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Biosecurity vs. Profits: A multi-objective model for the salmon aquaculture industry.

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Universidad de Concepción

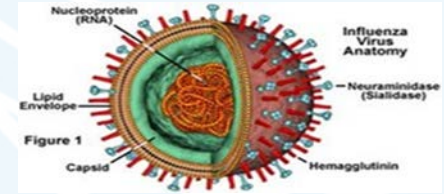Universidad Austral de Chile
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MOTIVATION

- Salmon aquaculture has grown rapidly in Chile the last three decades.

- Year 2007 the sector was hit by an infectious salmon anemia (ISA) disease outbreak.

- Huge impact on production, costs, employment, exports and financial situation of firms.

- Several sanitary regulations were implemented by a task force ("Mesa del salmón") integrated by authorities and firm representatives

Motivation, cont.

> ➢ Limits to fish density in net pens

> ➢ Minimum distance between farms increased

> ➢ Farms were grouped in so called "barrios", (many farms of the same geographic zone) with common 3 months relief periods.

- Regulations reduced the volume of salmon available for processing each year within the same space.

- These regulations reduce the risk for "sanitary emergencies" , but increase substantially unit production costs (trade-off).

AIM

- Propose a multi-objective model to analyze the trade off between sanitary and profit targets in the aquaculture industry.

- Specifically we concentrate on modelling the regulation that restricts the volume of salmon available for processing.

- The model allows us to calculate exchange rates between profits and sanitary conditions along the Pareto frontier and evaluate changes in some parameters (prices for different species)

- We apply the model to the salmon industry in the Región de Los Lagos (RLL) in year 2011

Model

- The model is composed of two objective functions

$$\sum_i \sum_j (\ p_i q_{ij}(\ x_j \ ) - C(\ x_j \ )) \qquad (1) \qquad \text{(Max profits)}$$

$$q_{ij} = A_{ij}(\ x_j \gamma_{ij} \ )^{\alpha_{ij}} , \qquad \text{(Production function)}$$

p_i is the FOB per exported ton, q_{ij} is the volume of exported tons, x_j is the total harvest of species j in tons, γ_{ij} is the proportion of input j in the production of good i, C_{ij} is the cost function.

Model, cont

We introduce the concept of "Sanitary desirable volume" (SDV) which is the space for farming salmon required to produce a volume of salmon compatible with a low probability of disease outbreak.

$$SDV = \sum_j \frac{(x_j^0 / hr_j)}{w_j} \Big/ n_j$$

where the "Sanitary Desirable Volume (SDV)" are the maximum tons of harvested salmon per year "translated" to a space metric (m^3) compatible with sanitary security. x^0_j is the harvest level compatible with this volume and n_j is the number of salmons per m^3 allowed by the sanitary regulation

Model, cont

In the same vein, we measure actual production in (m^3) space.

$$xadj_j = \sum_j \frac{(x_j/hr_j)}{w_j} \Big/ n_j$$

The biosecurity goal aims to minimize the probability of an epidemic outbreak

$$Min \ \{Prob(Sanitary \ outbreak) = F(z)\} \qquad (2)$$

- We assume the following probability distribution function for sanitary events:
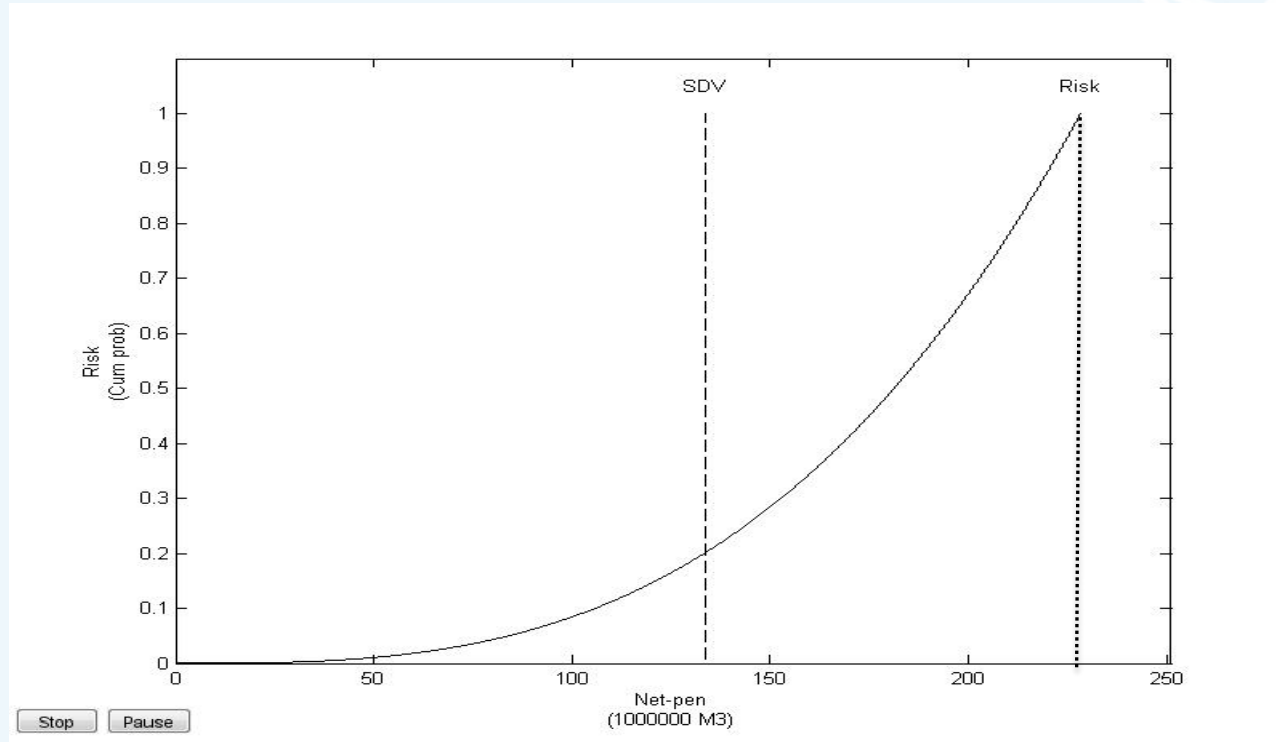
$$F(z) = \left(\frac{z}{A}\right)^3, \ 0 \leq z \leq A$$

where $z \equiv \sum_j xadj$ and $A \approx 1.7 \ SDV$

- This implies a density function $f(z) = \dfrac{3z^2}{A^3}$

To calculate A, we have assumed that the actual set of sanitary regulations generates a volume of production equal to the SDV, and that this implies a 20% accumulated probability of a disease outbreak.

Probability function for sanitary events

- According to ec. (2) higher levels of activity generate higher risks for losses in sanitary security. This is considered a threat to industry stability
- It is assumed that industry attempts to optimize both functions simultaneously.
- Nevertheless, a trade off exists between these goals. Given an optimal situation, more biosecurity can only be attained with lesser profits, and viceversa.

EMPIRICAL APPLICATION

- Mix of econometric estimation, parametrization, and numerical optimization. Year = 2011

- Estimate the production functions.

- Use information of export prices by good an species, proportion of inputs, salmon harvested, etc.

- We calibrate the model to reproduce the values of year 2011.

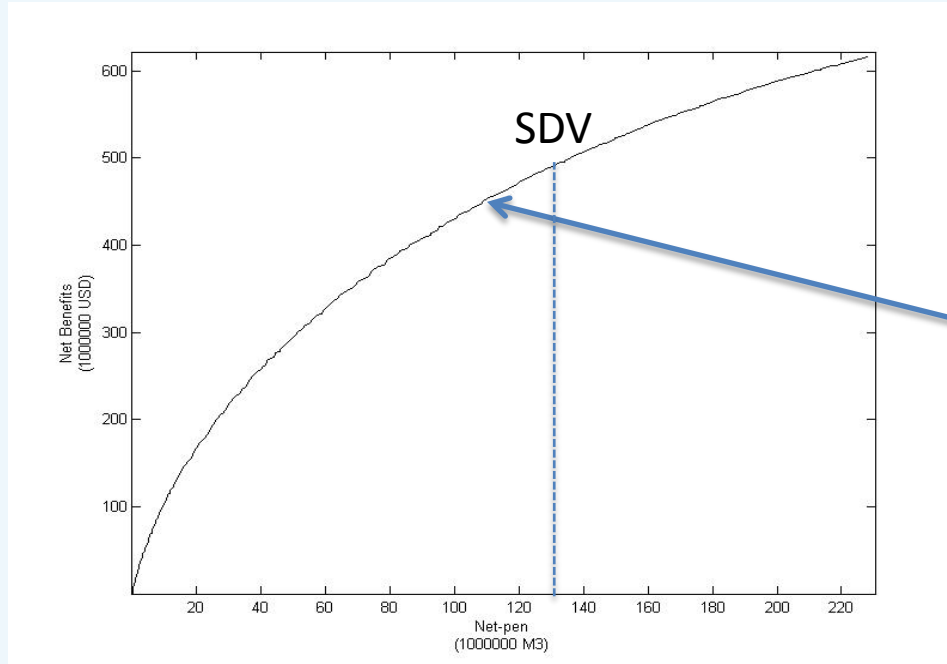- Numerical optimization of the model.

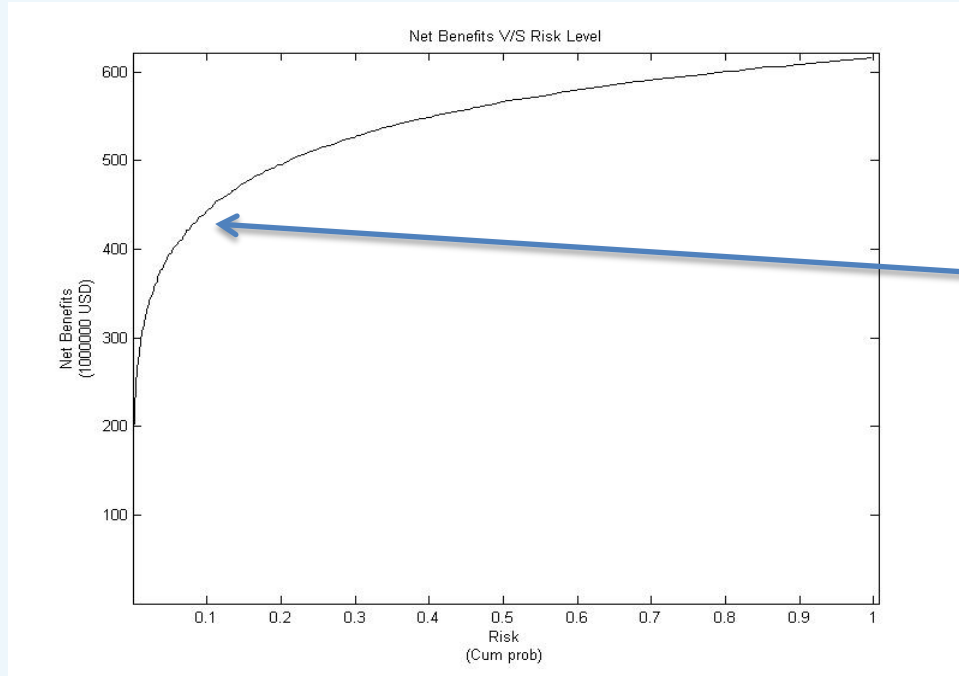# Results

Aggregated net benefits and volume of net-pens

Curvature of the function shows the costs of space sanitary regulations in terms of forgone profits

Results, cont.

Pareto Frontier for profits and probability of sanitary outbreaks

Zone of high variability in substitution rates

Discrete substitution rates

Net-pen (1,000,000 m3)	Susbtitution rates forgone profits (USD/m3)	Susbtitution rate of net benefits and risk increase (million of USD/percentage point)
0.00		
22.61	7.7	180,148
45.21	4.7	15,671
67.82	2.4	2,900
90.42	3.1	1,970
113.03	2.2	833
135.64	**1.9**	**481**
158.24	1.9	343
180.85	1.1	146
203.45	1.1	120

Conclusions.

- We model and calculate the trade-off between biosecurity and profits. We coin the concept of sanitary desirable volume.

- The results show that the regulations that limit salmon production, for sanitary reasons, in the Chilean case are having an important cost for firms in terms of forgone profits. This stresses the importance of selecting a cost effective way to regulate sanitary conditions, even when the sanitary restriction is justified on biosecurity grounds.

- Regulations seem to have been determined with little information about their effectiveness. It seems important to try to measure carefully the required SDV level for assuring biosecurity.

Conclusions, cont.

- We present some evidence that suggests that the present level of SDV in Chile, as reflected by the actual regulations, lies at a stable segment of the exchange relation between profits and space. If this is correct, then there is space for policy decisions.

- The trade – off not only depends on level of the SDV, but also on the market situation that the different products face.

- Finally, the model presented suggests that firms do react to changes in SDV and prices, accommodating their production processes to take advantage of the relative profitability changes between final products.

Thank you for your attention