The School of Mathematics

THE UNIVERSITY
of EDINBURGH

My Incredible Thesis

by

My Name

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Supervised by
Dr Very Important

Abstract

Here comes your abstract ...

Acknowledgments

Here come your acknowledgments ...

Own Work Declaration

Here comes your own work declaration

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1 Introduction

Here I will write a very good, precise and brief introduction. Particularly Section 2 is good!

2 Background

In the following, I explain some background stuff. I should really cut this short, but BlaBlaBlaBla BlaBlaBlaBlaBla Bla Bla BlaBlaBla Bla Bla BlaBlaBla Bla BlaBla BlaBla Bla BlaBlaBlaBla Bla BlaBla Bla Bla Bla BlaBla BlaBlaBlaBla BlaBlaBlaBlaBla Bla Bla BlaBlaBla Bla. Bla BlaBlaBla Bla BlaBla BlaBla Bla BlaBlaBlaBla Bla BlaBla Bla Bla Bla BlaBla BlaBlaBlaBla. BlaBlaBlaBlaBla Bla Bla BlaBlaBla Bla Bla BlaBlaBla Bla BlaBla BlaBla Bla BlaBlaBlaBla Bla BlaBla Bla Bla Bla BlaBla BlaBlaBlaBla BlaBlaBlaBlaBla Bla Bla BlaBlaBla Bla Bla BlaBlaBla Bla BlaBla BlaBla Bla BlaBlaBlaBla Bla BlaBla Bla Bla Bla BlaBla BlaBlaBlaBla BlaBlaBlaBlaBla Bla Bla BlaBlaBla Bla Bla BlaBlaBla Bla BlaBla BlaBla Bla. BlaBlaBlaBla Bla BlaBla Bla Bla Bla BlaBla BlaBlaBlaBla BlaBlaBlaBlaBla Bla Bla BlaBlaBla Bla Bla BlaBlaBla Bla BlaBla BlaBla Bla BlaBlaBlaBla Bla BlaBla Bla Bla Bla BlaBla.

Note that I start a new paragraph when I have an empty line like this. BlaBlaBlaBla BlaBlaBlaBlaBla Bla Bla BlaBlaBla Bla Bla BlaBlaBla Bla BlaBla BlaBla Bla BlaBlaBlaBla Bla BlaBla Bla Bla Bla. BlaBla BlaBlaBlaBla BlaBlaBlaBlaBla Bla Bla BlaBlaBla Bla Bla BlaBlaBla Bla BlaBla BlaBla Bla BlaBlaBlaBla Bla BlaBla Bla Bla Bla BlaBla BlaBlaBlaBla BlaBlaBlaBlaBla Bla Bla BlaBlaBla Bla Bla BlaBlaBla. Bla BlaBla BlaBla Bla BlaBlaBlaBla Bla BlaBla Bla Bla Bla BlaBla BlaBlaBlaBla BlaBlaBlaBlaBla Bla Bla BlaBlaBla Bla Bla BlaBlaBla Bla. BlaBla BlaBla Bla BlaBlaBlaBla Bla BlaBla Bla Bla Bla BlaBla BlaBlaBlaBla BlaBlaBlaBlaBla Bla Bla BlaBlaBla Bla Bla BlaBlaBla Bla BlaBla BlaBla Bla BlaBlaBlaBla Bla BlaBla Bla Bla Bla BlaBla.
But I can also end a line with a double backslash.

2.1 Models

Models are *very* helpful because.

- They're good.
- They're helpful.

2.2 Techniques

Techniques even better because.

1. They're magnificent.
2. If they work.

3 Technical Stuff

Now it's getting very technical ... I will cite [2, 1]. I will also show my incredible α, β and γ mathematics and do some other fancy stuff.

3.1 Formulae

For example look at this

$$\min \sum_{s\in\mathcal{S}} Pr_s \left[\sum_{t=1}^{T}\left(\sum_{g\in\mathcal{G}}\left(\alpha_{gts}C_g^0 + p_{gts}C_g^1 + \left(p_{gts}\right)^2 C_g^2\right) + \sum_{g\in\mathcal{C}} \gamma_{gts}C_g^s\right)\right], \tag{3.1}$$

and you will see that it has a little number on the side so that I can refer to it as equation (3.1). Now if I do this

$$\begin{aligned} \sum_{i=1}^{n} k_i &= 20 \qquad (3.2) \\ \sum_{j=20}^{m} \delta_i &\geq \eta \end{aligned}$$

I can align two formulae and control which one has a number on the side. It is (3.2). I can also do something like this

$$Y_l = \begin{bmatrix} \left(y_s + i\frac{b_c}{2}\right)\frac{1}{\tau^2} & -y_s\frac{1}{\tau e^{-i\theta^s}} \\ -y_s\frac{1}{\tau e^{i\theta^s}} & y_s + i\frac{b_c}{2} \end{bmatrix},$$

and it won't have a number on the side. Now if I have to do some huge mathematics I'd better structure it a little and include linebreaks etc. so that it fits on one page.

$$\begin{aligned} p_l^f &= G_{l11}\left(2v_{F(l)}\bar{v}_{F(l)} - \bar{v}_{F(l)}^2\right) \qquad (3.3) \\ &+ \bar{v}_{F(l)}\bar{v}_{T(l)}\left[B_{l12}\sin\left(\bar{\delta}_{F(l)} - \bar{\delta}_{T(l)}\right) + G_{l12}\cos\left(\bar{\delta}_{F(l)} - \bar{\delta}_{T(l)}\right)\right] \\ &+ \begin{bmatrix} \bar{v}_{T(l)}\left[B_{l12}\sin\left(\bar{\delta}_{F(l)} - \bar{\delta}_{T(l)}\right) + G_{l12}\cos\left(\bar{\delta}_{F(l)} - \bar{\delta}_{T(l)}\right)\right] \\ \bar{v}_{F(l)}\left[B_{l12}\sin\left(\bar{\delta}_{F(l)} - \bar{\delta}_{T(l)}\right) + G_{l12}\cos\left(\bar{\delta}_{F(l)} - \bar{\delta}_{T(l)}\right)\right] \\ \bar{v}_{F(l)}\bar{v}_{T(l)}\left[B_{l12}\cos\left(\bar{\delta}_{F(l)} - \bar{\delta}_{T(l)}\right) - G_{l12}\sin\left(\bar{\delta}_{F(l)} - \bar{\delta}_{T(l)}\right)\right] \\ \bar{v}_{F(l)}\bar{v}_{T(l)}\left[-B_{l12}\cos\left(\bar{\delta}_{F(l)} - \bar{\delta}_{T(l)}\right) + G_{l12}\sin\left(\bar{\delta}_{F(l)} - \bar{\delta}_{T(l)}\right)\right] \end{bmatrix} \cdot \begin{bmatrix} v_{F(l)} - \bar{v}_{F(l)} \\ v_{T(l)} - \bar{v}_{T(l)} \\ \delta_{F(l)} - \bar{\delta}_{F(l)} \\ \delta_{T(l)} - \bar{\delta}_{T(l)} \end{bmatrix}, \end{aligned}$$

This is a lot of fun!

3.2 Important Things

Finally we should have a nice picture like this one. However, I won't forget that figures and table are environments which float around in my document. So LaTeX will place them wherever it thinks they fit well with the surrounding text. I can try to change that with a float specifier, e.g. [!ht]. Now I want to use one of my own environments. I want to define something.

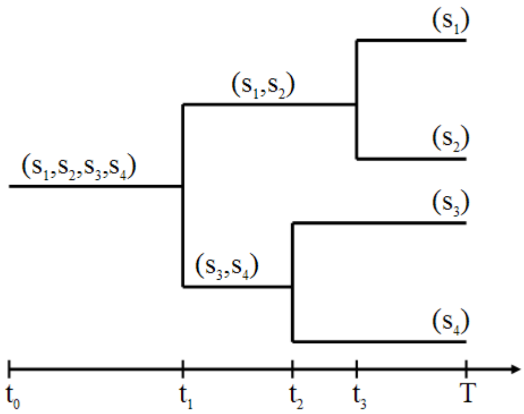

Figure 1: Look at this scenario tree with funny times t_1 and scenarios s_1 etc.

Definition 3.1 *I define*

$$\Gamma_\eta := \sum_{i=1}^{n} \sum_{j=i}^{n} \xi(i,j)$$

I definitely need some good tables, so I do this. I should really refer to Table 1.

Case	Generators	Therm. Units	Lines	Peak load: [MW]	[MVar]
6 bus	3 at 3 buses	2	11	210	210
9 bus	3 at 3 buses	3	9	315	115
24 bus	33 at 11 buses	26	38	2850	580
30 bus	6 at 6 buses	5	41	189.2	107.2
39 bus	10 at 10 buses	7	46	6254.2	1387.1
57 bus	7 at 7 buses	7	80	1250.8	336.4

Table 1: Something that doesn't make sense.

3.3 And now something else

Let:

$$\begin{aligned}
\Omega_0 &= \{(x,y,z,f): \text{ satisfying } (9)-(19)\},\\
\Omega_1 &= \{(x,y,z,f): \text{ satisfying } (9),(11)-(20)\},\\
\overline{\Omega}_0 &= \{\mathbf{0} \leq (x,y,z,f) \leq \mathbf{1}: \text{ satisfying } (9)-(18)\},\\
\overline{\Omega}_1 &= \{\mathbf{0} \leq (x,y,z,f) \leq \mathbf{1}: \text{ satisfying } (9),(11)-(18),(20)\}.
\end{aligned}$$

where **0** and **1** are vectors of appropriate dimensions with 0's and 1's, respectively. Next we see that both Ω_0 and Ω_1 give equivalent formulations for the A-MSSP. In particular, the following statements hold:

Proposition 1 $\Omega_0 \subseteq \Omega_1$.

Proof. Let us suppose there exists $(x,y,z,f) \in \Omega_1$ such that $(x,y,z,f) \notin \Omega_0$. Then, there exist indices $i \in I$ and $t \in \{0,\ldots,|T|-s_i\}$ with $x_i^t > 0.5\left(\sum_{h=1}^{s_i} x_i^{t+h} + 1\right)$. By definition, $x_i^t = 1$ and $x_i^{t+h} = 0$ for all $h \in \{1,\ldots,s_i\}$. By (11) and (12), $\sum_{h=1}^{s_i} f_i^{th} = 1$, so $f_i^{th'} = 1$ for some $h' \in \{1,\ldots,s_i\}$. But then,

$$0 \;=\; x_i^{t+h'} \;=\; \sum_{h=\max\{1,t+h'-(|T|-s_i)\}}^{\min\{s_i,t+h'\}} f_i^{t+h'-h,h} \;\geq\; f_i^{th'} \;=\; 1\,,$$

as $h' \in [\max\{1, t+h'-(|T|-s_i)\}, \min\{s_i, t+h'\}]$. □

This immediately gives us

Corollary 1 *AS is a valid formulation for the A-MSSP.*

Next we compare the Linear Programming (LP) relaxations of the two formulations.

Proposition 2 $\overline{\Omega}_1 \subseteq \overline{\Omega}_0$.

Proof. Homework □

4 Conclusions

I have no idea how to conclude, so I don't write much. But the stuff that follows is important.

References

[1] N. Gröwe-Kuska and W. Römisch. *Stochastic unit commitment in hydro-thermal power production planning*. Preprints aus dem Institut für Mathematik. Humboldt-Universität zu Berlin, Institut für Mathematik, 2001.

[2] T. Shiina and J. R. Birge. Stochastic unit commitment problem. *International Transactions in Operational Research*, 11(1):19–32, 2004.

Appendices

A An Appendix

Some stuff.

B Another Appendix

Some other stuff.