UNIVERSITEIT VAN AMSTERDAM

Amsterdam School of Economics

Writing a master's thesis Actuarial Science & Mathematical Finance

Rob Kaas[1]   July 31, 2014

Contents

1 Introduction

As from the academic year 2012–2013, the master's thesis Actuarial Science and Mathematical Finance has to be written in English, unless otherwise agreed between student, supervisor and thesis coordinator.

Also, because mathematical texts do not lend themselves well for non-specialized word processors, we insist on the use of TeX/LaTeX to typeset the documents.

The purposes of this text are to describe:

- the process of writing a thesis AS&MF;

- how to get software to produce TeX documents: MiKTeX and TeXworks;

- how to use that software;

- the template that we provide for a TeX-thesis; not just to give such theses a uniform look, but also to spare you a lot of trouble.

2 Writing a master's thesis for AS&MF

The formal rules and regulations are described in the FEB's "Teaching and Examination Regulations", notably the appendix "Regulations Governing Master's Theses FEB".

2.1 Text in the study guide

For how the regulations work for the master AS&MF, see the corresponding page of the Study guide to be found on `http://studiegids.uva.nl/web/uva/sgs/nl/c/12854.html`. The following is quoted (almost) verbatim from this page:

Master's Thesis Actuarial Science and Mathematical Finance

Study guide number   6414M0147Y

Credits   15 (420 hours)

Entry requirement   At least 20 EC completed of the Master's programme; it is for the thesis coordinator (R. Kaas) to decide if starting with the Master's thesis earlier or in another period than the second semester is feasible.

Period(s)   Semester 2

Coordinator   prof. dr. R. Kaas

Learning goals   A Master's thesis is an academic paper in which a research question is developed and analysed through original empirical and/or theoretical research, supplemented with a literature review.
   A Master's thesis has the following components:

- a research question, with a thorough explanation why this question is of interest;

- a discussion of relevant literature related to the research question;

- an overview of relevant methods in the literature to analyze the research question;

- a more detailed description of the methodology used in the thesis;

- a synthesis analyzing the research question based on the methods described;

- a section summarizing the conclusions of the research.

As a guideline, a Master's thesis should contain 25 to 40 pages, excluding tables and appendices.

Starting with the thesis   As a first step, a student approaches the Thesis Coordinator with a draft of a thesis plan. A thesis plan should contain the following items:

- research question: a central research question with several sub questions;

- explanation of the research question (basically the introduction to the thesis);

- a short description of related theory and a preliminary list of references;

- suggestions for tackling the problem, and research methods by sub question: for example literature study, data collection, model building, statistical analysis, application of existing software, market research and so on;

- draft table of contents of the thesis;

- time schedule specifying concrete intermediate goals.

The thesis coordinator appoints a staff member as the first supervisor, as well as a second marker. The thesis plan is fine-tuned in cooperation with the first supervisor.

Supervision period   A student has a right to supervision for a period of six months after the start of the thesis. After that period, no supervision will take place, and just once, the students can ask what remains to be done to get a passing grade for the thesis.

At the end of the process

- There is no defense of the thesis; the process is finished with handing in the final version;

- The final version of the thesis will be made available through the university library at http://scriptiesonline.uba.uva.nl/

- If the thesis contains confidential material, the student may ask that such publication is delayed for three years (six in exceptional cases), or restricted to a parallel version of the thesis;

- The first supervisor determines which of the elements below will be considered in the evaluation of the thesis, and how they are weighted. The student has a right to be informed about this at an early stage, and also to get an explanation of the evaluation in the end. For the thesis itself, the following elements are considered: statement of the research problem, structure, originality, choice and processing of the literature, choice and processing of the research methods, quality of the analysis, quality of the conclusion, use of language and technical presentation. The attitude of students will be judged on the basis of: independence, pace of work, handling suggestions, contacts with supervisor and possibly other elements to be specified;

- The first supervisor determines the mark; the second reader may suggest an adjustment, limited in principle to one half point. After the *final version* was handed in, the verdict (passing mark/revise) should be given within 4 weeks;

- The thesis evaluation form must be filled in by the supervisor, discussed (if needed) with the student, and handed to the BES who will register the grade;

- The FEB uses software to detect plagiarism (Ephorus).

Exemptions   Unlike for other elements of the Master's programme, exemptions for the thesis are not granted in the Master's programme for students who entered the programme in or after September, 2012.

Language   The Master's thesis will be written in English, or, if the first supervisor agrees, in Dutch; in that case adding an English summary to the thesis is required. Unless permitted otherwise by the thesis coordinator, theses should be typeset in LaTeX. Visit the site "Master Thesis Actuarial Science and Mathematical Finance" on Blackboard https://blackboard.ic.uva.nl/ to find information on how to obtain the software MiKTeX/TeXworks that can be used, as well as a template for the thesis.

Internship   The thesis may be combined with an internship. The activities performed during the internship are used in writing the thesis, e.g. results from interviews, observations, or desk research. The performance at the internship will not in any way influence the grade for the thesis.

2.2   Some explanatory remarks

Thesis plan

First, in cooperation with your supervisor, set up your thesis plan. It should contain the following items:

- research question: a central research question with several subquestions, see below;

- explanation of the research question (basically the introduction to your thesis);

- a short description of related theory and a preliminary list of references;

- suggestions for tackling the problem, and research methods by subquestion: for example literature study, data collection, model building, statistical analysis, application of existing software, market research and so on;

- draft table of contents of the thesis;

- time schedule specifying concrete intermediate goals.

Research question

Choosing a research topic and a research question can be done in three ways:

1. find a suitable topic yourself;

2. obtain a topic from a company or some thesis database;

3. ask a professor to suggest a topic.

The last option is not very desirable; it is part of your education to be able to find your own research topic.

> **Important:** We may restrict the freedom of students to choose their own topic in case of capacity problems.

A useful research question is well-defined. Some examples of too broadly defined research questions:

- What is the influence of IAS on the balance sheet of an insurer?

- How effective are ALM studies for pension funds?

- Solvency testing after Solvency II: what are the consequences of implementing this?

2.3 Supervision

You should meet at least once every month with your supervisor; more often in the beginning. Discuss the further process at your first meeting with your supervisor: when to meet, when to deliver draft chapters. Submit your final version after your supervisor agrees you can do so; his marking it should fit in his time schedule.

If you experience any problems with the supervision process, consult the thesis coordinator.

Conversely, if the supervisor finds you do not keep promises or do not contact him for a long while, the supervision deal can be broken, after consulting the thesis coordinator. In that case, perhaps a new supervisor and a new topic will have to be found.

The period in which you get actual supervision for the thesis project ends *six months* after your official start. After this period, you can finish your thesis unsupervised. The end-product will be graded, and if needed the supervisor will indicate **once** what remains to be done to get a passing grade.

3   About TeX

Working with TeX is different from working with a WYSIWYG (What You See Is What You Get) word processor such as Word. It is more like writing a program in a computer language like Pascal, with as output a pdf containing, in the end, a beautifully typeset thesis. In a nutshell, LaTeX works like this:

- First, you use a text editor (like TeXworks) to create a LaTeX document named for example `YourFilename.tex`. This is an ordinary text-file, with mark-up codes like a html-file.

- Then, you run a LaTeX compiler (like MiKTeX) to produce the file `YourFilename.pdf`.

- Finally, you need to use some kind of viewer/previewer (like the one built into TeXworks) to view or print the formatted file `YourFilename.pdf`.

3.1   Getting the necessary TeX-software

If you already have a TeX-system on your computer, do use it. If not, we advise you to download MiKTeX. From its Wikipedia page: "This typesetting system for Microsoft Windows was developed by Christian Schenk. It consists of an implementation of TeX and a set of related programs. MiKTeX provides the tools necessary to prepare documents using the TeX/LaTeX markup language, as well a simple TeX-editor (TeXworks)." And: "MiKTeX can update itself by downloading new versions of previously installed components and packages, and has an easy installation process. Additionally, it can ask users whether they wish to download any packages that have not yet been installed but are requested by the current document. The current version of MiKTeX is 2.9 and is available at the MiKTeX homepage."

You can do everything from TeXworks, set up to control MiKTeX. We will describe below which steps to take of downloading, installing, configuring, and working with MiKTeX, TeXworks. It goes as follows[2] (be sure to follow *all* of the directions below, *in order*):

1. Go to http://miktex.org.

2. Choose the Download[3] menu on top.

3. Press "Basic MiKTeX 2.9.4757 Installer // Version 2.9.4757, Windows 32-bit // Size: 152.53 MB" (details change as new versions are installed).

4. Save the file `basic-miktex-2.9.4757.exe`. Downloading might take a few minutes, depending on the speed of your connection. If you are physically wired to a network it will be much faster.

5. After it finishes downloading, double-click on the file to open it and select "Run" on the security warning. The Setup Wizard will now open.

6. Accept the license agreement and click "Next" three times *without changing anything.*

7. At the settings, choose "A4" for preferred paper size and "Yes" for installing packages on the fly. Click "Next" and then click "Start".

8. Wait for the computer to finish ($\pm$5–10 minutes) the install and then click "Next" and "Close".

9. Delete the installer `basic-miktex-2.9.4757.exe`, which is still located where you downloaded it.

10. Create a folder in which you will save all your future work.

11. Please note that MiKTeX is a shareware product. For a voluntary $15.00 donation ($\pm$€11) they will provide direct email support; see their registration page.

12. If you want to learn all the details, there is a reference to the section "Installing MiKTeX" in the MiKTeX manual.

13. When you have installed MiKTeX, it is recommended that you run the update wizard in order to get the latest updates.

If you are compelled to do so, it is possible to run TeX from a USB-stick (follow the instructions on the "Portable" page):

- you carry MiKTeX on a portable storage device for use on any Windows computer;

- configuration settings are stored on the portable storage device and not in the Windows Registry of the host computer;

- by using MiKTeX Portable, you leave no traces on the host computer;

- you do not need administrator privileges on the host computer.

Having installed either version of MiKTeX, you are good to go. Start the program TeXworks; you might want to put a shortcut to it on your deksktop.

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[2]Thanks to Eric Errthum of Winona State University (Minnesota) for posting http://course1.winona.edu/eerrthum/LaTeX/Windows.html

[3]For how to get a portable version, see below

3.2 Creating a simple document using LaTeX

Now we're ready to write a document in LaTeX. The instructions below will take you through the process of creating a very simple example document. Open the TeXworks program. If you don't use the portable version, this can probably be found in your Start Menu, Programs, MikTeX 2.9, TeXworks. Or you already created a shortcut to this on the desktop.

Write: In TeXworks, type this:

```
\documentclass{article}
\begin{document}
Hello world!
\end{document}
```

A LaTeX document should begin with a `\documentclass` command, and any text to be printed must be included between the `\begin{document}` and `\end{document}` commands. The commands before `\begin{document}` are called the *preamble*. It normally contains commands that affect the entire document. They set the page-style, load additional packages and set up user-defined control sequences.

Save: Save this file as `hello.tex` to whatever directory you choose. Be sure the extension is `tex` and NOT `txt`. Once you have given your text a name, this saving goes automatic when you compile the text.

Compile: Make sure the drop-down menu in your toolbar says "pdfLatex". Then either click the compile button in the toolbar (looks like a green dot with a triangle in it) or press CTRL+T. If there are no compiling errors in your `.tex` file, then in the same directory where you saved `hello.tex` there should be new files: `hello.aux`, `hello.log`, `hello.pdf` and `hello.synctex.gz`. These files will be updated every time you run `latex` on `hello.tex`. Check this in your directory/folder.

View: If there were no compiling errors in your `.tex` file, then a pdf-copy of your document should have opened up in a separate window. If nothing shows up, then see the section below about handling compiling errors.

Repeat: Now if you want to modify your file, go back and repeat the steps above: Write, (Save,) Compile, View.

3.3 Handling compiling errors

LaTeX is a very picky typesetting program, and a lot of tiny things can cause compiling errors. By following the instructions below you will introduce an error into your `hello.tex` file and then see how to deal with it.

Change your `hello.tex` file so that it looks like this:

```
\documentclass{article}
\begin{document}
Hello world!
```

```
The & is a special character.
\end{document}
```

Save `hello.tex` and try to compile it (as described above). Notice that the last line of the log file says that 1 error occurred.

Read the last few lines of information in the log window (bottom-left). It should look something like this:

```
! Misplaced alignment tab character &.
l.4 The &
         is a special character.
```

In LaTeX, the "&" character is used for tabbing (alignment) in certain environments, but it is not a legal character on its own; that is what the first line of the error message above is saying—that the character "&" is being used somewhere it shouldn't. The "l.4" at the beginning of the next line of the error message tells you that the error is on line 4 (it says "lowercase ell dot four" not "one dot four" at the beginning of the line). Notice also that the line breaks where the compiler thinks your error might be: at the "&" character. It's pretty clear that we need to get rid of or modify that "&", but for the sake of this exercise, let's say you don't understand the error message completely, but you do think that line 4 could be the culprit. One thing you can do is "comment out" the line in question, by inserting a "%" symbol at the start of the line. In LaTeX, the rest of the line following a "%" symbol is ignored by the compiler. Do this, and then compile again, and you should not get any errors. Of course, after the step above, you got rid of the error, but you also didn't get the document to say what you wanted; let's fix the error. In LaTeX, the character "&" can be produced by typing "\&". Un-comment line 4 (i.e. remove the "%" symbol) and put a backslash "\" in front of the ampersand "&". Recompile and everything should work.

TeX error messages are not always overly clear, unfortunately, making debugging somewhat of a hassle sometimes.

4 Writing your thesis

To help you in writing your thesis without having to master TeX fully (if that's even possible), we have prepared a template that you only have to fill in.

4.1 Using the provided template

From the Blackboard-site, download the file `ThesisTemplateASMF.zip` and unzip the files in it to your working directory. There are a few `.tex` files and some other files. Open the file `ThesisTemplateASMF.tex` in TeXworks, and compile it by pressing Ctrl-T (make sure the drop-down menu in your toolbar says "pdfLaTeX"). You should see a marked-up text-file on the left on your screen, a pdf on the right. In your working directory there will be new files `ThesisTemplateASMF.aux` (auxiliary), `ThesisTemplateASMF.log` (log of messages), `ThesisTemplateASMF.toc` (table of contents), `ThesisTemplateASMF.synctex.gz` (information enabling jumping from the pdf to the corresponding place in the text and back) and `ThesisTemplateASMF.pdf` (the printable and viewable output of the compilation). These files will be updated every time you run LaTeX on `ThesisTemplateASMF.tex`.

Note that LaTeX writes the information to make a Table of Contents to the `.toc` file, but it creates the table of contents based on the information from the previous compilation. The same is true for all references to tables, figures and equations, which are stored in the `.aux` file. Because of this, you may have to compile your file more than once to get the final result in order.

You will find that we pre-cooked your thesis up to a point where you only have to change a few lines in the file `ThesisTemplateASMF.tex` (the ones with `<====` in them), and write your own versions of the files containing summary, keywords, preface, chapters, appendices (if any) and references (see Section 8). Also, you might want to replace the pictures on the front page by your own, or just delete them. In this way, your thesis will automatically have the proper structure with page-breaks in the right places.

Later on in this document (Section 5) you can find how to create equations, tables and figures.

4.2   Structuring your thesis

Using TeX will encourage you to give your thesis a clear structure, by dividing it into smaller and smaller chunks as follows:

Chapters Documents of class 'report' such as `ThesisTemplateASMF.tex` are divided in chapters. The first one could be called 'Introduction', or 'Introduction and overview'. It should describe the research question and might dwell on questions like

- What is the problem?
- Why is it a problem?
- What is the solution?
- Why is this a good/best solution?
- How do you obtain the solution?

The last one might contain 'Conclusions and further research'.

Sections For example in the first chapter, 'The problem', 'Research question', 'Towards a solution', 'Overview of the literature', 'Relevance', 'History', 'Outline of the thesis', . . .

Subsections Like 'Heuristic methods', 'Recursions', . . .

Subsubsections Like 'Panjer's recursion', . . . Subsubsections are not numbered.

(Sub)paragraphs Avoid this level of detail.

4.3   Do's and don't's

Here are some things you should definitely avoid:

1. Using **bold** or, the horror, <u>underline</u> to emphasize. For typographical reasons, using `\emph{}`, producing *italics*, is much preferred.

2. Starting a sentence with a mathematical formula.

3. Starting a sentence after a formula with 'Where c is the . . .'; instead, end the formula with a comma and write 'where c is the . . .'. Or, end the formula with a dot and write 'Here c is the . . .'.

4. Putting complicated formulas in the text; use display style.

5. Using footnotes and/or endnotes; they distract the reader. The contents of the footnote can be incorporated[4] in the text[5].

6. Using abbreviations like e.g. or i.e.; use 'for example' and 'that is'.

Things you should do:

1. Since formulas are part of the sentence around it, end a formula with a comma or a dot, whichever is appropriate.

2. Distinguish mathematical symbols like X from X in the text as well, not just in formulas.

3. Install and use the spell-checker. American English ('col$o$r', 'center', 'minimi$z$e', 'analog', 'mode$l$ing', 'aging') is preferred over British English, but this is not a big deal, as long as you are consistent. For an overview, see http://www.en.wikipedia.org/wiki/American_and_British_English_spelling_differences.

4. Since e $= 2.71828\ldots$, i $= \sqrt{-1}$ and the d in integrals/differentials are not variables, they should not be italicized. Therefore in equations, use for example `\text{d}` or `\textrm{d}` instead of just `d`.

5. In Dutch, it is quite common to encounter very long words like *Arbeidsongeschiktheidsverzekering* that must be hyphenated but on which TEX's English hyphenation rules fail. In that case, manually insert `\-` where you want the hyphen to be placed.

6. In formulas, instead of just writing `$SCR_i$`, write `$\text{SCR}_i$` or if you want italics, `$\textit{SCR}_i$`, resulting in SCR_i, SCR$_i$ and SCR_i. Note the difference in spacing between the letters; in math, TEX typesets as if SCR is the product of the variables S, C and R, without 'kerning'. Be consistent with how you write SCR or SCR in the text.

   To demonstrate the effect of kerning (adjusting the spacing between characters to achieve a visually pleasing result), study the position of the horizontal serifs in

   WAVE WAVE WAVE $WAVE$ *WAVE*

   which originates from

   ```
   {\Large WAVE W{}A{}V{}E $\text{W}\text{A}\text{V}\text{E}$ $WAVE$ \emph{WAVE}}
   ```

A link that might give you food for thought is http://faculty.chicagobooth.edu/john.cochrane/research/papers/phd_paper_writing.pdf.

5 How-to's

5.1 Listings

To include a listing of for example an R-script in your text, just put it in a 'verbatim' environment, like this:

---

[4] if needed, in parentheses ()

[5] do as I say, not as I do

```
\begin{verbatim}
"Your R-script here"
\end{verbatim}
```

This results in:

```
"Your R-script here"
```

In the last section, we'll show that to create a 'verbatim' environment, all you have to do in TeXworks is type 'bve' and then press [TAB].

5.2 Equations

Here is a simple equation linking many important mathematical symbols: $\text{e}^{\text{i}\pi} + 1 = 0$. To get it into your text (with e and i in roman, not italic, typeface), type

```
... mathematical symbols: $\text{e}^{\text{i}\pi} + 1 = 0$
```

The same equation can also be displayed more prominently, as follows:

```
\begin{equation*}
\text{e}^{\text{i}\pi} + 1 = 0.
\end{equation*}
```

This results in the following output, with the formula centered on a separate line:

$$\text{e}^{\text{i}\pi} + 1 = 0.$$

Without the *'s, the equation is labeled:

```
\begin{equation}\label{eipi+1=0}
\text{e}^{\text{i}\pi} + 1 = 0.
\end{equation}
```

This results in:

$$\text{e}^{\text{i}\pi} + 1 = 0. \tag{1}$$

This equation can be referred to as equation (1) by typing `\eqref{eipi+1=0}`. There are not many restrictions on what can be put in a label.

Notice the difference in the output if you leave a blank line before and/or after an equation, as we did for equation (1). In this case, a new paragraph is started after the equation, with indentation; before the equation there is a little more white space.

The package `amsmath` provides facilities to format multi-line equations. For example, consider the following equation

$$y = (x + 1)^2,$$

which as is well-known expands to

$$y = x^2 + 2x + 1. \tag{2}$$

To produce this output, you can type:

```
\begin{align}
   y &= (x+1)^2,\notag %% no equation number here
   \intertext{which as is well-known expands to}
   y &= x^2+2x+1.
\end{align}
```

Because they are within an `align` environment, these equations have the equals signs aligned with one another (recall from Subsection 3.3 that the & serves as a tab character), and each line carries a separate label, unless suppressed by `\notag`. Adding *'s, so using `\begin{align*}` and `\end{align*}`, drops all labels. Replacing the `\intertext` line by `\\` then gives:

$$y = (x+1)^2$$
$$y = x^2 + 2x + 1.$$

For long formulas, the `multline` environment aligns the first line to the left, the last one (with the label) to the right, while the remainder is centered:

$$(x+y+z)^4 = z^4 + 4yz^3 + 4xz^3 + 6y^2z^2 + 12xyz^2+$$
$$6x^2z^2 + 4y^3z + 12xy^2z + 12x^2yz + 4x^3z+$$
$$y^4 + 4xy^3 + 6x^2y^2 + 4x^3y + x^4 \quad (3)$$

is produced by

```
\begin{multline}
(x+y+z)^4 = z^4 + 4 y z^3 + 4 x z^3 + 6 y^2 z^2 + 12 x y z^2 + \\
6 x^2 z^2 + 4 y^3 z + 12 x y^2 z + 12 x^2 y z + 4 x^3 z + \\
y^4 + 4 x y^3 + 6 x^2 y^2 + 4 x^3 y + x^4
\end{multline}
```

If you want just one vertically centered label, use `aligned`:

```
\begin{equation}\label{eqn:3.27}
\begin{aligned}
f(0) &= \begin{cases}
           \Pr[N=0]          & \text{if } p(0)=0; \\
           \text{m}_N\big(\log p(0)\big) & \text{if } p(0)>0; \\
        \end{cases}\\
f(s) &= \frac{1}{1-a p(0)}
        \sum_{h=1}^{s}\Big(a+\frac{bh}{s}\Big)p(h)f(s-h),
        \quad s=1,2,\ldots
\end{aligned}
\end{equation}
```

This produces formula MART (3.27) (notice the `\big` and `\Bigger` brackets):

$$f(0) = \begin{cases} \Pr[N=0] & \text{if } p(0) = 0; \\ \mathrm{m}_N\big(\log p(0)\big) & \text{if } p(0) > 0; \end{cases}$$
$$f(s) = \frac{1}{1-ap(0)} \sum_{h=1}^{s}\Big(a + \frac{bh}{s}\Big)p(h)f(s-h), \quad s = 1,2,\ldots \quad (4)$$

Also note the use of `cases` in the initialization part of Panjer's recursion.

Fractions   To generate (partial) derivatives like this

$$f'(x) = \frac{\mathrm{d}}{\mathrm{d}x} f(x); \qquad \frac{\partial f(x,y)}{\partial x}; \qquad \frac{\partial^2 f(x,y)}{\partial x \partial y}, \tag{5}$$

do

```
\begin{equation}
f'(x) = \frac{\text{d}}{\text{d}x} f(x); \qquad
\frac{\partial f(x,y)}{\partial x}; \qquad
\frac{\partial^2 f(x,y)}{\partial x \partial y},
\end{equation}
```

Note the use of `\qquad` to enforce horizontal spacing; one `\qquad` equals two `\quad`'s, which is the width of the character M. Smaller spaces, if needed, are `\,`, `\:`, `\;`, `\␣` (backslash+space), being 3/18, 4/18, 5/18 and 9/18 of a `\quad`. Sometimes negative space is needed; for this, use `\!` which is $-3/18$ of a `\quad`.

To generate a binomial coefficient and an 'is defined as', like this

$$\binom{n}{m} \stackrel{\text{def}}{=} \frac{n!}{(n-m)!m!}, \tag{6}$$

do

```
\begin{equation}
\binom{n}{m} \stackrel{\text{def}}{=} \frac{n!}{(n-m)!m!},
\end{equation}
```

Brackets   For complex equations with many nested brackets, use `\left\{`:

$$\left. \left[\left\{ \left(\frac{x^3 - y^3}{x - y} \right)^2 \right\}^3 \right]^4 \right|_{x=y} \tag{7}$$

which is produced by typing:

```
\begin{equation}
\left. \left[ \left\{ \left( \frac{x^3 - y^3}{x - y}
\right)^2 \right\}^3 \right]^4 \right|_{x=y}
\end{equation}
```

Left and right brackets must be balanced, explaining the `"\left."` (giving no output) at the beginning. Note that to get a curly bracket }, you should type `\}`; the \ is treated as an escape character by TEX.

Alternatively, generate bigger brackets and other symbols as follows:

```
\begin{equation}
\uparrow \big\uparrow \Big\uparrow \bigg\uparrow \Bigg\uparrow \dots
\Bigg\Downarrow \bigg\Downarrow \Big\Downarrow \big\Downarrow \Downarrow
\end{equation}
```

resulting in:

$$\uparrow \big\uparrow \Big\uparrow \bigg\uparrow \Bigg\uparrow \dots \Bigg\Downarrow \bigg\Downarrow \Big\Downarrow \big\Downarrow \Downarrow \tag{8}$$

Adorning symbols Estimates, averages, vectors are generated as follows:

```
\begin{equation}
\text{don't use }\hat\lambda \text{ but rather } \widehat\lambda;
\qquad \text{prefer } \overline{X} \text{ over }\bar X;
\qquad \vec p.
\end{equation}
```

resulting in:

$$\text{don't use } \hat\lambda \text{ but rather } \widehat\lambda; \qquad \text{prefer } \overline{X} \text{ over } \bar X; \qquad \vec p. \tag{9}$$

Accented symbols in the text are easy to generate: `\^o, \"u, \'e, \`a` give ô, ü, é, à.

Life-actuarial symbols To produce the notorious life-actuarial symbols with left and right indices, double dots and half-boxes is tricky. Some Google-ing will help. To produce the probability that (x) will live to $x + n$, and an annuity:

$$_np_x \qquad \text{and} \qquad \ddot{a}_{\overline{n}i} \qquad a_{\overline{n}|i}.$$

do:

```
\DeclareRobustCommand{\annuity}[1]{%
\def\arraystretch{0}%
\setlength\arraycolsep{.7pt}%
\setlength\arrayrulewidth{.3pt}%
\begin{array}[b]{@{}c|}\hline
\\[\arraycolsep]%
\scriptstyle #1%
\end{array}%
}
\[ _n p_x \qquad \ddot{a}_{\annuity{n}i} \]
```

Limits, sums, integrals Limits like $\lim_{n\to\infty} x_n$, when displayed, are typed as

```
\begin{equation}
\lim_{n \to \infty}x_n; \qquad \textstyle\lim_{n \to \infty}x_n;
\qquad \displaystyle\lim_{n \to \infty}x_n.
\end{equation}
```

resulting in:

$$\lim_{n\to\infty} x_n; \qquad \lim_{n\to\infty} x_n; \qquad \lim_{n\to\infty} x_n. \tag{10}$$

Integrals are formed like this:

```
\begin{equation}
\int_0^\infty\varphi(x)\, \text{d}x;
\qquad \int\limits_0^\infty\varphi(x)\, \text{d}x;
\qquad \textstyle\int_0^\infty\varphi(x)\, \text{d}x.
\end{equation}
```

This results in

$$\int_0^\infty \varphi(x)\,\mathrm{d}x; \qquad \int\limits_0^\infty \varphi(x)\,\mathrm{d}x; \qquad \int_0^\infty \varphi(x)\,\mathrm{d}x. \tag{11}$$

Sums (and products) are done like this:

```
\begin{equation}
\sum_{i=0}^\infty x_i;
\qquad \textstyle\prod_{i=0}^\infty x_i.
\end{equation}
```

The result is

$$\sum_{i=0}^\infty x_i; \qquad \prod_{i=0}^\infty x_i. \tag{12}$$

5.3   Tables

Here is a simple table of numbers aligned on a decimal dot, if any. It gives a right-aligned column, no space, then a left-aligned column. The heading '*Amounts*' is spanning two columns, centered. End each row (except the last) by \\, separate columns by &. Specifying less than two columns is okay.

```
\begin{tabular}{r@{}l}
\multicolumn{2}{c}{\it Amounts}\\
987 & .65\\
54229 & .13\\
1000\\
3&.1416
\end{tabular}
```

The result is:

Amounts
987.65
54229.13
1000
3.1416

See also Subsection 5.4 for how to import tables out of R.

I reproduce Table 8.1 from Modern Actuarial Risk Theory (top of page); here, it is the first numbered table in this document of class article, therefore referred to, and captioned, as Table 1. The TEX-code to generate this table (without the middle lines and most of the caption) is the following:

```
\begin{table}[t]
\caption{\em Observed numbers of accidents ...... of moments.}
\label{Table:8.1}
\begin{center}
\begin{tabular}{c@{\qquad}c@{\qquad}c@{\qquad}c@{\qquad}c}
\hline\noalign{\smallskip}%%more space above and below lines
```

Table 1: *Observed numbers of accidents in some portfolio, and fitted values for a pure Poisson model and a negative binomial model fitted with ML, and a mixed Poisson model fitted by the method of moments.*

k	n_k	$\widehat{n}_k$ (Poisson)	$\widehat{n}_k$ (Neg.Bin.)	$\widehat{n}_k$ (good/bad)
0	96 978	96 689.5	96 980.8	96 975.1
1	9 240	9 773.4	9 230.9	9 252.0
2	704	494.0	708.6	685.0
3	43	16.6	50.0	56.9
4	9	0.4	3.4	4.6
5+	0	0.0	0.2	0.3
χ^2		191.	0.1	2.1

```
$k$ & $n_k$        & $\widehat{n}_k$ (Poisson)
                 & $\widehat{n}_k$ (Neg.Bin.)
                  & $\widehat{n}_k$ (good/bad)\\
\noalign{\smallskip}\hline\hline\noalign{\smallskip}
0   &   96\,978  &    96\,689.5 &    96\,980.8 &     96\,975.1 \\
.........\\
$\chi^2$
    &            &       191. &          0.1 &         2.1  \\
\noalign{\smallskip}\hline
\end{tabular}
\end{center}
\end{table}
```

Note the [optional] parameter of the `table` environment: t=top page, h='here', c=center, b=bottom, and h! is 'here!'; all only 'if fitting'. Also note what you have to do if you want a little white space around the horizontal lines produced by `\hline`. The "\," gives a small space acting as thousands separator.

A smaller table, without caption, number or the possibility of placement on top/bottom is produced by:

```
\begin{tabular}{c*{6}{@{\quad}c}}
& \multicolumn{2}{c}{\bf Region 1}
 &  \multicolumn{2}{c}{\bf Region 2}
  & \multicolumn{2}{c}{\bf Region 3}\\
 {\bf Gender} & Policies & Claims & Policies
            & Claims & Policies & Claims\\\hline\hline
1&   2400 & 490 &   2400 & 110 &   1200 & 110\\
2&   1600 & 160 &   1600 & 90 &    800 & 90\\\hline
\end{tabular}
```

Some explanation: the mandatory parameter of the `tabular` environment says that each line in the table is to start with a centered column, then six times a `\quad` space (same width as

the character M) followed by a centered column. The headings Region 1, 2, 3 span over two columns.

The result is

	Region 1		Region 2		Region 3	
Gender	Policies	Claims	Policies	Claims	Policies	Claims
1	2400	490	2400	110	1200	110
2	1600	160	1600	90	800	90

5.4   Importing tables produced by R

The package `xtable` offers interesting possibilities when working with R.

```
install.packages("xtable")  ## Pick 'Amsterdam' as CRAN mirror
library(xtable)
xtable(matrix(1:15,3))
```

These commands directly produced the TeX-code to create the following table:

	1	2	3	4	5
1	1	4	7	10	13
2	2	5	8	11	14
3	3	6	9	12	15

5.5   Importing figures from R

If you have managed to produce a nice-looking graph using R, right-clicking on it gives a menu including the option 'Save as postscript'. Use it, and give your plot a name like `Fig41.eps`. Just put the figure between your text like it was done on the title-page of `ThesisTemplateASMF.tex`, or when you have more figures and want a proper caption, do something like the code producing Figure 1. With some hints by you, TeX will determine where your figures end up, and in general does it well enough.

```
\begin{figure}[ht!]%%If possible here; otherwise on top of next page!
 \begin{center}
  \fbox{\includegraphics[width=.8\textwidth]{IG.eps}}
  \caption{IG densities for $\alpha = \beta = \frac14,\frac12,1,2,4,8,16,32$
         (tops from left to right).}
  \label{Fig31}
 \end{center}
\end{figure}
```

In the prelude to `ThesisTemplateASMF.tex`, packages are loaded that allow formats for pictures like `.jpg`, `.png`, `.pdf` or `.eps` (encapsulated postscript; converted to pdf-format on-the-fly by the `epstopdf` package).

Drop the `fbox{}` if you don't want the box around Figure 1.

Note that in a table, the caption is placed above the contents of the table, while for a figure, it should be below. So the `caption` comes after the `includegraphics` command in a figure, but before the `tabular` command in a table.
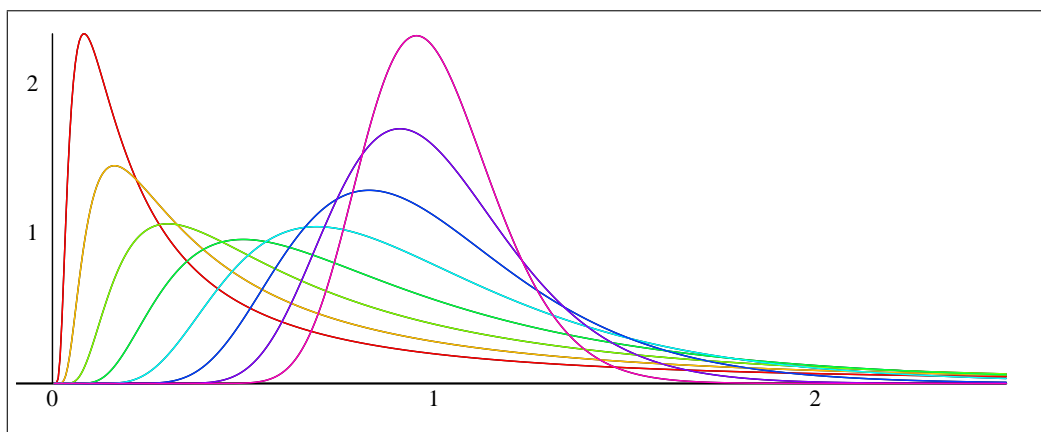
Figure 1: IG densities for $\alpha = \beta = \frac{1}{4}, \frac{1}{2}, 1, 2, 4, 8, 16, 32$ (tops from left to right).

6 TeX and TeXworks tips and tricks and manuals

6.1 Manuals

There is a wealth of material to be found on the Internet both about TeX/LaTeX and TeXworks. For example

- LaTeX documentation is found on http://latex-project.org/guides/.
- A short manual on TeXworks by A. Delmotte, S. Löffler and others is to be found on http://texworks.googlecode.com/files/TeXworks-manual-r1029.pdf.
- A rather extensive book on LaTeX is "The Not So Short Introduction to LATEX2e" by Tobi Oetiker, to be found on http://tobi.oetiker.ch/lshort/lshort.pdf.
- A lecture on TeXworks' roots, by one of its developers Jonathan Kew, can be seen on http://youtube.com/watch?v=9-Z43CSPgM0.
- On http://mecmath.net/latex-tutorial.pdf there is a LaTeX Mini-Tutorial.
- R to TeX: see http://texblog.org/2011/06/02/r-convert-table-r2latex and also http://cran.r-project.org/web/packages/xtable/vignettes/xtableGallery.pdf.
- More choices, for example the package `texreg` to TeXify regression output by R, are on http://stackoverflow.com/questions/5465314/tools-for-making-latex-tables-in-r.
- For students more comfortable reading Dutch, there is http://nl.wikibooks.org/wiki/LaTeX.
- There is also the Help-function in TeXworks, giving you access to "A short manual for TeXworks", located on your computer.
- Visit http://en.wikipedia.org/wiki/Help:Displaying_a_formula for more information on equations.

6.2 TeXworks settings and workings

Auto-completion   TeXworks is capable of auto-completion. For example typing `beq` and next pressing the [TAB] key produces the `equation` environment. Pressing [TAB] again adds *, then `eqnarray` appears, then `eqnarray*`.

For instance look at the two following entries in the file `tw-latex.txt` in the subdirectory `completion` of the `TeXworks` directory:

```
bite:=\begin{itemize}#RET#\item#RET##INS##RET#\end{itemize}*
biteo:=\begin{itemize}[#INS#]#RET#\item#RET#*#RET#\end{itemize}*
```

Here 'bite' is for the abbreviation ('bit' or even 'bi' work, too). Pressing [TAB] twice gives you the second line. Your cursor will be at `#INS#`, the `#RET#`'s are hard returns, the '*' symbols (actually •) are non-printing characters ignored by LaTeX; pressing Ctrl+[TAB] moves your cursor to that symbol.

Some other useful abbreviations and what they expand to on pressing [TAB]:

bite, benu	itemize, enumeration environments
\begin{ite	same as bite
btab	tabular, ...
\begin{tab, ...	`\begin{table}#RET##INS##RET#\end{table}*`
bf, em, sf, sc	bold, emphasized, ...
bmin	minipage
bmult	multiline
frac	fraction
tex, latex	TeX, LaTeX
\sec, \par	`\section{#INS#}#RET#`, ...
xa, xg, xcg, xcx	$\alpha, \gamma, \Gamma, \Xi$ etc. in math; from `tw-basic.txt`

Apart from saving keystrokes, this feature has the advantage of automatically providing the right syntax.

When things go awry   As stated, TeX is fussy and not always overly clear about your mistakes. If you added a new piece of text and suddenly compilation fails, try successively commenting out pieces of the new text to see where to look for your mistake(s).

> Sometimes it helps to delete auxiliary files (the existence of a faulty `.aux`-file might cause mysterious non-vanishing compilation errors).

Project management   For your convenience, we provide the file `ThesisTemplateASMF.tex`. It switches to reading from other files after commands like `\input{TheSummary.tex}`, essentially acting as if the contents of that file were pasted in. If you are compiling your summary, the first line `% !TeX root = ThesisTemplateASMF.tex` lets TeXworks know that the main file of the project is actually `ThesisTemplateASMF.tex`. If you change the file name of your main file, be sure to update the first lines of the other files as well.

Navigating back and forth between pdf and tex-files   A nice feature of TeXworks is that it allows you to easily jump from your TeX-input to the corresponding spot in your pdf-output, and back, by Ctrl+mouseclick. Note that this does not work properly when your filename contains spaces or weird symbols, so use for instance CamelCase instead of a space to distinguish parts of a filename.

Printing a finished LaTeX document If you want to print from the computer you are working on, it's easy; in the preview window, go to File, then Print Pdf... Either you will enter the print menu, or you will be asked if it is okay to open your regular pdf-viewer to handle the job. There is a warning to close the file after doing that; if it is still open, TeXworks cannot write its pdf-output to that file.

Alternatively, transport the pdf-file to a computer with a printer attached, and open and print that file.

Miscellaneous features of TeXworks

- TeXworks has a function to easily balance brackets. Inside a piece of text or math, just press Ctrl+B a few times to see left and right brackets and select the text in between.

- To make compiling by `pdfLatex` standard, press Edit → Preferences → Typesetting → Default → pdfLaTeX.

- Set Preferences → Editor → Syntax coloring → LaTeX to get the proper syntax coloring.

- Set Preferences → General → When launched, show → File Open dialog; this is the action you would probably want.

- To go to a line of which you know the number, press the bottom-right button in the `.tex` panel, or equivalently, Ctrl+L. In the `.pdf` panel, you can jump to a page number in the same way.

- To install the spell-checker, follow the instructions in Section 4.3 of the manual 'A short manual for TEXworks' found under the Help function.

7   Sources

Important: It is required that your list of references contains at least *three* academic papers that are basic to the thesis. Some relevant journals (available from our library) are in Table 2.

Name periodical	Area
ASTIN Bulletin	finance/(non-life)insurance
British Actuarial Journal	all actuarial areas
Belgian Actuarial Bulletin	all
Geneva Papers on Risk and Insurance: Theory	insurance economics
Geneva Papers on Risk and Insurance: Issues and Practice	insurance economics
Insurance: Mathematics and Economics	all
Journal of Actuarial Practice	all
Journal of Risk and Insurance	insurance economics
North American Actuarial Journal	all
Scandinavian Actuarial Journal	all
Journal of Finance	insurance economics
Pensioenmagazine	pensions
Pensions World	pensions
Employee Benefits Journal	pensions
AG-studies with report	all
European Actuarial Journal	all

Table 2: *Some relevant journals on actuarial science/practice and insurance*

Of course much material can be found on the Internet. But in academic papers such as your thesis, instead of happily copy-pasting, properly referencing your sources is required, and rewriting to make the text your own. See Section 8, and also the admonition on Blackboard about plagiarism. *Recall that the FEB uses quite competent software to detect plagiarism (Ephorus).*

8   About references

Use the format for references (Theoretical Economics) like in the file `TheReferences.tex`. That is, in the text refer to Kaas *et al.* (2008) (or Kaas *et al.*, 2008, if appropriate), not by number [1]; this is the so-called author-year referencing style. One of the files provided to you to help you write your thesis is `TheRefDatabase.bib`, which, as its name suggests, is a database with references for your bibliography. Working with a database like this ensures that your references are in the proper style, alphabetically ordered and consistent. The `hyperref` package used makes that in the pdf produced, urls, references to equations/tables/... and bibliographic references are 'clickable', which can be a great help for the reader.

An excerpt of the contents of the file `TheRefDatabase`:

```
This how to include the data for an article in a journal:
@article{LeeCarter92,
  title={Modeling and forecasting {US} mortality},
  author={Lee, R.D. and Carter, L.R.},
  journal={Journal of the American Statistical Association},
  volume={87},
  number={419},
  pages={659--671},
  year={1992},
  publisher={Taylor \& Francis Group}}
This is how to refer to a textbook or research monograph:
@book{MART2nd,
  author =    {Kaas, R. and Goovaerts, M.J. and Dhaene, J. and Denuit, M.},
  title =     {Modern Actuarial Risk Theory---Using R},
  edition =   {Second},
  publisher = {Springer},
  year =      {2008},
  address =   {Heidelberg}}
@book{vellekoop2011rekenen,
  title={Rekenen aan en op risico},
  author={Vellekoop, M.H.},
  series={VOR Economie en Bedrijfskunde},
  volume={392},
  year={2011},
  publisher={Vossiuspers UvA}}
As yet unpublished technical reports are included like this:
@techreport{BAV13,
  title={Structural changes ...---with an application to {D}utch ...},
  author={Berkum, Frank van and Antonio, Katrien and Vellekoop, Michel},
  institution={Faculty of Economics and Business, University of Amsterdam},
  year={2013}}
If you want to refer to an Internet page you visited, do it like this:
```

```
@MISC{Global13,
  author = {Wason, S.},
  title = {{A Global Framework for Insurer Solvency ... Association}},
  day = {14},
  month = feb,
  year = {2013},
  howpublished={\url{http://www.actuaries.org/LIBRARY/Papers/....pdf}}}
The R-developers appreciate being recognized whenever R is used:
@Manual{R12,
  title = {R: A Language and Environment for Statistical Computing},
  author = {{R Development Core Team}},
  organization = {R Foundation for Statistical Computing},
  address = {Vienna, Austria},
  year = {2012},
  note = {{ISBN} 3-900051-07-0},
  url = {http://www.R-project.org/}}
If you have used MASS, refer to:
@Book{MASS02,
  title = {Modern Applied Statistics with S},
  author = {W.N. Venables and B.D. Ripley},
  publisher = {Springer},
  edition = {Fourth},
  address = {New York},
  year = {2002},
  note = {ISBN 0-387-95457-0},
  url = {http://www.stats.ox.ac.uk/pub/MASS4}}
If you have used a package like the xtable package below,
include a reference to the next item.
An easy way to get the needed information is to enter citation("xtable") in R.
@Manual{xtable,
  title = {xtable: Export tables to LaTeX or HTML},
  author = {D.B. Dahl},
  year = {2012},
  note = {R package version 1.7-0},
  url = {http://CRAN.R-project.org/package=xtable}}
```

The first line of each item, after the brace, contains the key by which you are going to refer to this publication. The further lines (order is not important) contain the bibliographic information.

The references are processed by BibTeX, which is another program included in MiKTeX. Here's how BibTeX works. BibTeX takes as input a `.aux` file produced by LaTeX in an earlier run, and a `.bst` file (the BibTeX style file) that specifies the general reference-list style and the way individual entries are formatted. It is written by a style designer in a special-purpose language. The `.bib` file(s) constitute a database of all reference-list entries the user might ever hope to use. BibTeX chooses from the `.bib` file(s) only those entries specified by the `.aux` file (that is, those given by LaTeX's `\cite` or `\nocite` commands), and creates as output a `.bbl` file containing these entries together with the formatting commands specified by the `.bst` file. LaTeX will use the `.bbl` file, perhaps edited by the user, to produce the reference list.

The following steps must be taken to get the desired output:

1. Run PdfLaTeX on your thesis to produce a valid `.aux` file

2. Run BibTeX

3. Run PdfLaTeX twice again

Skip the first step if you already have a valid `.aux` file, and do the last ones only if you have made changes to the `.bib` file.

You might prefer to refer to a book or website or paper by a short name, or by listing all its authors. This is achieved by

```
\defcitealias{MART2nd}{MART}
The 'Schade\slash Non-life' textbook \citetalias{MART2nd} can be
referred to as \citet*{MART2nd} or as \citet{MART2nd}.
```

This results in:

> The 'Schade/Non-life' textbook MART can be referred to as Kaas, Goovaerts, Dhaene, and Denuit (2008) or as Kaas *et al.* (2008).

Actually, the style used proscribes the unstarred version Kaas *et al.* (2008), but sometimes the other authors appreciate the longer version. For two authors, there is no difference; Lee and Carter (1992) results with or without star.

If you have used R, it is expected that you express your gratitude to the R Development Core Team explicitly by entering `\citet{R12}` somewhere, or tacitly by including it only in the bibliography through `\nocite{R12}`, where R12 is the key for the 2012 reference to the R team.

If you have used the MASS package, cite Venables and Ripley (2002) by `\citet{MASS02}`. If you have used other packages such as `xtable`, for example, refer to Dahl (2012). Bibliographical information for your package can be obtained in R by entering `citation("yourpackage")`.

The difference between `\citet{key}` and `\citep{key}` is that the latter form adds parentheses, see below. In fact, the `\cite` command functions as follows:

`\citet{key}`	$\Longrightarrow$	Jones *et al.* (1990)
`\citet*{key}`	$\Longrightarrow$	Jones, Baker, and Smith (1990)
`\citep{key}`	$\Longrightarrow$	(Jones *et al.*, 1990)
`\citep*{key}`	$\Longrightarrow$	(Jones, Baker, and Smith, 1990)
`\citep[chap. 2]{key}`	$\Longrightarrow$	(Jones *et al.*, 1990, chap. 2)
`\citep[e.g.][]{key}`	$\Longrightarrow$	(e.g. Jones *et al.*, 1990)
`\citep[e.g.][p. 32]{key}`	$\Longrightarrow$	(e.g. Jones *et al.*, 1990, p. 32)
`\citeauthor{key}`	$\Longrightarrow$	Jones *et al.*
`\citeauthor*{key}`	$\Longrightarrow$	Jones, Baker, and Smith
`\citeyear{key}`	$\Longrightarrow$	1990

You can easily combine references, for example you get (Lee and Carter, 1992; Vellekoop, 2011) by entering `\citep{LeeCarter92,vellekoop2011rekenen}`. For more information, consult http://en.wikibooks.org/wiki/LaTeX/Bibliography_Management.

For websites you visit you must enter the data into the file `TheRefDatabase.bib` by hand in the form as given in the examples.

Google Scholar is a very convenient tool for including academic references:

1. go to http://scholar.google.nl

2. find your publication by entering (part of) title, author and so on

3. click on 'Import into BibTeX', select (Ctrl+A) and copy (Ctrl+C); if this does not appear, adjust your settings

4. then paste (Ctrl+V) into the `.bib` file, and do editing as needed; for example, you adapt the key to your liking, and put capitals that you want retained in a title between curly brackets, for example to prevent `US` from being changed to `us`.

For the key, Google Scholar proposes `<author><year><first 'long' word in title>`, but you might prefer another style, like BAV13 and LC92, or other mnemonics. Make it easy to remember and to use.

If some entries in the bibliography are uncited, you can still include them in the bibliography, one by one by `\nocite{R12}` or all remaining items by `\nocite{*}`.

Everything not in an item (after @) is ignored; note that in `.bib` files, % is not the comment sign. All the items in the database are found in the list of references below, and in the proper style as regards punctuation in the text, since we included the commands:

```
\bibliographystyle{TheorEco}
\bibpunct{(}{)}{;}{a}{,}{,}
\addcontentsline{toc}{section}{References}\label{LoR}
\bibliography{TheRefDatabase}  %% Don't append .bib here!
\nocite{*}
```

The last command ensures that all items in the database, explicitly cited or not, are listed, as below.

References

Berkum, Frank van, Katrien Antonio, and Michel Vellekoop (2013), "Structural changes in mortality rates—with an application to Dutch and Belgian data." Technical report, Faculty of Economics and Business, University of Amsterdam.

Dahl, D.B. (2012), *xtable: Export tables to LaTeX or HTML*. URL http://CRAN.R-project.org/package=xtable. R package version 1.7-0.

Dhaene, J., R.J.A. Laeven, S. Vanduffel, G. Darkiewicz, and M. Goovaerts (2008), "Can a coherent risk measure be too subadditive?" *Journal of Risk and Insurance*, 75, 365–386.

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Wason, S. *et al.* (2004), "A Global Framework for Insurer Solvency Assessment, Report of the Insurer Solvency Assessment Working Party, International Actuarial Association." http://www.actuaries.org/LIBRARY/Papers/Global_Framework_Insurer_Solvency_Assessment-members.pdf, consulted on August 11, 2013.