

Table of Contents

Abstract	i
Zusammenfassung	iii
Note	vii
1 Introduction	1
1.1 Motivation	1
1.2 Research goal and research questions	3
1.3 Structure and contribution of the thesis	4
2 Literature on economic and environmental efficiency	6
2.1 Basic concepts of efficiency analysis	6
2.1.1 Production technology	6
2.1.2 Efficiency measurement	7
2.1.3 Stochastic frontier analysis (SFA)	10
2.2 Measuring environmental efficiency: Literature review	14
3 Nitrogen use in agriculture and nitrogen pollution	18
3.1 Nitrogen cycle in agriculture	18
3.2 Nitrogen pollution	19
3.3 Environmental indicators of nitrogen use in agriculture	20
4 Background on Swiss agriculture	23
5 Heterogeneous farm output and technical efficiency estimates	26
5.1 Introduction	26
5.2 Methodology	29
5.2.1 Distance function approach	29
5.2.2 Estimation methods	29
	ix

5.3	Data description and empirical specification	30
5.4	Results and discussion.....	35
5.4.1	Testing.....	35
5.4.2	Parameter estimates	37
5.4.3	Technical efficiency.....	39
5.4.4	Effect of farm characteristics.....	41
5.5	Conclusions.....	43
6	Performance of Swiss dairy farms under provision of public goods	44
6.1	Introduction.....	44
6.2	Methodology	47
6.2.1	Production technology and efficiency measure	47
6.2.2	Estimation of the production technology.....	48
6.3	Empirical Analysis.....	50
6.3.1	Data.....	50
6.3.2	Specification of the model.....	50
6.4	Results and Discussion.....	52
6.4.1	Testing.....	52
6.4.2	Technological parameters	52
6.4.3	<i>Marginal products</i>	55
6.4.4	Technical efficiency estimates.....	56
6.4.5	Determinants of efficiency.....	57
6.5	Conclusions.....	59
7	Environmentally harmful by-products in efficiency analysis: An example of nitrogen surplus on Swiss dairy farms	62
7.1	Introduction.....	62

7.2	Methodological framework.....	65
7.2.1	Direct approach - Approach 1.....	65
7.2.2	Indirect approach - Approach 2.....	65
7.3	Data.....	66
7.3.1	Economic data.....	66
7.3.2	Nitrogen balance.....	67
7.4	Specification of models and hypotheses.....	69
7.4.1	Representation of production technology.....	69
7.4.2	Environmental efficiency.....	71
7.4.3	Hypotheses regarding differences in environmental efficiency (EE) across farms.....	72
7.5	Results and discussion.....	74
7.5.1	Representation of technology, including by-products.....	74
7.5.2	Efficiency results.....	76
7.5.3	Factors explaining differences in the environmental efficiency (EE) of farms.....	77
7.5.4	Comparison of EE with other indicators of environmental performance.....	78
7.6	Conclusion.....	79
8	Measuring environmental performance of Swiss farms using a hyperbolic distance function.....	81
8.1	Introduction.....	81
8.2	Theoretical concepts.....	85
8.2.1	Hyperbolic and enhanced hyperbolic distance functions.....	85
8.2.2	Parametric estimation of hyperbolic distance functions.....	86
8.2.3	Shadow prices.....	87
8.3	Data.....	88
8.3.1	Sample.....	88

8.3.2	Nitrogen balance at the farm level.....	88
8.3.3	Descriptive statistics	89
8.4	Empirical specification of the models.....	90
8.5	Results and discussion.....	92
8.5.1	Technology representation.....	92
8.5.2	Environmental performance.....	94
8.5.3	Shadow prices of nitrogen pollution.....	95
8.6	Conclusion.....	98
9	Synthesis and concluding remarks.....	101
9.1	Main results and answers to the research questions.....	101
9.2	Policy implications.....	108
9.3	Critical appraisal of the results and research outlook	109
	References	112
	Appendix	127
	Acknowledgments.....	136
	Curriculum Vitae	137