



UvA-DARE (Digital Academic Repository)

Bounded rationality and learning in market competition

Kopányi, D.

Publication date

2015

Document Version

Final published version

[Link to publication](#)

Citation for published version (APA):

Kopányi, D. (2015). *Bounded rationality and learning in market competition*. [Thesis, fully internal, Universiteit van Amsterdam]. Tinbergen Institute.

General rights

It is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), other than for strictly personal, individual use, unless the work is under an open content license (like Creative Commons).

Disclaimer/Complaints regulations

If you believe that digital publication of certain material infringes any of your rights or (privacy) interests, please let the Library know, stating your reasons. In case of a legitimate complaint, the Library will make the material inaccessible and/or remove it from the website. Please Ask the Library: <https://uba.uva.nl/en/contact>, or a letter to: Library of the University of Amsterdam, Secretariat, Singel 425, 1012 WP Amsterdam, The Netherlands. You will be contacted as soon as possible.



Dávid Kopányi

Bounded Rationality and Learning in Market Competition

This thesis promotes the use of bounded rationality in economic models. The assumption of perfect rationality often imposes high informational and computational burden on economic agents and predictions based on this assumption are not in line with observed behavior in some cases. Models of bounded rationality may better explain actual behavior in such situations.

In the thesis we consider market models where firms are boundedly rational: they do not know the demand for their product and they use different learning methods to determine the optimal price, they have incorrect beliefs about their competitors' behavior or they do not make use of all the available information. We investigate how bounded rationality affects the market outcome and what the possible welfare effects are.

Dávid Kopányi (1985) holds an MSc degree in Economics from the Corvinus University of Budapest and an MPhil degree in Economics from the Tinbergen Institute. After graduating he joined the Center for Nonlinear Dynamics in Economics and Finance at the University of Amsterdam as a PhD student. Currently he is a Research Fellow at the University of Nottingham. His main interests include bounded rationality, learning methods, industrial organization, dynamical systems and agent-based modeling.

Bounded Rationality and Learning in Market Competition

Dávid kopanyi



**Bounded Rationality and Learning
in Market Competition**

ISBN 978 90 361 0421 0

Cover design: Crasborn Graphic Designers bno, Vakenburg a.d. Geul

This book is no. **604** of the Tinbergen Institute Research Series, established through cooperation between Thela Thesis and the Tinbergen Institute. A list of books which already appeared in the series can be found in the back.

Bounded Rationality and Learning
in Market Competition

ACADEMISCH PROEFSCHRIFT

ter verkrijging van de graad van doctor
aan de Universiteit van Amsterdam
op gezag van de Rector Magnificus
prof. dr. D.C. van den Boom
ten overstaan van een door het college voor promoties
ingestelde commissie,
in het openbaar te verdedigen in de Agnietenkapel
op vrijdag 13 februari 2015, te 14:00 uur

door

Dávid Kopányi

geboren te Gyula, Hongarije

Promotiecommissie:

Promotores: Prof. dr. J. Tuinstra
Prof. dr. C.H. Hommes

Overige leden: Dr. M. Koster
Dr. A.M. Onderstal
Prof. dr. M.P. Schinkel
Prof. dr. N.J. Vriend
Dr. F.O.O. Wagener

Ancsának, Nórinak és Robinak

Acknowledgements

Now that I have finished writing my dissertation and my journey in Amsterdam has come to an end, this is a good moment to take a look back at the last 5 years. Actually, I should go back in time even further. In 2007 I spent a semester at the University of Amsterdam as an exchange student. One of the courses I followed, Non-linear Economic Dynamics, has particularly arisen my interest. Not only the topic was extremely interesting, the lecturer, Mikhail Anufriev, made the material and the lectures even more enjoyable. Some of the MPhil students of the Tinbergen Institute also followed this course and this is how I got to know about the TI. Pretty much these experiences attracted me towards TI and my research group CeNDEF.

After finishing our Master's program at the Corvinus University of Budapest, my girlfriend¹ Anita and I applied for the MPhil program of the TI. Both of us got accepted and we moved to Amsterdam in 2009. The two years of the program (especially the first one) was very demanding but it was also fun thanks to the fellow students we got to know, especially Boris, Łukasz, Mark, Matze, Nadine and Tomasz. I would also like to thank Adriaan, Arianne, Ester and Judith for the help and support we received from TI.

After the MPhil program I joined the *Center for Nonlinear Dynamics in Economics and Finance* as a PhD Candidate and I spent 3 years there in a great environment with wonderful colleagues. So thank you Anghel, Cars, Cees, Daan, Domenico, Florian, Florian, Isabelle, Jan, Marcin, Marco, Marius, Maurice, Michiel, Misha, Paolo, Tatiana, Te, Tomasz and Zhenxing. I am especially grateful for Tomasz, with whom I shared an office for 3 years. I will miss the entertaining conversations we had about politics in Poland and Hungary, LaTeX and program-

¹Her status was updated to wife in 2010.

ming, not to mention the great times we had on conferences.

The people who had the greatest impact on my thesis are Mikhail Anufriev, Cars Hommes and Jan Tuinstra. Jan and Misha supervised my MPhil thesis at TI. I really enjoyed working with them not only because of their good guidance but also because of the great atmosphere of our meetings. They were constantly pulling each other's leg, which I really enjoyed. They continued to supervise me during the PhD as well but at some point Misha must have got fed up with jumping between Bertrand and Cournot competition with homogeneous and heterogeneous goods because he decided to move to Sydney. After that Jan was my main supervisor with whom I had a regular contact and Cars gave me feedback on the first draft of my thesis. Jan has always been very supportive and gave me good guidance to become a researcher, which I really appreciate. He reminded me about the beauty of economics whenever I drifted away towards the technical beauty of problems. Besides giving helpful comments on positioning my thesis in the literature, I am grateful to Cars for the opportunity of being his research and teaching assistant. Both duties were extremely influential on my view of economics as a complex system.

I want to thank the other members of my PhD committee, Maurice Koster, Sander Onderstal, Maarten Pieter Schinkel, Nicolaas Vriend and Florian Wagener for reading the manuscript and providing some feedback on it. Theo Offerman, Sander Onderstal and Randolph Sloof are also thanked for their comments that improved our experimental design in Chapter 5. Sander and Róbert Somogyi gave useful feedback on an earlier version of Chapter 4, for which I am really grateful.

After submitting my thesis, my family and I moved to Nottingham and I have joined the Nottingham School of Economics as a Research Fellow. I would not have been able to get this position without the help of some people. First of all, I would like to thank Cars, Jan and Nick for writing recommendation letters for me. I would also like to thank Christina and José Luis for all the support I got for the job market preparations.

Leaving Amsterdam also means that we had to say good bye to some friends. I am very grateful to our Hungarian friends in Amsterdam, who helped a lot with looking after our children

and with moving between apartments in Amsterdam. Also, we spent delicious lunches and dinners together. So thank you Andreas², Böbi, Eszter, Gergő, Klausz, Noémi, Pisti, Sanyi and Viki. I will miss you guys.

I am grateful to our family in Hungary as well, especially the grandma's, who frequently came to Amsterdam to help us with the children when we had busy periods. Their help is much appreciated. And last but not least, I am grateful to my wife Anita and our children Robi and Nóri. Beside providing a great environment where I could relax after work, they helped my work in other ways as well. Anita provided me extra time in the last year so that I could finish on time. Moreover, Chapter 5 of the thesis is based on a joint work with her. Concerning the children's contribution (especially those of Robi), every now and then I got the opportunity to work during the night as I could not fall asleep again after they stopped crying. These times were excellent for checking exam questions and solving exercises for the TA sessions.

Nottingham, 28 November 2014

²Although it is not correct technically, I consider him as a Hungarian friend.

Contents

1	Introduction	1
2	Learning Cycles under Competing Learning Rules	11
2.1	Introduction	11
2.2	Related literature	14
2.3	The market structure	17
2.4	Learning methods	19
2.4.1	Least squares learning	19
2.4.2	Gradient learning	28
2.5	Heterogeneous oligopoly with fixed learning rules	33
2.5.1	Steady states and stability	33
2.5.2	Simulation results	37
2.6	Endogenous switching between learning mechanisms	40
2.6.1	The switching mechanism	40
2.6.2	Learning cycles	42
2.7	Concluding remarks	46
	Appendix 2.A Proofs of Propositions	49
3	Coexistence of Stable Equilibria under Least Squares Learning	55
3.1	Introduction	55
3.2	The circular road model	58

3.2.1	Homogeneous consumers	58
3.2.2	Heterogeneous consumers	61
3.3	Market dynamics under learning	64
3.3.1	Least squares learning	65
3.3.2	Equilibria under least squares learning	68
3.3.3	Stability of equilibria	73
3.4	Simulation results	77
3.4.1	Simulations with all observations	78
3.4.2	Simulations with the last τ observations	81
3.5	Discussion	86
	Appendix 3.A Proofs and derivations	91
4	Price-Quantity Competition under Strategic Uncertainty	109
4.1	Introduction	109
4.2	Related literature	112
4.3	Price-quantity competition	114
4.4	A model with strategic uncertainty and risk aversion	116
4.5	Symmetric pure-strategy equilibrium	118
4.6	Comparative statics	122
4.6.1	The effect of prices and production levels on the objective function	123
4.6.2	The effect of risk aversion	125
4.6.3	The effect of price uncertainty	126
4.6.4	The effect of output uncertainty	129
4.6.5	Welfare analysis	130
4.7	Discussion and concluding remarks	133
	Appendix 4.A The first-order conditions for the symmetric pure-strategy equilibrium	136
	Appendix 4.B The marginal effect of prices and production levels in equilibrium	144
	Appendix 4.C Expected welfare in the standard model	149

5	Endogenous Information Disclosure in Experimental Oligopolies	151
5.1	Introduction	151
5.2	Market and information structures	155
5.3	Experimental design and procedures	157
5.4	Hypotheses	160
5.5	Results	164
5.5.1	Output decisions	164
5.5.2	Consequences of information sharing on output decisions	167
5.5.3	Coordination	170
5.5.4	Factors influencing behavior	173
5.6	Conclusion	178
	Appendix 5.A Instructions for Treatment I-NF	181
6	Summary	187
	Bibliography	191
	Samenvatting (Summary in Dutch)	201