

Example of the Economics of Public R&D: Economic Feasibility for Establishing FMD Vaccine Center

1. Introduction

Facts

- FMD (foot-and-mouth disease: 구제역) damages livestock industry a lot. The vaccine for FMD might be helpful for improving these situations around the livestock industry.
- Although the foundation of the FMD vaccine center is required for the livestock industry, the construction and maintenance costs are relatively high. (Currently, FMD vaccine is imported from other countries)
- Hence, the Cost and Benefit analysis regarding the establishment of FMD vaccine center is required
- According to the plan of the government, FMD vaccine center will produce antigen(항원) and vaccine companies will produce FMD vaccine by purchasing the antigen from the center.

2. Demand for FMD vaccine

Projection of future livestock

We have to know how much livestock could need a FMD vaccine in order to figure out the validity of the center.

Livestock that needs FMD vaccine	# of livestock (unit=1,000) at the base year of 2012
Cow	9,669
Pig	21,146
Goat	874
Deer	190
Total	31,779

2. Demand for FMD vaccine

Required number of vaccinations

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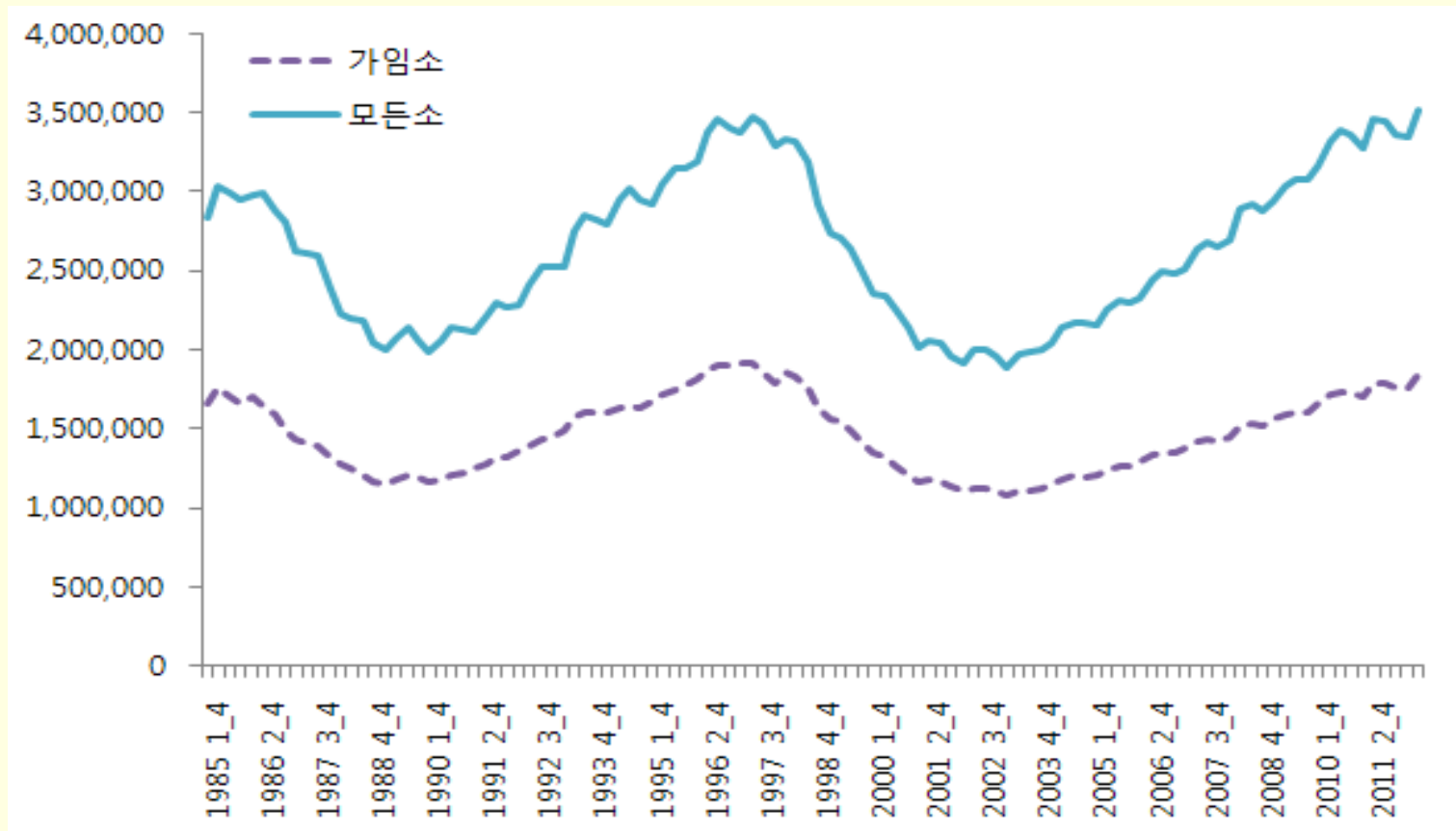
Vaccine demand for each livestock

Livestock		Vaccine requirement	Estimated herds (1000)
Cow	Calf(송아지)	Pregnant cattle $1,771,000 \times 75\% \times 2\text{times}$	2,657
	Total Cow	$3,456,000 \times 2 \text{ times}$	6,912
	Sub total		9,669
Pig	Piglet(자돈) (for breeding)	Sow $843,000 \times 2.1 \text{ times a year} \times 10(\text{delivered piglets}) \times 1\text{time}$	17,702
	Sow(모돈)	Sow $843,000 \times 2 \text{ times}$	1,770
	Piglet for Sow	Piglet for Sow $80,000 \times 2.1 \text{ times a year} \times 10(\text{delivered piglets}) \times 50\%(\text{♀}) \times 2\text{times}$	1,674
	Sub total		21,146
Goat	Nanny goat(어린염소)	$114,000 \times 1.7 \times 2\text{times}$	387
	Goat over 1 year old	$244,000 \times 2 \text{ times}$	487
	Sub total		874
Deer	Baby deer	$30,000 \times 2\text{times}$	60
	All dear	$65,000 \times 2\text{times}$	130
	Sub total		190
Total			31,779

2. Demand for FMD vaccine

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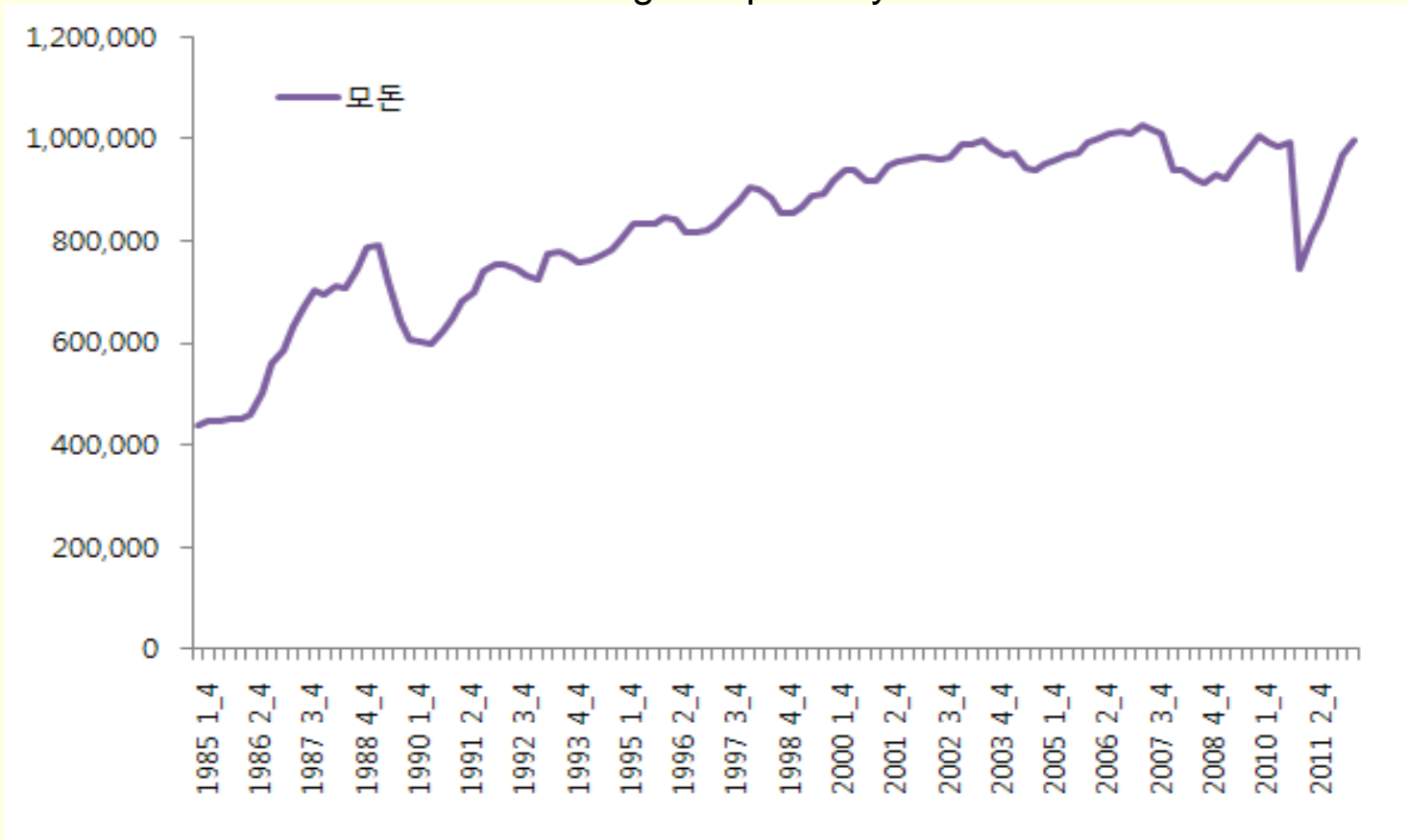
Number of Cows at quarterly basis



2. Demand for FMD vaccine

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Number of Pigs at quarterly basis



2. Demand for FMD vaccine

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Time series estimation of livestock for Projections

ARMA(n, m)- Autoregressive Moving Average Model

$$X_t = \alpha_0 + \sum_{i=1}^n \alpha_i X_{t-i} + \sum_{j=1}^m \beta_j \epsilon_{t-j} + \epsilon_t$$

X_t : number of livestock at time t

ϵ_t : error at time t

2. Demand for FMD vaccine

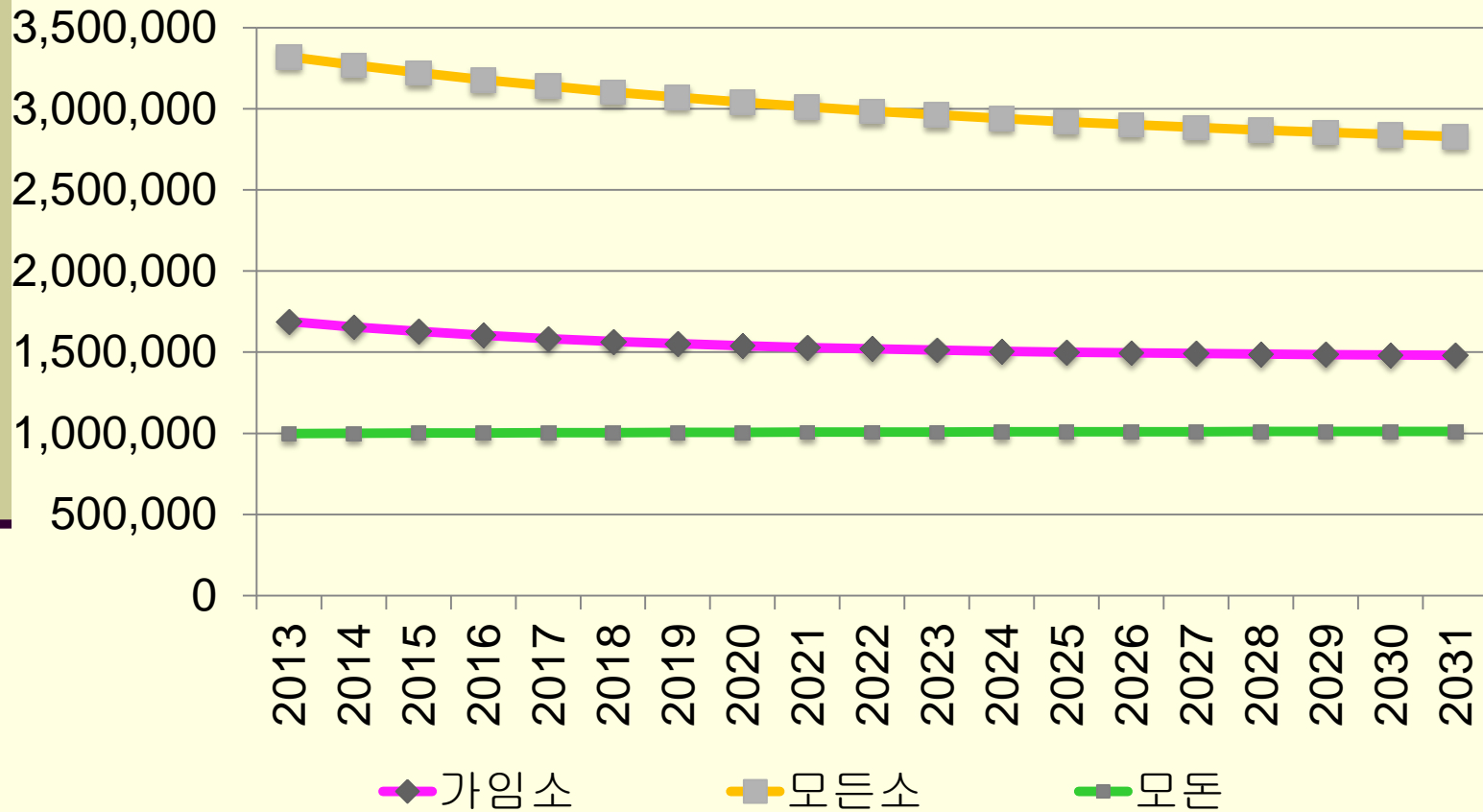
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- Estimations Results for Cow and Pig

	Pregnable cow	Total cow	Pig
Constant	1,469,171***(8.1618)	2,691,827***(4.7166)	1,013,766***(29.2357)
AR(1)	1.4813***(17.7427)	0.9791***(42.1371)	0.9729***(147.21)
AR(2)	-0.5004***(-5.9702)		
MA(1)		0.2552***(3.0973)	
MA(2)		-0.1850**(-2.3232)	
MA(3)			-0.3641***(-4.2650)
MA(4)		0.5596***(7.3937)	-0.3204***(-3.7543)
MA(5)			-0.3153***(-3.7579)
R ²	0.9793	0.9873	0.9574

2. Demand for FMD vaccine

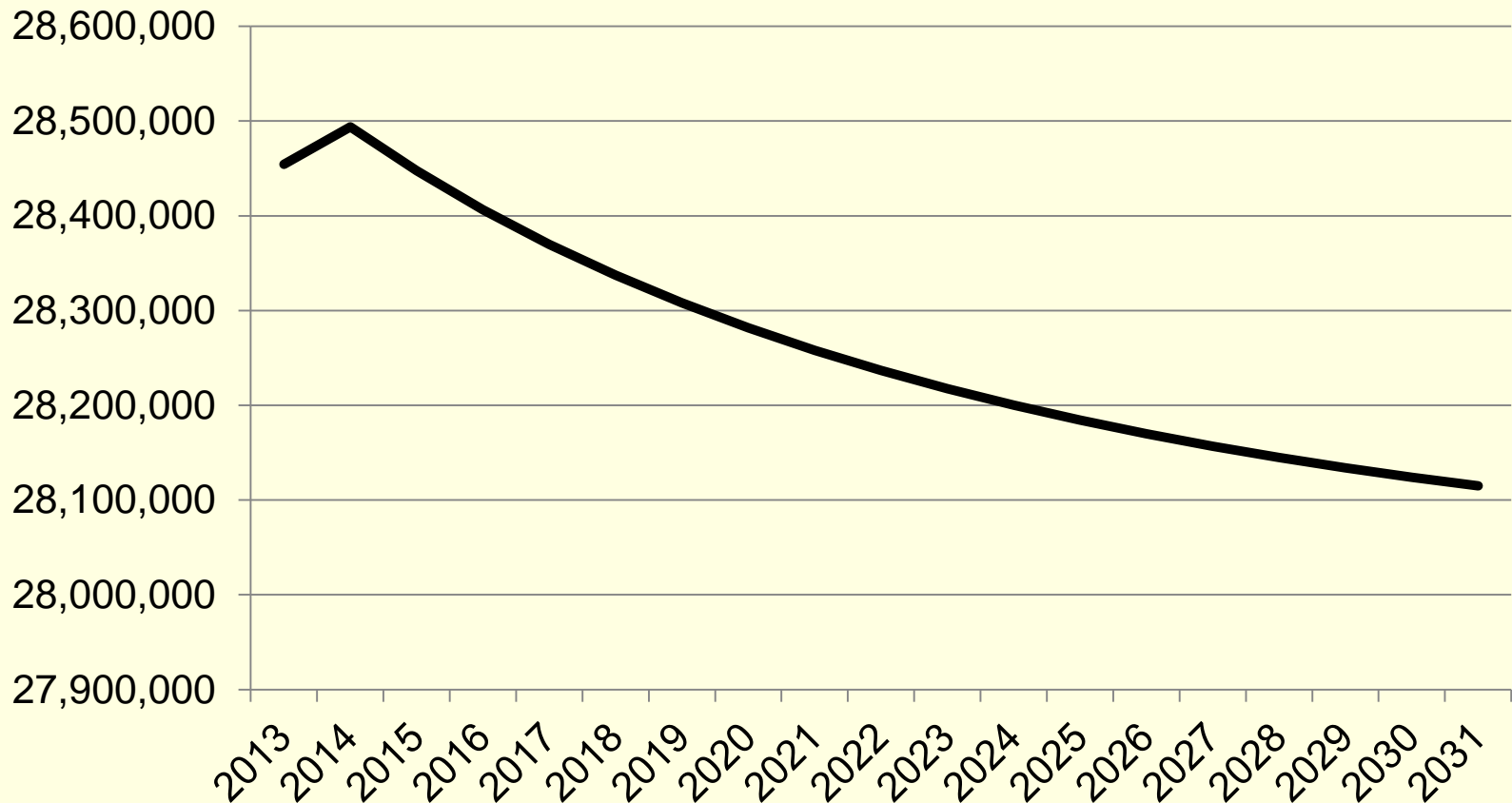
- Projected number of cows



2. Demand for FMD vaccine

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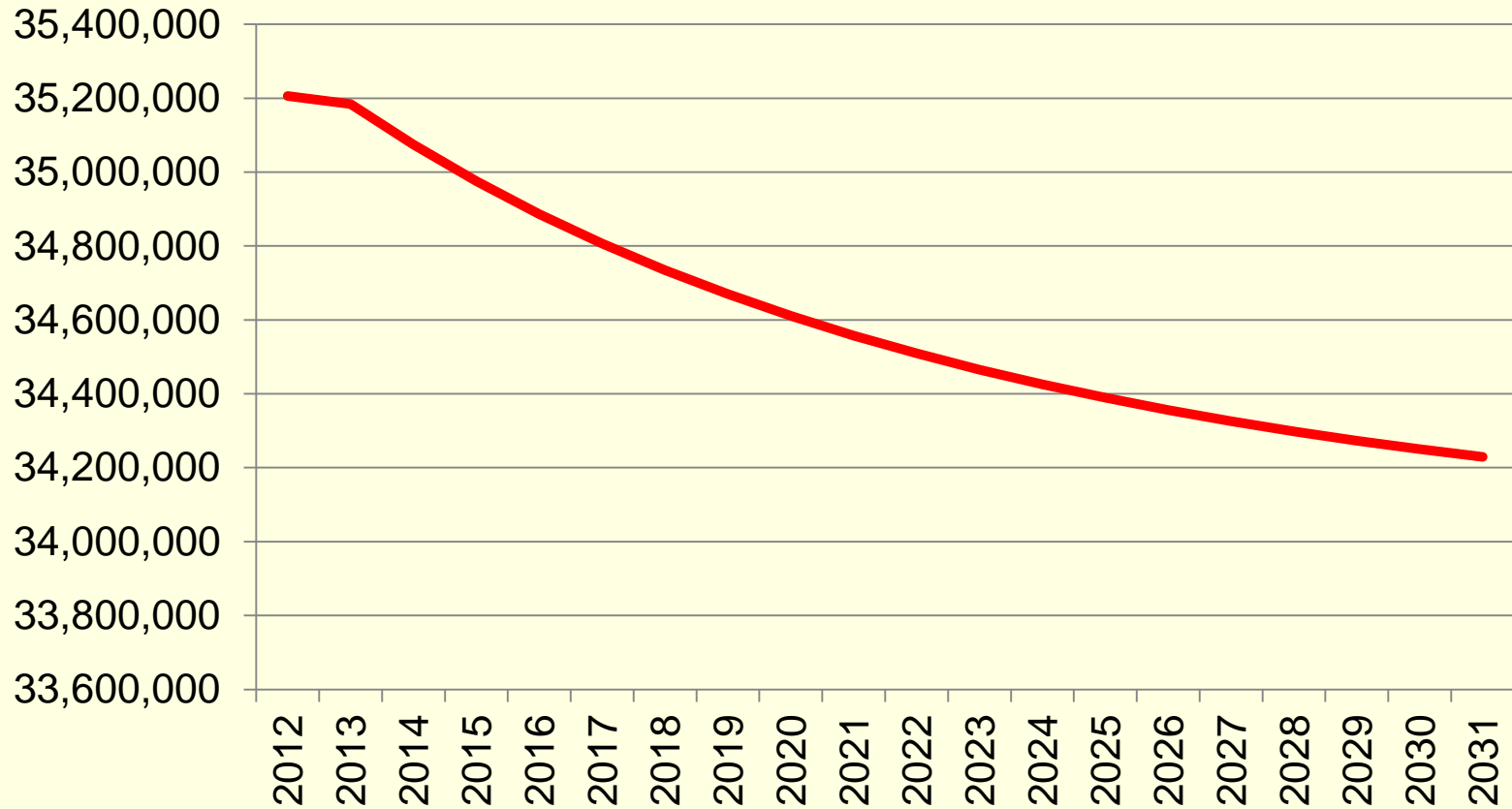
- Aggregation of the projected numbers of cows, pigs, goats and deer



2. Demand for FMD vaccine

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- Total number of livestock that vaccination is required



3. Benefits from FMD vaccine center

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There is import-substitution effect by storing the vaccines (antigen) developed in the vaccine center

If FMD outbreaks, we need vaccinations. In this case, vaccine center obtains the revenue by selling the developed antigen.

Unit: million won

	No vaccination	Vaccination for 1 year	Vaccination for 3 years	Vaccination for 5 years	Vaccination for 7 years	Vaccination for 10 years
Benefits	15,000	32,403	67,105	101,689	136,176	187,762

4. Cost of FMD vaccine center

Assumptions: Wage for personnel in the center = 60mil won / year

Unit: million won

Year	# of working person	R&D cost	construction cost	operation cost	Labor cost	Total cost
2009	5	1,500	0	0	300	1,800
2010	5	1,500	0	0	300	1,800
2011	9	2,000	0	0	540	2,540
2012	9	2,500	0	0	540	3,040
2013	9	2,500	1,100	0	540	4,140
2014	9	2,500	12,500	0	540	15,540
2015	9	2,500	12,500	2,000	540	17,540
2016	20	3,000	0	2,000	1,200	6,200
2017	20	3,000	0	2,000	1,200	6,200
2018	20	3,000	0	2,000	1,200	6,200
2019	20	3,000	0	2,000	1,200	6,200
2020	20	3,000	0	2,000	1,200	6,200
2021	20	3,000	0	2,000	1,200	6,200
2022	20	3,000	0	2,000	1,200	6,200
2023	20	3,000	0	2,000	1,200	6,200
2024	20	3,000	0	2,000	1,200	6,200
2025	20	3,000	0	2,000	1,200	6,200
2026	20	3,000	0	2,000	1,200	6,200
2027	20	3,000	0	2,000	1,200	6,200
2028	20	3,000	0	2,000	1,200	6,200
2029	20	3,000	0	2,000	1,200	6,200
2030	20	3,000	0	2,000	1,200	6,200
2031	20	3,000	0	2,000	1,200	6,200
Total		63,000	26,100	34,000	22,500	145,600

5. B/C analysis

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NPV: net present value

The summation of future net benefits

$$NPV = - \sum_{i=0}^n C_{t-i} (1+R)^i + \sum_{j=1}^m \frac{(B_{t+j} - C_{t+j})}{(1+R)^j}$$

The summation of investment costs at past periods

- C_{t-i} : investment cost and maintenance cost at “t-i” period
- B_{t+j} : benefit at “t+j” period
- R : discount rate (social discount rate : 5.5% is assumed)
- $t-n$: the period when investment started
- m : the maximum future period ($m=15$ is assumed)

5. B/C analysis

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NPV evaluated at 2012

Unit: million won

	No vaccination	Vaccination for 1 year	Vaccination for 3 years	Vaccination for 5 years	Vaccination for 7 years	Vaccination for 10 years
NPV	-89,798	-76,482	-51,970	-30,022	-10,358	15,386

Assumptions

1. The center can sell the FMD antigen to the vaccine-producing company at 25% of vaccine price. (1dose= 500won)
2. The antigen and vaccine productions will begin at 2017

5. B/C analysis

B/C ratio

$$B/C \text{ Ratio} = \frac{\sum_{j=1}^m \frac{B_{t+j}}{(1+R)^j}}{\sum_{i=0}^n \frac{C_{t-i}}{(1+R)^i} + \sum_{j=1}^m \frac{C_{t+j}}{(1+R)^j}}$$

- C_{t-i} : investment cost and maintenance cost at “t-i” period
- B_{t+j} : benefit at “t+j” period
- R : discount rate (social discount rate : 5.5% is assumed)
- $t-n$: the period when investment started
- m : the maximum future period ($m=15$ is assumed)

If $B/C \text{ ratio} > 1 \rightarrow$ Economic feasibility exists

If $B/C \text{ ratio} < 1 \rightarrow$ No economic feasibility

5. B/C analysis

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B/C ratio evaluated at 2012

Unit: million won

	No vaccination	Vaccination for 1 year	Vaccination for 3 years	Vaccination for 5 years	Vaccination for 7 years	Vaccination for 10 years
NPV	0.08	0.22	0.47	0.69	0.89	1.16

Assumptions

1. The center can sell the FMD antigen to the vaccine-producing company at 25% of vaccine price. (1dose= 500won)
2. The antigen and vaccine productions will begin at 2017

5. B/C analysis

International Rate of Return: IRR

→ The discount rate that satisfies following equation

$$NPV = - \sum_{i=0}^n C_{t-i} (1 + R^*)^i + \sum_{j=1}^m \frac{B_{t+j} - C_{t+j}}{(1 + R^*)^j} = 0$$

- C_{t-i} : investment cost and maintenance cost at “t-i” period
- B_{t+j} : benefit at “t+j” period
- R : discount rate (social discount rate : 5.5% is assumed)
- $t-n$: the period when investment started
- m : the maximum future period ($m=15$ is assumed)

If $IRR >$ market discount rate → Economic feasibility exists

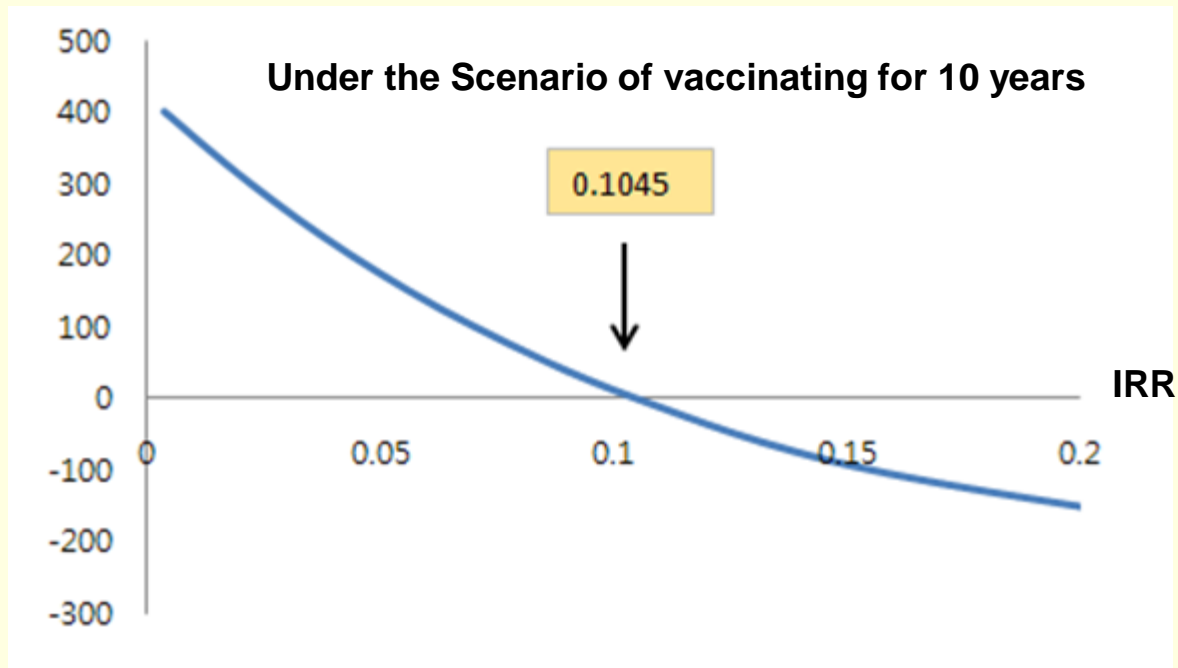
If $IRR <$ market discount rate → No economic feasibility

5. B/C analysis

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IRR evaluated at 2012

NPV (bill. Won)



5. B/C analysis

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Simulated prices of antigen that make NPV is 0

Unit: won

	Vaccination for 1 year	Vaccination for 3 years	Vaccination for 5 years	Vaccination for 7 years	Vaccination for 10 years
Price of antigen	3,372	1,187	751	565	427

5. B/C analysis

Conclusions

- **NPV** is calculated to be -90~15 billion won thus the and **B/C ratio** is derived to be 0.08~1.16.
- To sum up, there exist economic feasibility for establishing the FMD vaccine center only when vaccination is performed for 10 years.