

The impact of farmers' strategic behavior on the spread of animal infectious diseases

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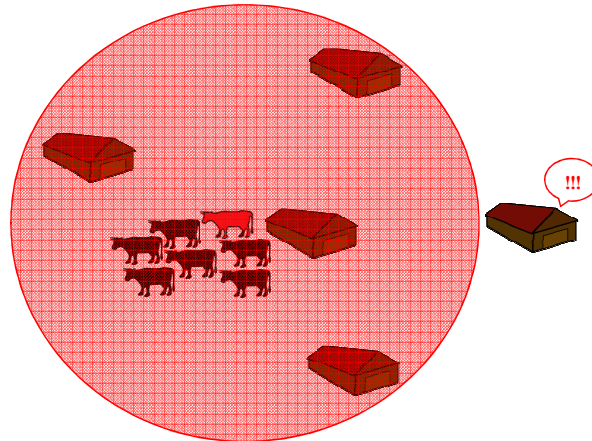
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Roadmap

- Background and motivation
- Economic model – Anticipation effects
- Epidemiological model
- Results
- Conclusions

Background and motivation Movement Restriction Policy (MRP)



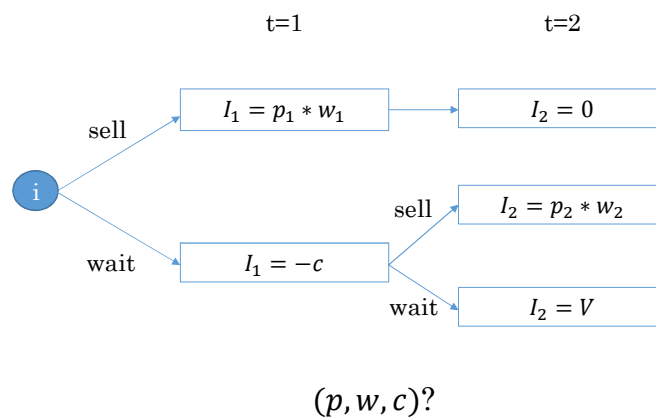
Background and motivation Movement Restriction Policy (MRP)

Year 1

Year 2



Economic model – Two periods ($t=\{1,2\}$)

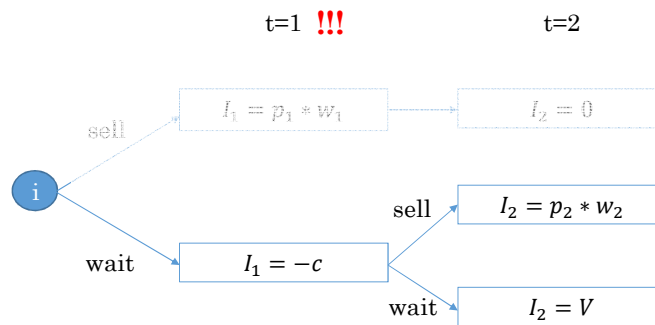


Economic model – Simplifying assumptions

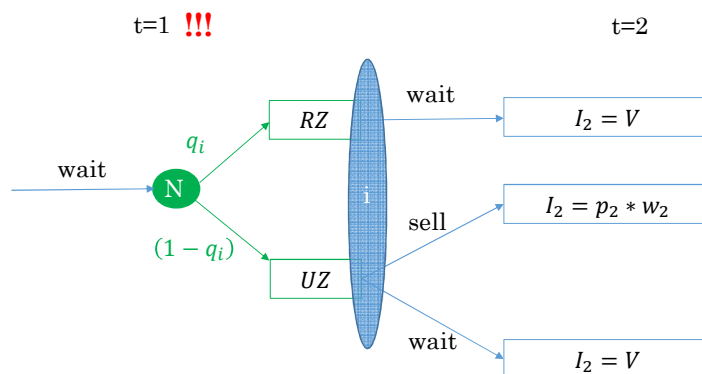
- $p_1 = p_2 = p$
- $w_2 = w_1 * (1 + d)$
- $V < p * w_1 * (1 + d)$
- Animals ready to be sold at $t = 2$
 $c < p * w_1 * d$, dominant strategy:

(wait, sell)

Economic model – MRP



Economic model – MRP



- q_i : Farmer i 's probability of being located in the RZ the next period.

Economic model – Anticipation effects

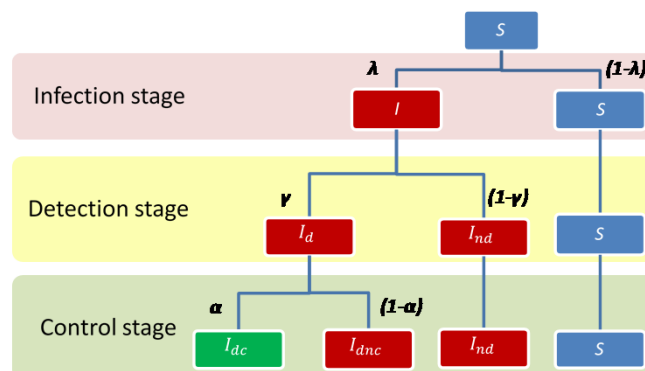
- Farmer i will decide to anticipate if:

$$p * w_1 > q_i * (V - c) + (1 - q_i) * (p * w_1 * (1 + d) - c)$$

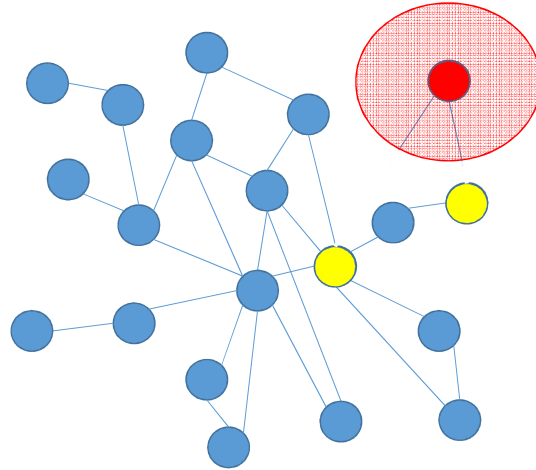
$$\text{i.e. } q_i > \frac{p * w_1 * d - c}{p * w_1 * (1 + d) - V} (= \hat{q})$$

If $[V - c] < p * w_1$ then $\hat{q} \in (0,1)$

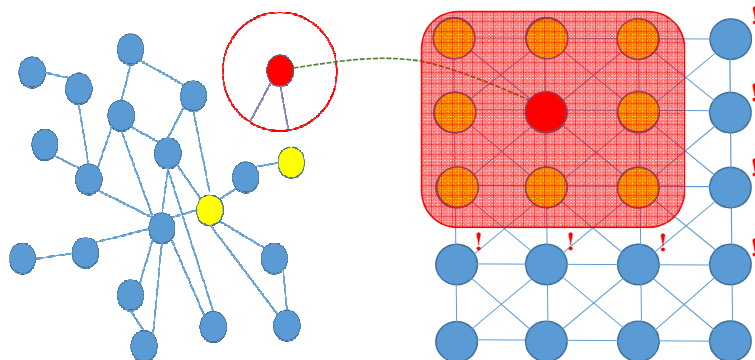
Epidemiological model - Stages



Epidemiological model – Commercial Network
Node = Farm



Epidemiological model – Geographical Network
vector borne



Trade Network

Geo Network

300 MC simulations

- Source of uncertainty:
 - Probability of trading (activated node) at every t.
 - Initial infection.

Table 1
Main characteristics of the cattle trade network

	Rautureau (2011)	Model
Size (number of nodes)	244,097	10,000
Farms (number)	242,706	9,942
(% of total nodes)	99.43%	99.42%
Dealers (number)	1,315	54
(% of total nodes)	0.54%	0.54%
Markets (number)	76	4
(% of total nodes)	0.03%	0.04%
Type of network	Scale-Free	Scale-Free
gamma	2.15	2.15

Table 2
Calibration of the probability of selling

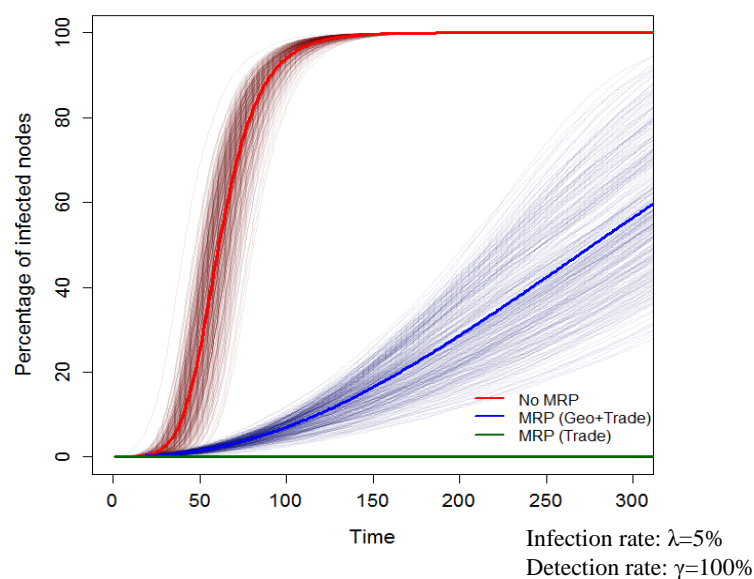
	Rautureau (2011)	Model
	Weekly participation *	Probability of selling**
Farms (mean)	48,179	18.9%
(min - max)	(32,920 - 58,605)	(13.6% - 24.1%)
Dealers (mean)	1,001	72.5%
(min - max)	(865 - 1,042)	(65.8% - 79.2%)
Markets (mean)	66	85.6%
(min - max)	(57 - 73)	(75.0% - 96.1%)

* This variable represents the number of nodes that have at least one transaction for a specific week.

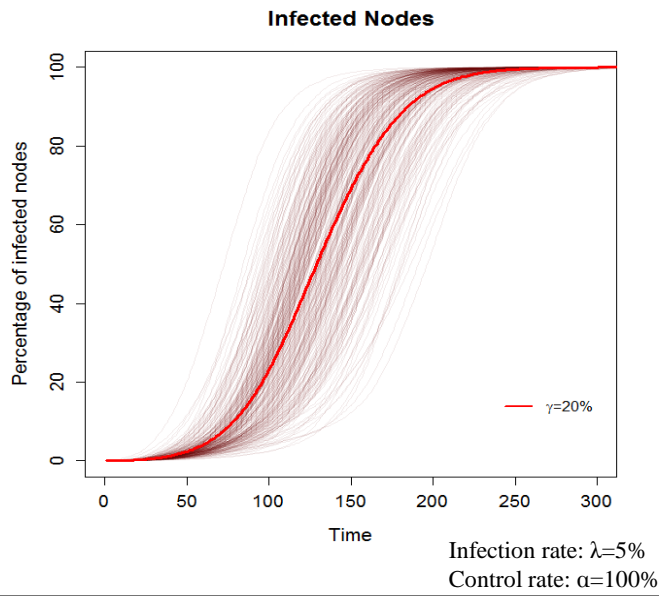
** This probability is computed as a function of the weekly participation

Results – MRP

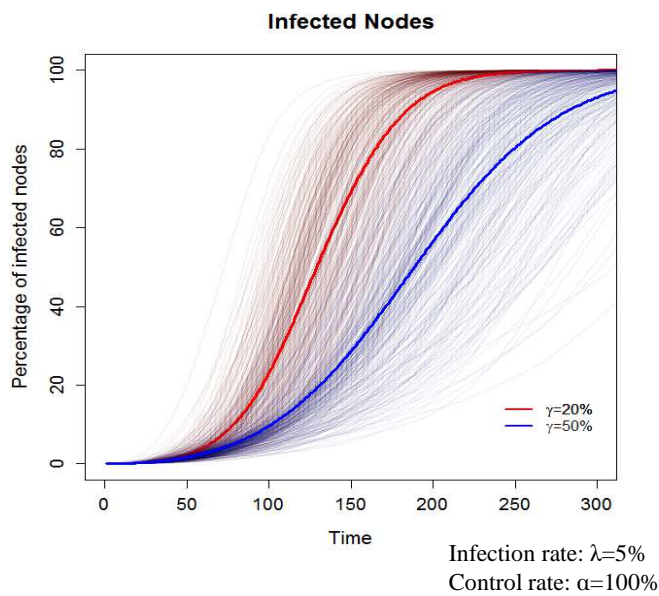
Infected Nodes



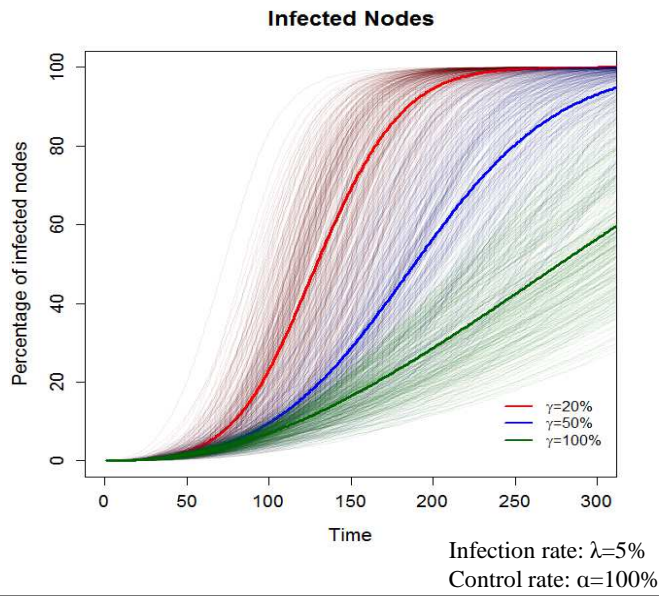
Results – Detection rate (gamma)



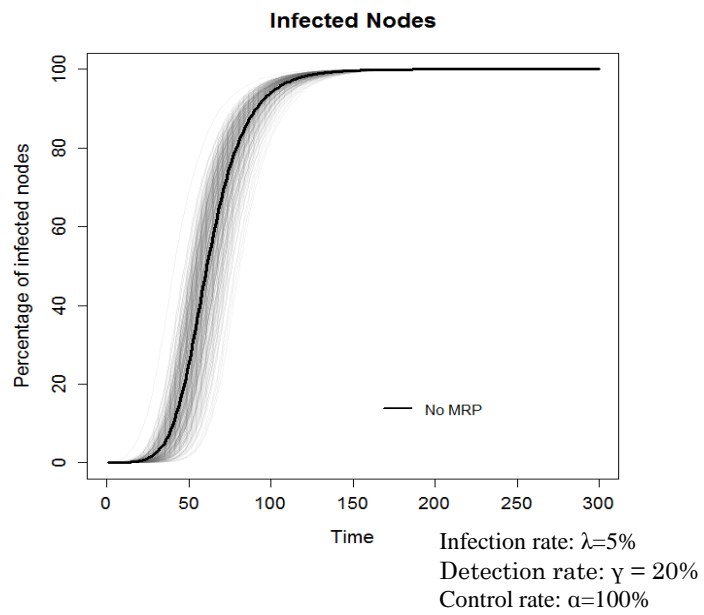
Results – Detection rate (gamma)



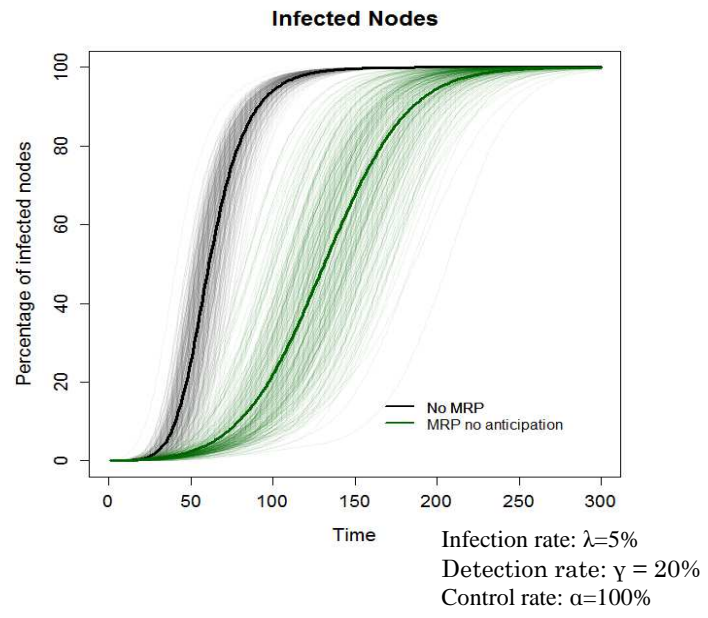
Results – Detection rate (gamma)



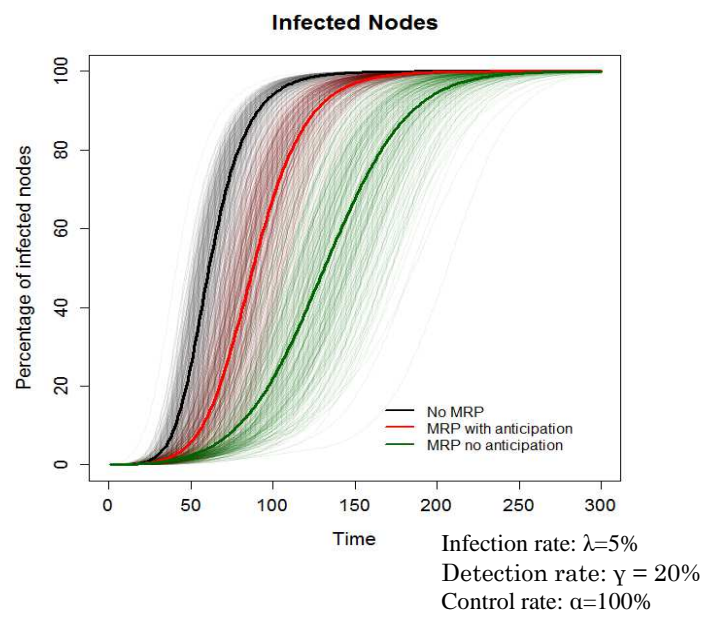
Results – Anticipation effects



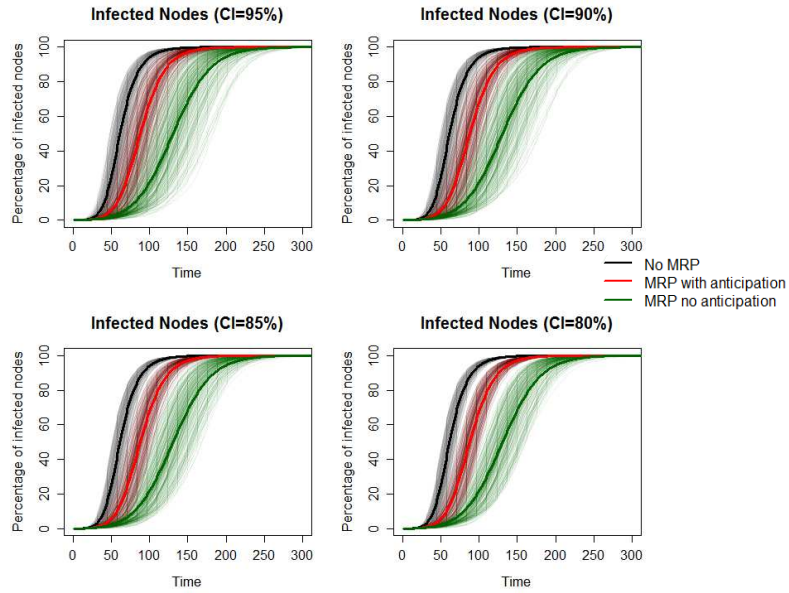
Results – Anticipation effects



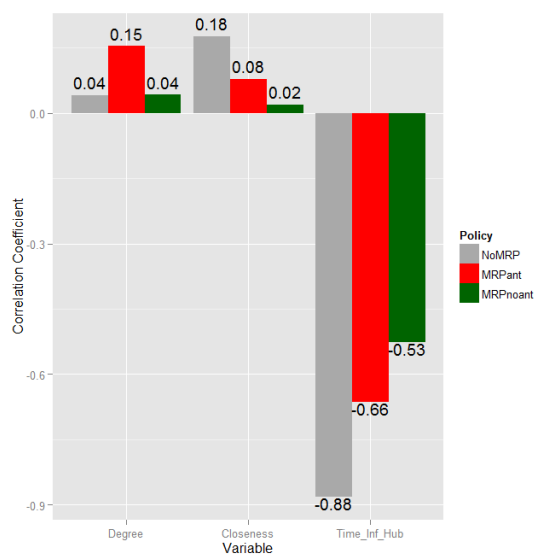
Results – Anticipation effects



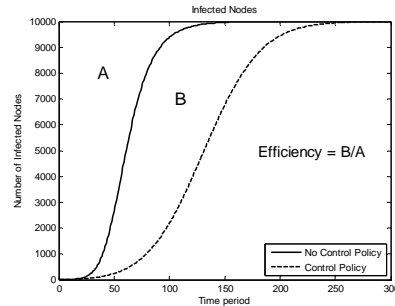
Confidence Intervals



Rank correlation coefficient analysis



Results – Efficiency



- Efficiency index of:

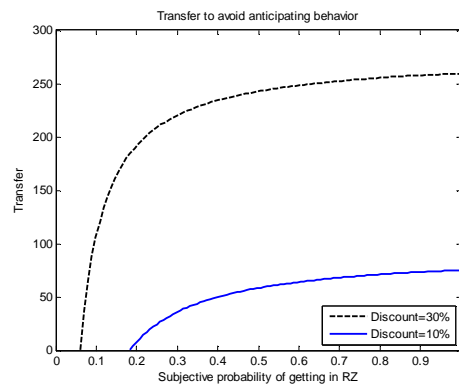
- MRP(no anticipation) = 1.06
- MRP(with anticipation) = 0.40

- 61 %

Results – Transfers as a mechanism to avoid anticipation

$$p * w_1 = q_i * (V - c + T) + (1 - q_i) * (p * w_1 * (1 + d) - c)$$

$$T = \begin{cases} \left[\frac{p * w_1}{q} - (V - c) \right] - \left(\frac{1 - q}{q} \right) * [p * w_1 * (1 + d) - c] & q > \hat{q} \\ 0 & q \leq \hat{q} \end{cases}$$



Parameters:
 p = 2.56 eur/kgwt
 w₁ = 350 kg
 d = 10/350
 c = 8.73 eur
 V = p*w₁*Discount

Conclusions

- The implementation of movement restrictions can trigger premature sales.
- Premature sales can increase the speed of spread of an infectious disease.
- Provision of financial aid is supported by public health concerns (not only compensatory).