THE ECONOMICS OF
ESCAPED FARMED SALMON

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INTRODUCTION

- Aquaculture is the world’s fastest growing food production technology
  - Salmon is one of the most successful species
- Innovations and productivity growth has increased production and scale
- Has also potential to increase ecological footprint and environmental externalities
- Escapeed salmon is regarded as one of the two largest externalities caused by the Norwegian industry to day
  - It not a pure externality, since farmers have incentives to reduce escapes
  - But the socially optimal number of escapes may be smaller than the private, creating a need for regulations
SALMON FARMING

Production has increased from

Have challenges

Fikset de fleste industriproblemene (ihvertfall i Norge)

60 70 80 90 100 1200 1400 1600 1800 2000

Prosent

1,000 tonn Norway

Total

Share

Potensielle økosystemproblemer

Rømming, konsekvenser, genetisk forurensing

3 0 10 20 30 40 50 60


Prosent

1,000 tonn Total Share
PRODUCTION, COST AND PRICES
A PEN FROM 1980 AND ONE FROM 2010
(today they might be even larger)
ENVIRONMENTAL CHALLENGES

- Disease outbreaks
- Sedimentation under the pens and nutrition discharges from farms
- Chemicals and antibiotics
- Salmon lice
- Escapes
ESCAPED FARMED SALMON

- A debate whether it is a large problem or not.
- Farmed salmon interbreed with wild and reduce genetic variability.
- Farmed salmon destroys wild salmons spawning beds
- Can transfer disease
- As long as it is seen as a problem! it is a problem
- An important issue for NGOs, regulators etc.
REASONS FOR ESCAPE
NO. OF ESCAPEs

- Escaped individuals
- Production

Thousand individuals

Thousand tonnes


No. of Escapes: 12
To examine how escapes influence cost-structure, we estimated a multi-product cost function with one good (salmon) and one bad (escaped salmon) output (Morrison-Paul et al, 2001).

- This specifications gives us the possibility to examine how escapes influence cost
  - directly
  - indirectly through input combinations

- Makes salmon production a multi-output process
  - Scope
  - Separability
DATA

- Norwegian Directorate of fisheries collect farm level data on production, escapes, cost etc.
- Most farms does not have escapes, so we used data aggregated to a regional level
- Yearly data 1998-2009
- 12 regions
EMPIRICAL ESTIMATION, Cost function

\[
\ln c_{it}(w, Y, K) = \beta_0 + \sum_{r=1}^{R-1} D_r + \sum_{b=1}^{2} \beta_b \ln w_{bit} + \beta_k \ln K_{it} + \sum_{o=1}^{2} \beta_o \ln Y_{oit} + \beta_t t
\]

\[
+ \frac{1}{2} \sum_{b=1}^{2} \sum_{c=1}^{2} \beta_{bc} \ln w_{bit} \ln w_{cit} + \frac{1}{2} \sum_{o=1}^{2} \sum_{p=1}^{2} \beta_{de} \ln Y_{oit} \ln Y_{pit}
\]

\[
+ \frac{1}{2} \beta_{kk} (\ln K_{it})^2 + \frac{1}{2} \beta_{tt} t^2 + \sum_{b=1}^{n} \beta_{bk} \ln w_{bit} \ln K_{it}
\]

\[
+ \sum_{b=1}^{2} \beta_{bt} \ln w_{bit} t + \sum_{o=1}^{2} \beta_{ok} \ln Y_{oit} \ln K_{it} + \sum_{d=1}^{n} \beta_{dt} \ln Y_{dit} t
\]

\[
+ \sum_{b=1}^{2} \sum_{d=1}^{2} \beta_{bo} \ln w_{bit} \ln Y_{oit} + \beta_{kt} \ln K_{it} t
\]
# RESULTS

<table>
<thead>
<tr>
<th></th>
<th>Test statistic</th>
<th>$p$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scale elasticities, salmon</td>
<td>1.216</td>
<td>0.000</td>
</tr>
<tr>
<td>Own price elasticity, feed</td>
<td>-0.118</td>
<td>0.000</td>
</tr>
<tr>
<td>Own price elasticity labor</td>
<td>-0.744</td>
<td>0.000</td>
</tr>
<tr>
<td>Cost elasticity, escaped salmon</td>
<td>-0.005</td>
<td>0.174</td>
</tr>
<tr>
<td>Cost elasticity, salmon</td>
<td>0.822</td>
<td>0.000</td>
</tr>
<tr>
<td>Economics of scope</td>
<td>-0.000</td>
<td>0.977</td>
</tr>
<tr>
<td>Separability, escapes</td>
<td>3.960</td>
<td>0.137</td>
</tr>
</tbody>
</table>
COST EFFECTS

- Cost elasticity for escape, negative -0.005, but not significantly different from zero
- Cost elasticity for salmon 0.822, clearly significant
- HENCE, increased escapes do not increase cost
COST EFFECTS

- Economics of scope: Negative, but less than 0.0005 and not significant.
- Escapes does not increase the cost of producing salmon
- Test for weak separability, *p-value* 0.137. Escapes do not influence input factor combination
CONCLUDING REMARKS

- Farmers does not have cost incentives to reduce escapes.

- They will not invest in more escapee prevention unless they get “other good reasons”
  - Regulations
  - Innovations and improvements in regulations are as important for future growth in aquaculture as product and process innovations

- Given our results (separability), regulation on escapes will not will not cause sub-optimal input factor combinations