

Analysis of Economic Driving Forces in Crop Protection

Institutional Change in Agriculture and Natural Resources
Institutioneller Wandel der Landwirtschaft und Ressourcennutzung

edited by/herausgegeben von
Volker Beckmann & Konrad Hagedorn

Volume/Band 46

José Hernández Rivera

**Analysis of Economic Driving Forces
in Crop Protection**

A Case Study of Apple Production in the EU

Shaker Verlag
Aachen 2012

Bibliographic information published by the Deutsche Nationalbibliothek

The Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data are available in the Internet at <http://dnb.d-nb.de>.

Zugl.: Berlin, Humboldt-Univ., Diss., 2011

Copyright Shaker Verlag 2012

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without the prior permission of the publishers.

Printed in Germany.

ISBN 978-3-8440-1137-1

ISSN 1617-4828

Shaker Verlag GmbH • P.O. BOX 101818 • D-52018 Aachen

Phone: 0049/2407/9596-0 • Telefax: 0049/2407/9596-9

Internet: www.shaker.de • e-mail: info@shaker.de

Aim and Scope of the Series

„Nothing endures but change“. Heraclitus the Ephesian (ca. 535–475 BC)

Institutions, defined as “the rules of the game”, are a key factor to the sustainable development of societies. They structure not only the multitude of human-human interactions of modern societies, but also most of the human-nature interactions. Poverty, famine, civil war, degradation of natural resources and even the collapse of ecosystems and societies often have institutional causes, likewise social and economic prosperity, sustainable use of resources and the resilience of socio-ecological systems. Agriculture, forestry and fisheries are those human activities where the interdependencies between human-human and human-nature interactions are perhaps most pronounced, and diverse institutions have been developed in history to govern them.

Social and ecological conditions are, however, ever changing, which continuously challenge the existing institutional structure at a given point in time. Those changes may be long-term, like population growth or climate change, medium-term, such as new technologies or changing price relations, or short-term, like floods or bankruptcies, but all of them pose the question whether the rules of the game need to be adapted. Failures to adapt timely and effectively may come at a high social cost. Institutional change, however, face a principal dilemma: on the one hand, institutions need to be stable to structure expectations and effectively influence human behaviors; on the other hand, they need to be adaptive to respond to the ever changing circumstance mentioned above. Understanding stability and change as well as developing adaptive institutions and effective, efficient and fair mechanisms of change are, therefore, of central importance for societies and an ongoing research challenge for social scientists.

If we want to improve the effectiveness, efficiency and adaptability of institutions, it stands to reason that we have to develop a good understanding of the causes, effects, processes and mechanism of stability and change. This is the aim of the series “Institutional Change in Agriculture and Natural Resources,” which attempts to answer the questions “How do processes and mechanism of institutional change actually work? What and who are the main determinants and actors driving, governing and influencing these processes? What are the economic, political, social and ecological consequences? How can adaptive institutions be designed and developed, and what governance structures are required to make them effective?” These are the questions at the heart of the series. The works published in this series seek to provide answers to these questions in different economic, social, political and historical contexts.

Volker Beckmann and Konrad Hagedorn

Ernst-Moritz-Arndt-Universität Greifswald und Humboldt-Universität zu Berlin

Acknowledgments

I am deeply grateful to my supervisors, Professor Dr. Dr. h.c. Konrad Hagedorn and Dr. Dr. habil. Stefan Mann. Professor Hagedorn leads the Division of Resource Economics of Humboldt-Universität zu Berlin and is the person who gave me an introduction to the wonderful world of Institutional Economics. Stefan heads the Research Group on Socioeconomics at the Research Station Agroscope Reckenholz-Tänikon ART; he always had good ideas as well as reasonable suggestions for helping me to efficiently advance my research.

I would like to express gratitude to my colleagues of the European Network of Excellence Endure – particularly to Gabi Mack, Franz Bigler, Bart Heijne, Volkmar Gutsche, Jörn Strassenmeyer, Burkhard Golla, Jesús Avilla and Joan Solé – for their interest in my work and for providing strong support, especially in coordinating the field work. I am also thankful to Jerry Cross, Christian Scheer and Riccardo Bugiani, who are experts on crop protection associated with the different research stations in the case study regions of my investigation. They helped me to contact various interview partners and to test the plausibility of my findings. Obviously, my sincere thanks go to all the interview partners too.

I appreciate very much my colleagues of the Research Group on Socioeconomics for creating a friendly and enjoyable work environment during my stay at Agroscope. I thank the PhD students associated with the Division of Resource Economics and to all the participants in the Research Colloquium on Institutional and Resource Economics for constructive academic discussions through which I could improve my work.

For their significant help and their essential labour, I would like to express my gratitude to the secretary staff and the IT team of Agroscope and also to Mrs. Sigrid Heilmann from the Division of Resource economics at Humboldt-Universität zu Berlin.

I am more than thankful to all the persons who acted as sources of motivation and encouraged me to finish this dissertation, in particular to my Agroscope colleagues, with whom I shared spontaneous discussions about research and life, and to the Agroscope PhD students: whose contextual situation was similar to mine, always had time to listen to me about my worries and who also trusted me enough to tell me about their dreams. I would like to specially mention Jennifer Schweiger, my officemate, Chiara Calabrese, Simone Helmreich, Maria-Pia Gennaio, Pierrick Jan, Frank Burose as well as Alexander Perez Carmona, my colleague at Humboldt and fellow countryman. And last, but not least, thanks so much to those with whom I am sharing my life: Fabienne, who held out patiently when I worked long, Alejandro who always shows me how happy life can be and my son Mateo who brings colour to my life.

Financial support provided by Agroscope and the European Commission (i.e. through the funding of the Network of Excellence Endure) is also gratefully acknowledged.

Winterthur, 20 July 2011

José Hernández Rivera

Contents

Acknowledgments.....	vii
List of Figures	vii
List of Tables.....	vii
List of Abbreviations.....	vii
1 Introduction.....	1
1.1 Rationale of the analysis	1
1.2 Structure of the monograph (outline of chapters).....	3
1.3 Framework of the investigation	6
2 Literature review	7
2.1 The importance of crop protection and the use of pesticides	7
2.1.1 Crop protection in today’s agriculture	7
2.1.2 Structure and components of crop protection strategies.....	8
2.1.3 Basis for and challenges of sustainability.....	9
2.1.4 Integrated Crop Protection: a science-based strategy	10
2.1.5 European Union legislation and the main concerns about pesticide use	11
2.1.6 The use of pesticides and trends over time in the European Union....	12
2.2 The evolution of economic evaluations of pesticide use	13
2.2.1 Economic value of pesticides.....	13
2.2.1.1 Marginal productivity of pesticides	13
2.2.1.2 Implications of the overestimation of the value of pesticides	15
2.2.2 Economic optimum use of pesticides	16
2.2.2.1 Maximum net benefits of pesticide use	16
2.2.2.2 Difficulties on assessing benefits and costs of pesticide use.....	18
2.2.3 Economic effects of reductions in use of pesticides	20
2.2.3.1 Methods to evaluate effects on crop production.....	20
2.2.3.2 Consequences of partial and total bans on use of pesticide.....	21
2.2.4 Economic benefits attained with sustainable use of pesticides	22

2.2.4.1	Assessment of effects on human health and the environment	22
2.2.4.2	Assessment of effects on farm incomes.....	23
2.2.4.3	Advantages attained with integrated pest management.....	24
2.2.5	Economic explanations of the adoption of sustainable use of pesticides	25
2.2.5.1	Factors associated with decisions to adopt sustainable strategies.....	25
2.2.5.2	Knowledge, perceptions and goals of growers in making farm decisions	27
2.3	Synopsis and characteristics of the present investigation.....	28
2.3.1	The use of pesticides is still an issue of concern	28
2.3.2	The chain of knowledge of agricultural economics research	29
2.3.3	Coherence between research and the objectives of public policies....	30
2.3.4	Lessons to be learned from previous investigations	30
2.3.5	Identification of the topics to be investigated.....	31
3	Classification of agricultural systems based on pesticide use attributes.....	33
3.1	Definition of agricultural systems.....	34
3.1.1	Types of systems.....	34
3.1.2	Proposed classification.....	35
3.2	Definition of pesticide use attributes	36
3.2.1	Pesticide use intensity	36
3.2.2	Pesticide use innovation.....	37
3.3	Selection of the case study crop.....	38
3.4	Intensity: the quantity of active ingredients applied.....	38
3.4.1	Statistical information	38
3.4.2	Data limitations and correction.....	40
3.4.3	Quantity applied at country level and European Union average	41
3.5	Innovation: the types of active ingredients applied	42
3.5.1	Innovation score for each active ingredient.....	42
3.5.1.1	Selection of variables and estimation of their significance	42
3.5.1.2	Characteristics of the variables and their scale of transformation	42

3.5.1.3	Data coverage.....	48
3.5.1.4	Aggregation of variables.....	49
3.5.2	National innovation scores and European Union average.....	51
3.6	Agricultural systems implemented in the production of fruit trees in the European Union	53
3.7	Robustness of this classification of agricultural systems.....	54
3.7.1	Sensitivity analysis for imputation of missing data.....	54
3.7.2	Sensitivity analysis for aggregation of variables	55
3.8	General observations.....	57
4	Conceptual framework.....	59
4.1	Theoretical Background.....	60
4.1.1	New Institutional Economics	60
4.1.1.1	Institutional analysis approach.....	60
4.1.1.2	Particular attributes and types of social rules	60
4.1.1.3	Rules and the structure of social interaction.....	61
4.1.1.4	Other factors that affect social interaction.....	65
4.1.2	The Institutional Analysis and Development Framework	65
4.1.2.1	Usefulness of frameworks and use of theories	65
4.1.2.2	Elements of institutional arrangements.....	65
4.1.2.3	Types of institutional analyses.....	66
4.2	Research procedure of the present analysis	67
4.2.1	Purposive sampling.....	68
4.2.2	Institutional analysis	68
4.2.3	Comparative analysis	69
4.3	Analysis of qualitative data: the Grounded Theory method.....	69
4.3.1	Objectivist and constructivist approaches.....	69
4.3.2	Researcher interpretation	69
4.3.3	Essential components.....	70
4.3.4	Levels of analysis.....	71
4.4	Research methodology followed in the present analysis.....	72
4.5	Analytic scheme (methods) for the present investigation.....	73

4.5.1	Selection of case study regions	74
4.5.2	Analysis of incentives in crop protection and pesticide use decisions	74
4.5.2.1	Theoretical description of driving forces in crop protection	75
4.5.2.2	Insight and directions for conceptualisation and integration of concepts.....	76
4.5.2.3	Explanation of pesticide use decisions	78
4.5.3	Hypothesising driving forces in crop protection.....	78
4.6	Research materials	79
4.6.1	Empirical data	79
4.6.2	Stakeholders survey	80
5	Results	83
5.1	Case study apple-growing regions	83
5.2	Descriptive view of crop protection: Crop protection in apple production	84
5.2.1	Apple production today.....	84
5.2.2	Phytosanitary problems and common tactics of crop protection.....	85
5.2.3	Measures to achieve sustainable use of pesticides.....	85
5.2.4	Particularities in apple growing	86
5.2.4.1	Emilia-Romagna, Italy	86
5.2.4.2	Lake Constance, Germany	87
5.2.4.3	Lerida, Spain	88
5.2.4.4	Kent, United Kingdom.....	90
5.3	Analytical view of crop protection: Incentives for pesticide use choices.....	91
5.3.1	Attributes: Complexity of pesticide use choices.....	91
5.3.1.1	Dynamic context of pesticide use choices	91
5.3.1.2	Types of agricultural practices and pesticide use choices	93
5.3.1.3	Boundaries of agricultural practices and pesticide use choices.....	97
5.3.2	Structural issues: Controls of pesticide use choices	100
5.3.2.1	Compliance with the European Union legislation	100
5.3.2.2	Voluntary adoption of private standards and crop guidelines	101

5.3.2.3 Use of advisory services	103
5.3.2.4 Implementation of agri-environmental measures	104
5.3.3 Contextual issues: Goals in crop protection	105
5.3.3.1 Low impacts and acceptable efficacy in the use of pesticides.....	105
5.3.3.2 Minimum use of pesticides and high food quality.....	105
5.3.3.3 Effective and environmentally favourable crop protection	105
5.3.3.4 Environmentally friendly crop protection.....	106
5.4 Explanatory view of crop protection: Driving forces behind pesticide use	106
5.4.1 Socio-economic factors in crop protection	106
5.4.1.1 Typical practice in the use of pesticides in the European Union..	108
5.4.1.2 Typical strategy of crop protection in the European Union	109
5.4.1.3 Predominant marketing scenario in the European Union	110
5.4.2 Causes of variation in pesticide use patterns	111
5.4.2.1 Explanation of differences on pesticide use intensity.....	111
5.4.2.2 Explanation of differences on pesticide use innovation	111
6 Discussion.....	113
6.1 Attainment of the research objectives of this investigation.....	113
6.2 Features in the design of crop protection strategies.....	114
6.2.1 Coordination and control in the production of apples	114
6.2.1.1 Powerful position of large-scale corporate entities in fruit retailing	114
6.2.1.2 Disproportionate distribution of commercial risk.....	114
6.2.1.3 Benefits or incentives for actors in the apple supply chain	115
6.2.2 Importance of local knowledge in the design of crop protection strategies.....	116
6.2.3 Control in the trade of apples and increased competition on the supply side.....	117
6.2.3.1 Homogenised requirements for the commercialisation of fruits ..	117
6.2.3.2 Reduced range of apple varieties in the market.....	117
6.2.3.3 Trade based on imperfect information.....	118
6.3 Options for reducing reliance on the use of pesticides	119

6.3.1	Structural issues	119
6.3.1.1	The role of associations in growers' environmental performance	119
6.3.1.2	Trade of regionally adapted varieties in local marketing scenarios	120
6.3.2	Technical issues	120
6.3.2.1	Direct methods of crop protection	121
6.3.2.2	Indirect methods of crop protection.....	123
6.4	Criteria and evaluation of the quality of this investigation.....	124
6.4.1	Evaluation of the underlying theoretical framework	125
6.4.1.1	Suitability of qualitative approach	125
6.4.1.2	Essential attributes of institutional analysis.....	126
6.4.2	Evaluation of the methods of data collection and analysis.....	127
6.4.2.1	Plausibility and applicability of the research findings.....	127
6.4.2.2	Methodological consistency of data collection and analysis.....	129
7	Conclusions.....	135
7.1	The message of this study	135
7.1.1	The general principles of Integrated Pest Management are already being implemented	135
7.1.2	Modern challenges for public authorities in crop protection issues .	136
7.2	Generation of knowledge and limitations of this investigation	137
7.3	Recommendations for further research.....	139
	References	141
	List of Annex.....	155

List of Figures

Figure 2-1:	Categorisation of crop protection strategies	9
Figure 2-2:	Expected marginal productivity of pesticides	15
Figure 2-3:	Maximum net benefits of pesticide use	17
Figure 2-4:	Minimum crop protection costs	18
Figure 2-5:	Knowledge generated in economic research on the use of pesticides.....	29
Figure 3-1:	Objectives of the first part of the analysis of driving forces in crop protection	33
Figure 3-2:	Agricultural systems based on pesticide use attributes	35
Figure 3-3:	Use of pesticides in the production of fruit trees in the European Union	53
Figure 4-1:	Objectives of the second part of the analysis of driving forces in crop protection	59
Figure 4-2:	Variables in any institutional arrangement.....	66
Figure 4-3:	Research procedure for the analysis of driving forces in crop protection	68
Figure 4-4:	Research aims and analytical strategies.....	71
Figure 4-5:	Analytical scheme for the present investigation.....	73
Figure 4-6:	Theoretical functioning of incentives in crop protection	75
Figure 4-7:	Conceptual guide for the analysis of pesticide use decisions.....	76
Figure 5-1:	Levels of pesticide use intensity and innovation in the case study regions	83
Figure 5-2:	Pesticide use actions, limits and apple production outcomes	92
Figure 5-3:	Possible, allowed and forbidden pesticide use actions	94
Figure 5-4:	Institutional arrangements in apple production in the European Union.....	107

List of Tables

Table 3-1:	Statistical data on the production of fruit trees in the European Union	39
Table 3-2:	Doses applied in the production of fruit trees in the European Union, 2000-2003	41
Table 3-3:	Innovation scores according to approval status	43
Table 3-4:	Innovation scores according to restrictions imposed in integrated production	44
Table 3-5:	Innovation scores according to hazardousness to human health	45
Table 3-6:	Innovation scores according to harmfulness levels on beneficial organisms	46
Table 3-7:	Innovation scores according to toxicity to natural species	47
Table 3-8:	Innovation scores according to potential to move toward groundwater	48
Table 3-9:	Indicators of pesticide use innovation in the production of fruit tree in the European Union, 2003	52
Table 3-10:	Effects of imputation of missing data on pesticide use innovation scores	55
Table 3-11:	Effects of aggregation of variables on pesticide use innovation scores	56
Table 4-1:	Functions of stakeholders interviewed in each region	80

List of Abbreviations

ADV	Asociación de Defensa Vegetal
AP	Assured Produce Scheme
CPC	Critical Point of Control
DEFRA	Department for Environment, Food and Rural Affairs
EMR	East Malling Research
EC	European Commission
ECPA	European Crop Protection Association
ENDURE	European Network for the Durable Exploitation of Crop Protection Strategies
EU	European Union
FAO	Food and Agriculture Organisation of the United Nations
GT	Grounded Theory
HDC	Horticultural Development Company
IRTA	Institut de Recerca i Tecnologia Agroalimentàries
IAD	Institutional Analysis and Development Framework
IOBC	International Organisation for Biological Control of Noxious Animals and Plants
KOB	Kompetenzzentrum Obstbau-Bodensee
LEAF	Linking Environment and Farming
MRL	Maximum Pesticide Residue Levels
MABO	Marktgemeinschaft Bodenseeobst
NPIC	National Pesticide Information Center of the United States
NIE	New Institutional Economics
OECD	Organisation for Economic Cooperation and Development
PAN	Pesticide Action Network
SSV	Servicio de Sanidad Vegetal Catalonia
SFR	Servizio Fitosanitario Regionale Emilia-Romagna
UNECE	United Nations Economic Commission for Europe
WHO	World Health Organisation
WGO	Württembergische Obst-und Gemüse-Genossenschaft