LEARNING-BY-DOING OR TECHNOLOGICAL LEAPFROGGING: PRODUCTION FRONTIERS AND EFFICIENCY MEASUREMENT IN NORWEGIAN PRODUCTION OF JUVENILE SALMONIDS

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Introduction

- In Norwegian salmon production, there has been a strong productivity growth caused by increased production and reduced costs.
- Two thirds of the reduction in costs that has taken place can be attributed to better and cheaper inputs (Tveterås and Heshmati 2002).
- If one is to obtain a better understanding of the factors that enhance the competitiveness it is useful to study the development of the supplier industries.
Norwegian Smolt Production

Sea only used for transport

Access to freshwater
Juvenile Production 1988-2012
Important innovations

New production technology: The use of Artificial light

New water technology: The Recirculation Aquaculture System
The innovations have made large changes

- Shorter production cycle (more of the *zero-year-old smolt*)
- More flexibility in deliveries to the grow-out plants
- More environment-friendly production
- Increased production per plant

The innovations have given a better control and reduced risk in the production process
The cost function and the effect of Technological Change (innovation)

Costs per unit (C/y)

\[ C_0(w_1, w_2, w_3, y, t_0)/y \]

\[ C_1(w_1, w_2, w_3, y, t_1)/y \]

Production volume in number of units (y)

INNOVATIONS (TC)
The cost function can be used as a frontier to measure the inefficiency of firms.

Costs per unit (C/y)  

Company A

Company B

Production volume in number of units (y)

COST FRONTIER (Best practice)  
C(w₁,w₂,w₃,y,t)/y

The impact of the age of the firm

TECHNICAL INEFFICIENCY
The aim of this study

- Investigate the inefficiency in juvenile production with a particular focus of the age of the firm. We test between Learning-by-doing and Technological Leapfrogging in this production.
- Learning-by-doing means that incumbent firms benefit from more experience and better locations.
- Technological Leapfrogging implies that firms entering innovative industries may be able to leapfrog incumbent firms by using newer and better technology.
The data set

- Panel dataset (unbalanced) on firm level offered by the Norwegian Directorate of Fisheries
- Time period: 25 years from 1988 to 2012
- Size: 70-100 hatcheries have attended each year and the dataset contains of 1925 observations

Include variables as:
- Production data; size of the license, starting year, county, number of employees, units of output
- Economic information from the accounts; costs, income, assets
Econometric estimations

- **METHOD**  Stochastic Frontier Analysis
- **MODEL**  Trans Log Cost Function

\[
\ln C = \alpha_0 + \sum_i \alpha_i \ln w_i + 0.5 \sum_i \sum_j \alpha_{ij} \ln w_i \ln w_j + \alpha_y \ln y + 0.5\alpha_{yy} (\ln y)^2 + \\
\sum_i \alpha_i \ln w_i \ln y + \alpha_{FRY} D_{FRY} + \alpha_{y,FRY} D_{FRY} \ln y + \sum_i \alpha_{wi,FRY} D_{FRY} \ln w_i + \\
\sum_t \alpha_t D_t + \sum_t \sum_i \alpha_{it} \ln w_i^* D_t + \sum_t \alpha_y \ln y^* D_t + \sum_r \alpha_r D_r + \mu_{it} + \nu_{ia}
\]

were
\[
\nu_{ia} = \sum_i \alpha_i \ln x_i + \alpha \text{ age}
\]

The impact of the age of the firm

Inefficiency caused by region

Technical Inefficiency
Results: The elasticity's

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<thead>
<tr>
<th></th>
<th>Elasticity</th>
<th>p-value</th>
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<td>Technical Change</td>
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</table>

*Technical Progress on average 4.8 % each year*

*Increasing Returns to Scale*
Regional specific inefficiency: 9.1%
Technical inefficiency (firm specific): 15.4%

Efficiency Score sorted from the most to the least efficient farm
The impact of age of the firm

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<tr>
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<th>Coefficient</th>
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<tbody>
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- We have found the presence of an age effect in the technical inefficiency function.
- Our results suggest that entering firms perform slightly better than incumbent firms with respect to technical inefficiency, and thereby, they support the technological leapfrogging hypothesis.
Conclusions

- There are inefficiencies associated with single companies as well as regions in the production of juvenile salmon.
- Our results indicate that inefficiency increases with age.
- A high productivity growth in juvenile production has given lower costs which has made it possible to give the grow-out farms smolt to much lower prices.
- The producers of smolt have therefore contributed to a better competitiveness for the Norwegian Salmon Industry.
Thank you for the attention

Questions?