Policy Impact Analysis in the Dairy Sector

- An Agent-Based Real Options Approach -

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Introduction

Motivation / Research Gap

- Abolishment of EU milk quota system by 2015
  - ⇨ Higher levels of (dis)investments in the dairy sector can be expected
- Extreme milk price fluctuations in 2007-2009
  - ⇨ Dairy farmers and lobbyists started to ask for additional political support
- Studies have proven that the real options approach (ROA) is more advantageous for analyzing dairy investments than traditional investment models
- However, no real options model yet allows the analysis of investments under consideration of competition and political schemes

Objectives

- Development of a conceptual agent-based real options market model allowing the impact assessment of different political schemes
- Application of the model to the German dairy sector by comparing exemplarily the effects of
  - lower price limits maintained by governmental purchases of excess supply
  - investment subsidies

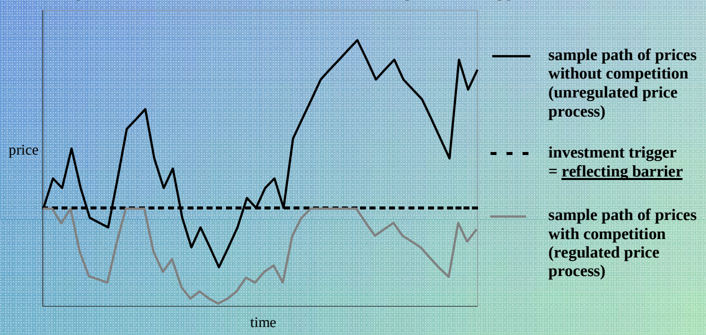
  on investment trigger prices, firm profitabilities and economic efficiencies

Theoretical Background

Real Options Approach

- Analyses investment decisions in a stochastic and dynamic context
- Exploits analogy between a financial option and an investment project to evaluate entrepreneurial flexibility
- In contrast to financial options, real investment projects are also open to other market participants, which affects the price dynamics
  - ⇨ Prices need to be determined endogenously
  - ⇨ Competition has to be taken into account

Price Dynamics with and without Competition (geometric Brownian Motion)



⇨ Numerical model allows endogenous derivation of price dynamics and investment triggers in competitive markets

Model Description

Basic Model Assumptions

- N homogenous competing risk-neutral firms
- Firms can make investments up to a given maximum output capacity
- Step-by-step investment possible over T years
- Production capacity can be adjusted via investments just once in a period
- Irreversible investment
- In every period, production declines corresponding to a geometric depreciation rate

Investment Behavior of the Firms and Optimization of the Model

- Rational expectations and complete information of the firms
  - ⇨ Each firm maximizes its expected net present value by finding the optimal investment trigger price
- Firms with lower trigger prices have a stronger tendency to invest
  - Firms are sorted according to their trigger price level, starting with the lowest
  - Firm n+1 does not invest, if firm n is not already completely invested
- In every period a "last" firm invests such that its trigger price equals the expected product price of the next period
- Optimal trigger prices are derived by a combination of genetic algorithms and stochastic simulation
- Economic efficiency of political schemes is calculated as quotient of welfare with political schemes and welfare without political schemes

Results

Effects of Lower Price Limits on Trigger Prices, Expected Net Present Values and Economic Efficiencies under General Conditions

- Model parameters:
  - Demand process: geometric Brownian Motion with drift = 0.0% or 2.5% and volatility = 20% or 40%
  - Price elasticity = -1, depreciation = 0%, risk-free interest rate = 6%, T = 100 years, N = 50 firms, total costs of investment per output unit = 1 €
- Lower price limits given in percentage of the total costs of investment

Lower Price Limit	Volatility / Drift	20%			40%		
		Trigger Price	Expected NPV	Econ. Efficiency	Trigger Price	Expected NPV	Econ. Efficiency
0%	**0%**	1.5819	-0.0042	100.00%	2.3934	-0.0413	100.00%
80%		1.3202	-0.0025	81.07%	1.5359	-0.0020	71.77%
95%		1.0841	0.0004	65.35%	1.0560	0.0018	55.34%
0%	**2.5%**	1.3809	0.0076	100.00%	2.1724	-0.0060	100.00%
80%		1.2244	-0.0036	86.96%	1.4460	0.0350	79.41%
95%		1.0398	0.0027	73.28%	1.0203	0.0538	67.22%

- Results summary:
  - Increase of lower price limit induces decline in trigger prices
  - Firms do not make any profits despite of lower price limit
  - Economic efficiency decreases with implementation and increase of lower price limit
  - Increasing drift rates induce decreasing trigger prices
  - The higher the volatility, the stronger the reduction in trigger prices and economic efficiencies by increasing lower price limits

Empirical Application to the German Dairy Sector: Comparison of the Effects of Lower Price Limits and Investment Subsidies

- Model parameters:
  - Demand process: geometric Brownian Motion assumed with estimated drift = 1.40% and volatility = 19.23% based on time series of inflation-adjusted milk prices
  - Price elasticity = -1.0, depreciation = 4.5%, inflation-adjusted interest rate = 3.69% based on time series, T = 100 years, N = 50 firms, total costs of investment per kg milk = 0.37 € (incl. variable costs for fodder, labor etc.)
- Lower price limits given in percentage of total costs of investment, investment subsidies given in percentage of the initial investment outlay
- Investment subsidies are fixed by iterative searching at the trigger price level of lower price limits

Lower Price Limit			Investment Subsidy		
Lower Price Limit	Trigger Price	Econ. Efficiency	Lower Price Limit	Trigger Price	Econ. Efficiency
0%	0.5060	100.00%	**0%**	0.5060	100.00%
80%	0.4538	88.89%	**81%**	0.4526	97.53%
95%	0.3870	75.85%	**180%**	0.3895	93.19%

- Results summary:
  - Both the increase of lower price limit and the investment subsidy induce decline in trigger prices and economic efficiency, as shown under general conditions
  - Investment subsidies cause less stronger welfare reductions than lower price limits for achieving the same trigger price level (this can also be confirmed under general conditions)

Summary

Main Conclusions

- Model provides a conceptual basis for policy impact analysis for competitive markets underlying real options effects
- Vast modeling flexibility by use of genetic algorithms and stochastic simulation
- Investment subsidies are preferable to lower price limits

Future Research

- Besides investments integration of disinvestments in the model
- Investigation of effects of the EU milk quota abolishment

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