} \tag{14.137}$$

14.10.7 Lists of variables from the model

\begin{table}

\caption{(#tab:variable-names-table_model)List of model variables from equations}

variable	description
α	Ratio of fixed interest mortgage debt
β	Parameter
χ	Return on equity
ϵ	Property income adjustment term
ψ	Return on pension stocks
$B2$	Gross operating surplus
c	Consumption: Real prices
C	Consumption: Nominal prices
CAB	Current account balance
$CPEN$	Financial Liabilities: Change in pension entitlements
D	Depreciation of fixed capital
EQA_{CG}	Financial Assets: Equity assets: Capital gains
EQA	Financial Assets: Equity assets
$EQATR$	Financial Assets: Equity assets: Transactions
FA	Financial Assets
$FATR$	Financial Assets: Transactions
FL	Financial liabilities
$FLTR$	Financial liabilities: Transactions
FNL	Financial Net Lending (Balance)
FNW	Financial net wealth
G	Government expenditure
i	Gross fixed capital formation (Investment): Real prices
I	Gross fixed capital formation (Investment): Nominal prices
$IBA^{F\sim H}_{A(FI)}$	Financial Assets: Interest bearing assets: FC on HH: Fixed interest
$IBA^{F\sim H}_{A(FL)}$	Financial Assets: Interest bearing assets: FC on HH: Flexible interest
$IBA^{F\sim H}_{CG}$	Financial Assets: Interest bearing assets: FC on HH: Capital gains
$IBA^{F\sim H}$	Financial Assets: Interest bearing assets: FC on HH
IBA_{CG}	Financial Assets: Interest bearing assets: Capital gains
IBA	Financial Assets: Interest bearing assets
$IBATR^{F\sim H}$	Financial Assets: Interest bearing assets: FC on HH: Transactions
$IBATR$	Financial Assets: Interest bearing assets: Transactions
$IBL(FI)$	Financial Liabilities: Interest bearing liabilities: Fixed interest
$IBL(FL)$	Financial Liabilities: Interest bearing liabilities: Flexible interest
$IBL^{F\sim H}_{CG}$	Financial Assets: Interest bearing liabilities: FC to HH: Capital gains
$IBL^{F\sim H}_{L}$	Financial Assets: Interest bearing liabilities: FC to HH
$IBL^{F\sim H}$	Financial Assets: Interest bearing liabilities: FC to HH
IBL_{CG}	Financial Assets: Interest bearing liabilities: Capital gains
IBL_{FI}	Financial Liabilities: Interest bearing liabilities: Fixed interest
IBL_{FL}	Financial Liabilities: Interest bearing liabilities: Flexible interest
IBL	Financial Liabilities: Interest bearing liabilities
$IBLTR^{F\sim H}$	Financial Liabilities: Interest bearing liabilities: FC to HH: Transactio
$IBLTR$	Financial Liabilities: Interest bearing liabilities: Transactions
k	Stock of Capital: Real prices
K	Stock of Capital: Nominal prices
K_{CG}	Stock of Capital: Capital gains
KTR	Capital transfers
LF	Labour force: Total number of employable persons
m	Imports: Real prices
M	Imports: Nominal prices
N	Labour force: Denmark for workers in production
NEQ_{CG}	Net financial stock: Equity: Capital gains
NEQ	Net financial stock: Equity
$NEQTR$	Net financial stock: Equity: Transactions

\end{table}

Bibliography

Abildgren, K. (2017). Historical statistics. *Historical data sets*.

Alpanda, S. and Zubairy, S. (2017). Addressing household indebtedness: Monetary, fiscal or macroprudential policy? *European Economic Review*, 92:47–73.

Andersen, H. Y. and Leth-Petersen, S. (2019). Housing wealth effects and mortgage borrowing.

Andersen, J. G. (2016). The Danish Pension System. Workingpaper, Policy network, Aalborg, Denmark.

André, C. (2016). Household debt in OECD countries: Stylised facts and policy issues. In *The Narodowy Bank Polski Workshop: Recent Trends in the Real Estate Market and Its Analysis-2015 Edition*.

Beckta, P. J. (2015). Modelling a Speculative Housing Market in a Stock-Flow Consistent Framework. *University of Ottawa, Masters disseration.*

Bernanke, B., Gertler, M., and Gilchrist, S. (1999). *Chapter 21 The financial accelerator in a quantitative business cycle framework*, volume 1.

Bernanke, B. S. (2007). The financial accelerator and the credit channel. In *The Credit Channel of Monetary Policy in the Twenty-first Century Conference*, volume 15, Atlanta, Georgia.

Bo, C., Burman, S., Winther, C., and Jensen, P. R. (2018). How big are Danish exports and who are our main trading partners? Technical report, Statistics Denmark, Copenhagen.

Buttiglione, L., Lane, P., Reichlin, L., and Reinhart, V. (2014). Deleveraging, what deleveraging? The 16th Geneva Report on the world economy. *International Center for Monetary and Banking Studies/Center for Economic Policy Research*, (September).

Byrialsen, M. R. and Raza, H. (2018). Macroeconomic effects of unemployment benefits in small open economies: A stock–flow consistent approach. *European Journal of Economics and Economic Policies: Intervention*, 15(3):335–363.

Byrialsen, M. R. and Raza, H. (2019). An empirical stock-flow consistent macroeconomic model for Denmark. *Levy Institute Working Papers*.

Caverzasi, E. and Godin, A. (2013). Stock-flow consistent modeling through the ages. *Levy Economics Institute Working Paper Series*, 745.

Caverzasi, E. and Godin, A. (2015). Post-Keynesian stock-flow-consistent modelling: a survey. *Cambridge Journal of Economics*, 39(1):157–187.

Chick, V. (2003). Theory, method and mode of thought in Keynes's General Theory. *Journal of Economic Methodology*, 10(3):307–327.

Chick, V. and Dow, S. C. (2001). Formalism, logic and reality: a Keynesian analysis. *Cambridge Journal of Economics*, 25(6):705–721.

Danmarks Nationalbank (2016). Financial Stability: 2nd Half 2016. Technical report, Danmarks Nationalbank, Copenhagen.

Disyatat, P. (2011). The Bank Lending Channel Revisited. *Journal of Money, Credit and Banking*, 43(4):711–734.

Dos Santos, C. H. (2006). Keynesian theorising during hard times: stock-flow consistent models as an unexplored 'frontier' of Keynesian macroeconomics. *Cambridge Journal of Economics*, 30(4):541.

Dow, S. C. (1985). *Macroeconomic thought: a methodological approach*. Blackwell Oxford.

Dow, S. C. (2001). Post Keynesian methodology. In Holt, R. P. F. and Pressman, S., editors, *A New Guide to Post Keynesian Economics*, chapter 2, pages 11–20. Routledge, London, UK.

ECB (2019). Monetary policy decisions, September. Technical report, ECB, Directorate General Communications, Frankfurt am Main, Germany.

Englund, P. (1999). The Swedish banking crisis: roots and consequences. *Oxford review of economic policy*, 15(3):80–97.

Falch, C. E., Sørensen, J. P., Holbek, S., Østergaard, J. W., and Andersen, N. T. B. (2017). Danish Covered Bond Handbook: The covered bond handbook of mortgage banks in Denmark. Technical report, Danske Bank, A/S, Copenhagen.

Fontana, O. and Godin, A. (2013). Securitization, housing market and banking sector behavior in a stock-flow consistent model. Technical report, Economics Discussion Papers.

Godley, W. and Lavoie, M. (2007). Monetary Economics: An Integrated Approach to Credit, Money, Income, Production and Wealth. *Monetary Economics: An Integrated Approach to Credit, Money, Income, Production and Wealth*.

Godley, W. and Lavoie, M. (2012). *Monetary economics: An integrated approach to credit, money, income, production and wealth*. Palgrave Macmillan UK, Basingstoke, UK, 2 edition.

Haldrup, K. (2017). On security of collateral in Danish mortgage finance: a formula of property rights, incentives and market mechanisms. *European Journal of Law and Economics*, 43(1):1–29.

Holbek, S., Falch, C. E., Sillemann, B. T., Kuoppamäki, P. P., Jullum, F., and Grahn, M. (2017). Nordic Covered Bond Handbook: The handbook of the Nordic covered bond markets and issuers. Technical report, Danske Bank, A/S, Copenhagen.

Jordà, Ò., Schularick, M., and Taylor, A. M. (2017). Macrofinancial history and the new business cycle facts. *NBER macroeconomics annual*, 31(1):213–263.

Justiniano, A., Primiceri, G., and Tambalotti, A. (2015). Household leveraging and deleveraging. *Review of Economic Dynamics*, 18(1):3–20.

Keynes, J. M. (1937). The general theory of employment. *The quarterly journal of economics*, 51(2):209–223.

Kohlscheen, E., Mehrotra, A. N., and Mihaljek, D. (2018). Residential investment and economic activity: evidence from the past five decades.

Kristoffersen, M. S. and Spange, M. (2016). Exchange rate pass-through to Danish import and consumer prices. Technical report, Danmarks Nationalbank, Copenhagen.

Laustsen, K. (2009). Mortgage financing and the Danish balance principle. *Nycredit Finans/Invest*, (6).

Lunde, J. and Whitehead, C. (2014). Introduction: Milestones in Housing Finance across Europe. *Mortgage Info*, (ENHR Special Edition):1–4.

Nationalbank, D. (2009). Danish Government Borrowing and Debt 2008. *Danmarks Nationalbank*.

Nikiforos, M. and Zezza, G. (2017). Stock-flow consistent macroeconomic models: A survey. *Journal of Economic Surveys*, 31(5):1204–1239.

Pill, H. (2001). Monetary analysis: Tools and applications (Summary). In Klöckers, H.-J. and Willeke, C., editors, *Monetary Analysis: Tools and Applications*. European Central Bank (ECB), Frankfurt am Main, Germany.

Raberto, M., Teglio, A., and Cincotti, S. (2012). Debt, deleveraging and business cycles: An agent-based perspective. *Economics*, 6.

Ryoo, S. and Skott, P. (2008). Financialization in Kaleckian economies with and without labor constraints. *European Journal of Economics and Economic Policies: Intervention*, 5(2):357–386.

Scanlon, K., Lunde, J., and Whitehead, C. (2008). Mortgage product innovation in advanced economies: More choice, more risk. *European Journal of Housing Policy*, 8(2):109–131.

Scanlon, K., Lunde, J., and Whitehead, C. (2011). Responding to the housing and financial crises: Mortgage lending, mortgage products and government policies. *International Journal of Housing Policy*, 11(1):23–49.

Seppecher, P. and Salle, I. (2015). Deleveraging crises and deep recessions: a behavioural approach. *Applied Economics*, 47(34-35):3771–3790.

Sheehy, R. (2014). Denmark: Financial sector assessment program. Systemic issues in mortgage loans and covered bond finance - Technical note.

Skinhøj, J., Gottschalck, M., Kunde, G. D., and Isaksen, J. (2019). Danish covered bonds. Technical report, Nykredit Markets, Copenahgen.

Skinhøj, J., Kunde, G. D., and Rasmussen, K. M. F. (2018). Danish Covered Bonds. Technical report, Nykredit Markets, Copenhagen.

Smith, A. (1776). Capter VII: Of the natural and market Price of Commodities. In TODD, W. B., CAMPBELL, R. H., and SKINNER, A., editors, *An Inquiry into the Nature and Causes of the Wealth of Nations*, chapter B. 1, Ch., pages 70–81. Liberty Classics, Indianapolis, Indiana, edinburgh edition.

Statistical Office of the European Communities. (2013). *European system of accounts : ESA 2010*.

Zezza, G. (2008). U.S. growth, the housing market, and the distribution of income. *Journal of Post Keynesian Economics*, 30(3):375–401.

Zezza, G. and Zezza, F. (2019). On the design of empirical stock-flow-consistent models. *Levy Economics Institute of Bard College, Working Paper*, (919).