
# Resource use in efficiency in livestock farming, how to measure improvements?

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FAO Workshop: Closing livestock's natural resource use efficiency gap
Rome, April 2nd – 4th 2012

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# Measuring resource use inefficiency

## RATIONAL & OBJECTIVE

- Livestock is using resources in an inefficient way

⇒**potential for improvements**

- Various ways to measure(in)efficiency

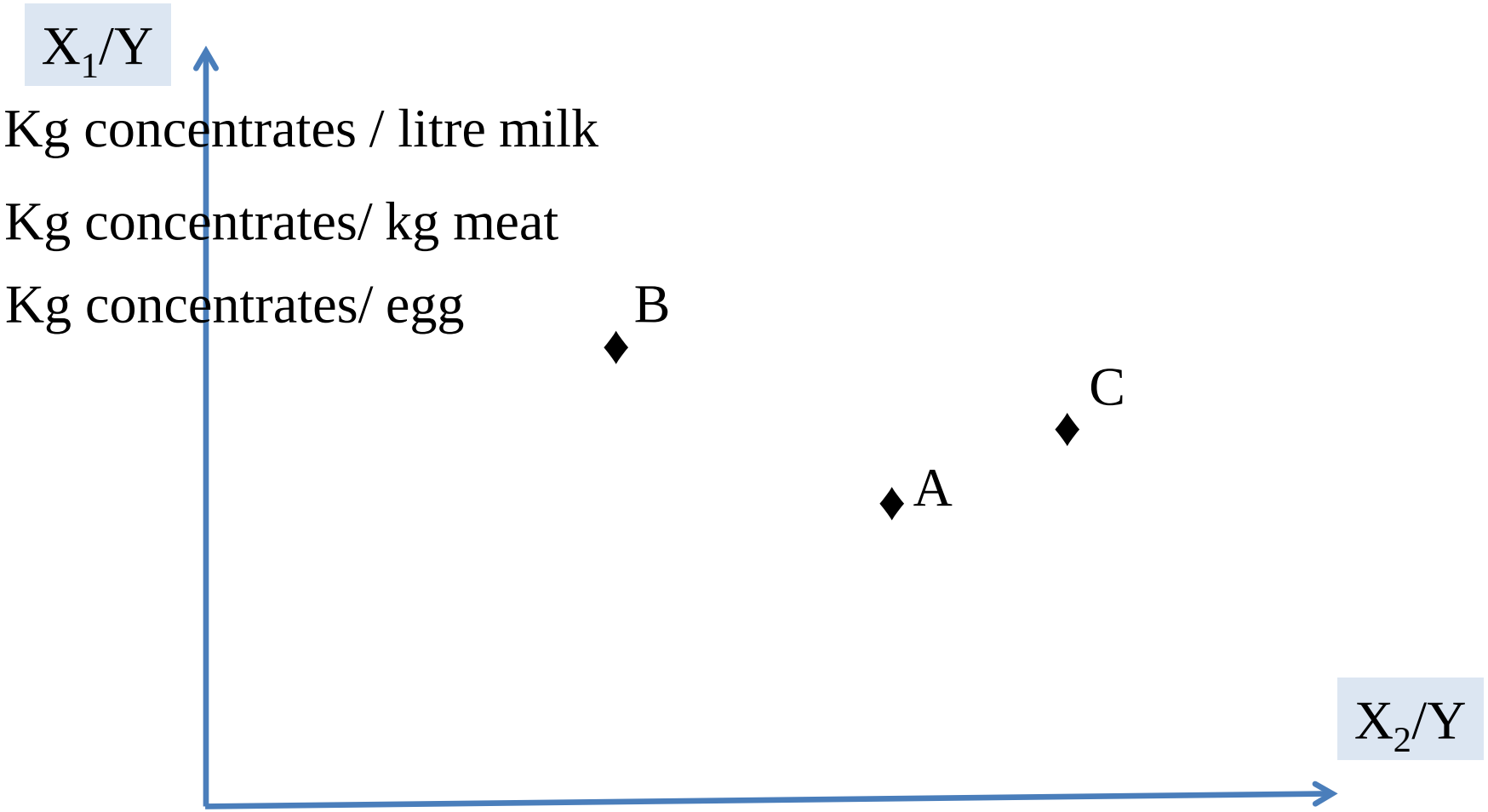
⇒**attention for definition and techniques to allow for the right improvements**

# Measuring resource use inefficiency

## OUTLINE

- The efficiency notion & frontier techniques
- Some essential adjustments, e.g. the materials-balance-based methods
- A glance on ongoing and future research:
  - Diagnosis and advisory
  - Footprints efficiency
  - Sustainable value
  - Integrative frameworks

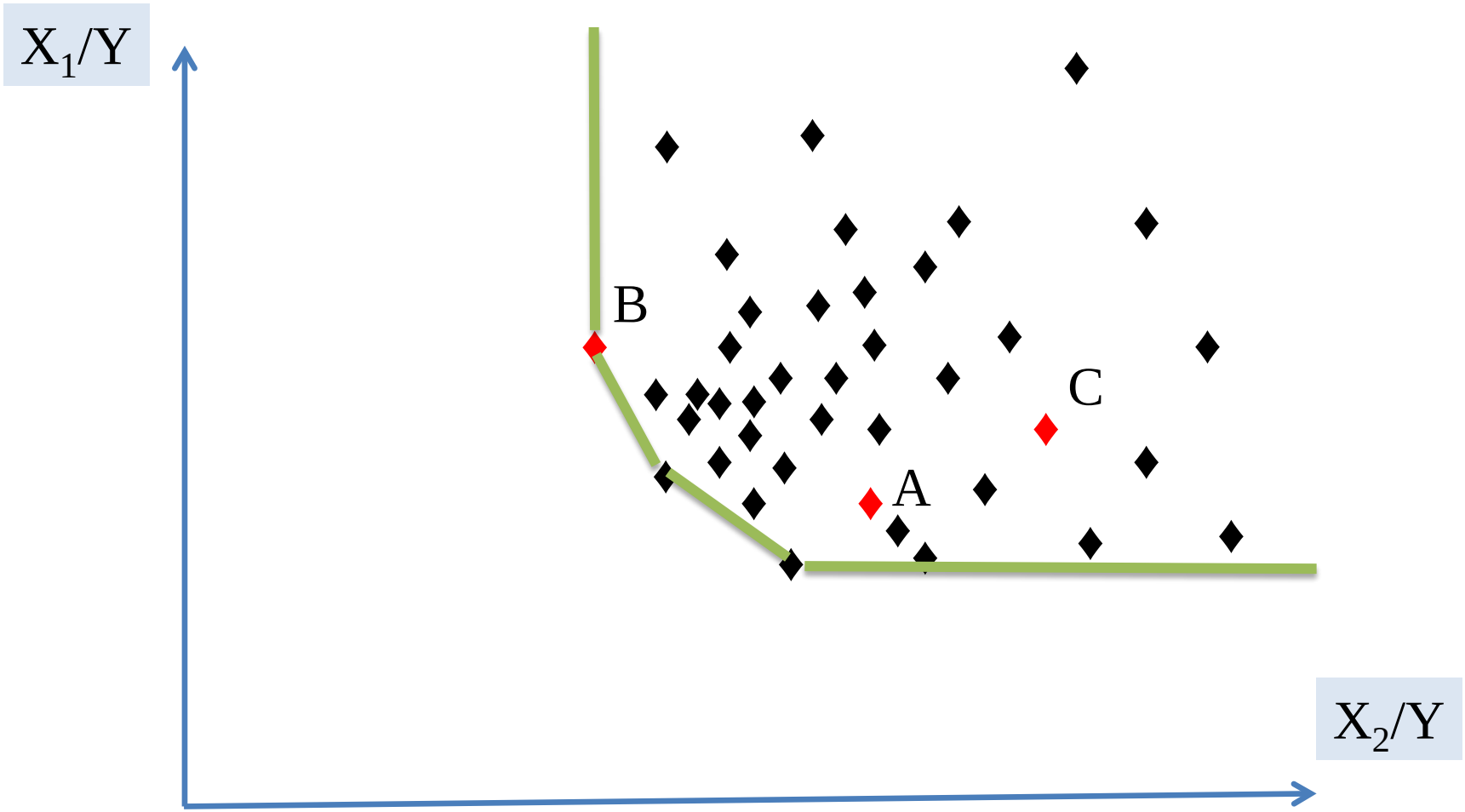
# The efficiency notion




Is B better than A, C, etc ?

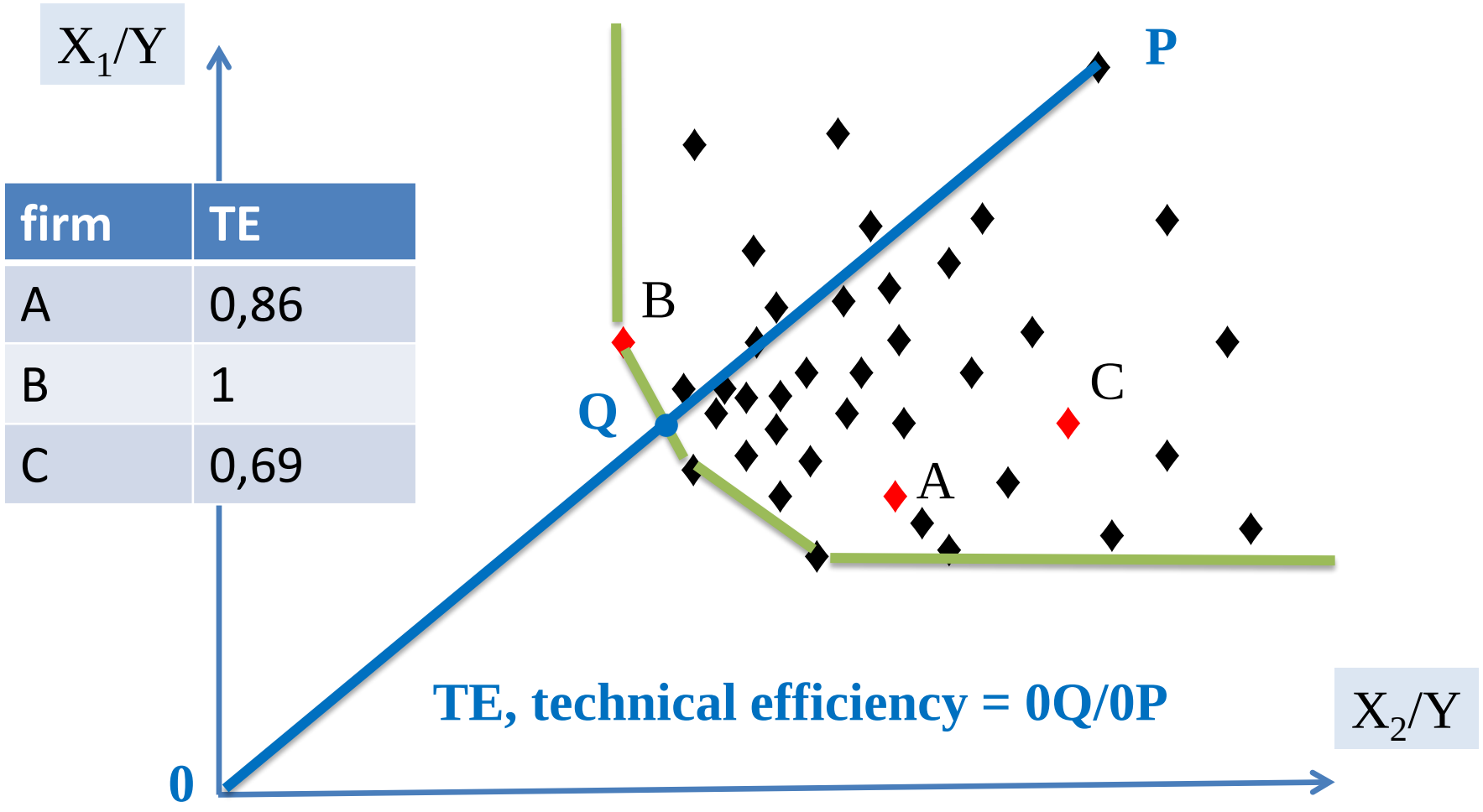
Kg roughage/ litre
Piglets /kg meat
Joules / egg

# The efficiency notion




=>A frontier of efficient points

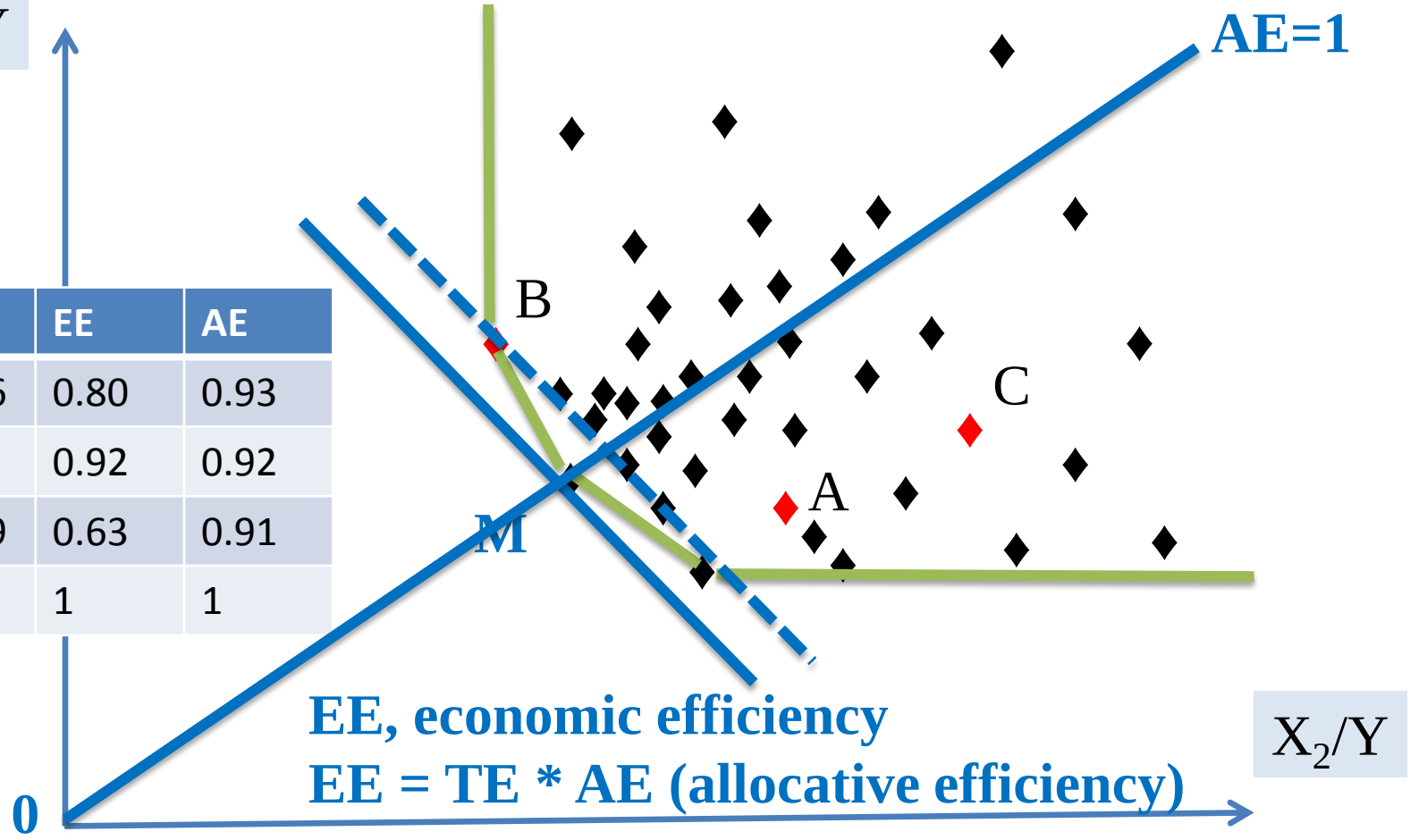
# The efficiency notion




| firm | TE |
|---|---|
| A | 0,86 |
| B | 1 |
| C | 0,69 |

=>the method: DEA, data envelopment analysis

# The efficiency notion




| firm | TE | EE | AE |
|---|---|---|---|
| A | 0.86 | 0.80 | 0.93 |
| B | 1 | 0.92 | 0.92 |
| C | 0.69 | 0.63 | 0.91 |
| M | 1 | 1 | 1 |

=>various DEA models to combine TE and EE

# The efficiency notion

## DEA (AND SFA) LITERATURE

- Dairy:
  - Amara & Romain (1990). Dairy sector Québecμ
  - Balcombe et al. (2006) . Australian dairy farms
  - Bravo-Ureta & Reiger (1991)
  - D'Haese et al. (2009) milk production on Reunion Island
  - Fraser & Cordina (1999). Irrigated dairy farms
  - Hailu et al. (2005). Alberta and Onatario dairy farms
  - Hannson (2007) . Sweden
  - Jaforullah & Whiteman (1999) New –Zealand dairy industry
  - Jong Moo Kim . Korean dairy farms
  - Kumbhakar et al. (1991) US dairy farms
  - Kumbhakar et al (2000). Swedish dairy farms
  - Lapar et al. (2005). Smalholder dairy

# The efficiency notion

## DEA (AND SFA) LITERATURE

- Dairy:
  - Louchichi eta l (2004) Réunion Island
  - Mbaga et al. (2003).Québec dairy farms
  - Piesse et al (1996). Slovene dairying
  - Stokes et al. (2007)
  - Tauer (2001). Small NewYork dairy farms
  - Weersink et al (1990) Ontario dairy farm
- Pigs:
  - Asmild & Hougaard (2006). Danish pig farms
  - Galanopoulos et al (2006). Greek pig farms
  - Oude Lansink & Reinhard (2004); Dutch pig farms
  - Sharma et al. (1997, 1999). Hawaian Swine industry
  - Van Meensel et al. (2010). Pigs, Belgium

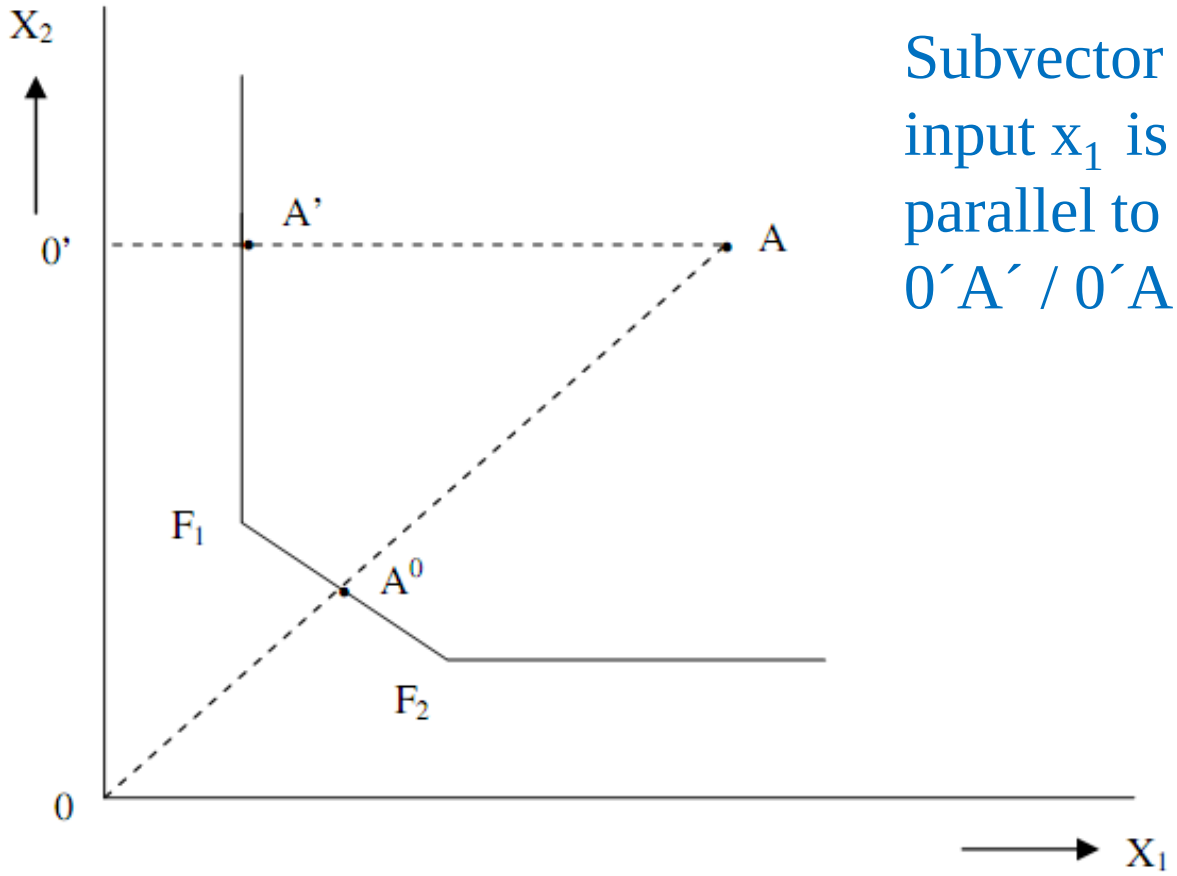
# Resource use & environmental efficiency

## INCORPORATION IN THE FRONTIER FRAMEWORK

- DMU's still related to the multidimensional production frontier
- Specific inputs or outputs from the production process can be considered
- Subvector efficiencies allow for studying the resource use efficiency or environmental impacts
- This approach is interesting for scarce inputs (water, land, energy, …) or undesirable outputs (pollutants)

# Inefficient use of a specific resource

## SUBVECTOR EFFICIENCY




Subvector efficiency for input $x_1$ is determined parallel to the axe for $x_1$ : $0´A´ / 0´A$

# Some examples

## LAND USE EFFICIENCY

- Study on dairy sector on Reunion island (D'Haese et al., 2009)
- Critical factor for increasing the local milk production is the limited availability of arable land because of the small size and the volcanic nature of the island
- Results indicate that subvector efficiencies for land use are lower than overall technical efficiency
- Inefficient  farms are smaller on average and appear to have too many animals per ha, also investing too little to attain high milk production

| item | Efficient farms | Less efficient farms |
|---|---|---|
| Milk prodcution , liter | 233,938 | 132,499 |
| Milk production per cow | 5445 | 4099 |
| Number of cow | 42 | 31 |
| Ha of land | 20.7 | 13.4 |
| Labor, FTE | 2.6 | 2.2 |
| Costs for livestock, euros | 61,751 | 38,766 |
| Operational costs, euros | 18,446 | 12,393 |

Source: D'Haese M., Speelman S., Alary V., Lecomte P., 2009. Efficiency In Milk Production On Reunion Island: Dealing With Land Scarcity. J. Dairy science. 92 (8) 3676-3683

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# Some examples

## Environmental impacts (undesirable outputs)

- Can be incorporated in the model as detrimental inputs
- Study on dairy sector in Netherlands (Reinhard et al., 2000): context: environmental problems caused by agriculture (nitrogen and phosphate surplus and energy
- It is investigated to which extent it is possible to reduce these undesirable outputs (nitrogen/phosphate) and the energy use

# Some examples

## ENVIRONMENTAL IMPACTS (UNDESIRABLE OUTPUTS)

– Can be looked at together (all bads) or separately

Table 6
DEA Technical and environmental efficiency scores

| | | Technical (%) | | Environmental (%) | | | |
|---|---|---|---|---|---|---|---|
| | | Output | Input | All bads | Nitrogen | Phosphate | Energy |
| Overall mean | | 78.37 | 81.10 | 51.95 | 40.82 | 18.98 | 53.30 |
| Lower quartile | | 70.10 | 73.74 | 33.84 | 24.07 | 2.87 | 37.71 |
| Median | | 77.54 | 80.00 | 50.73 | 35.09 | 6.57 | 52.67 |
| Upper quartile | | 86.35 | 88.15 | 65.49 | 50.53 | 19.63 | 64.53 |
| Mean | 1991 | 78.54 | 81.27 | 52.57 | 42.17 | 20.50 | 54.63 |
| | 1992 | 78.21 | 80.91 | 51.85 | 40.54 | 18.67 | 53.05 |
| | 1993 | 77.64 | 80.44 | 50.74 | 39.25 | 17.60 | 51.67 |
| | 1994 | 79.12 | 81.84 | 52.77 | 41.53 | 19.34 | 54.05 |

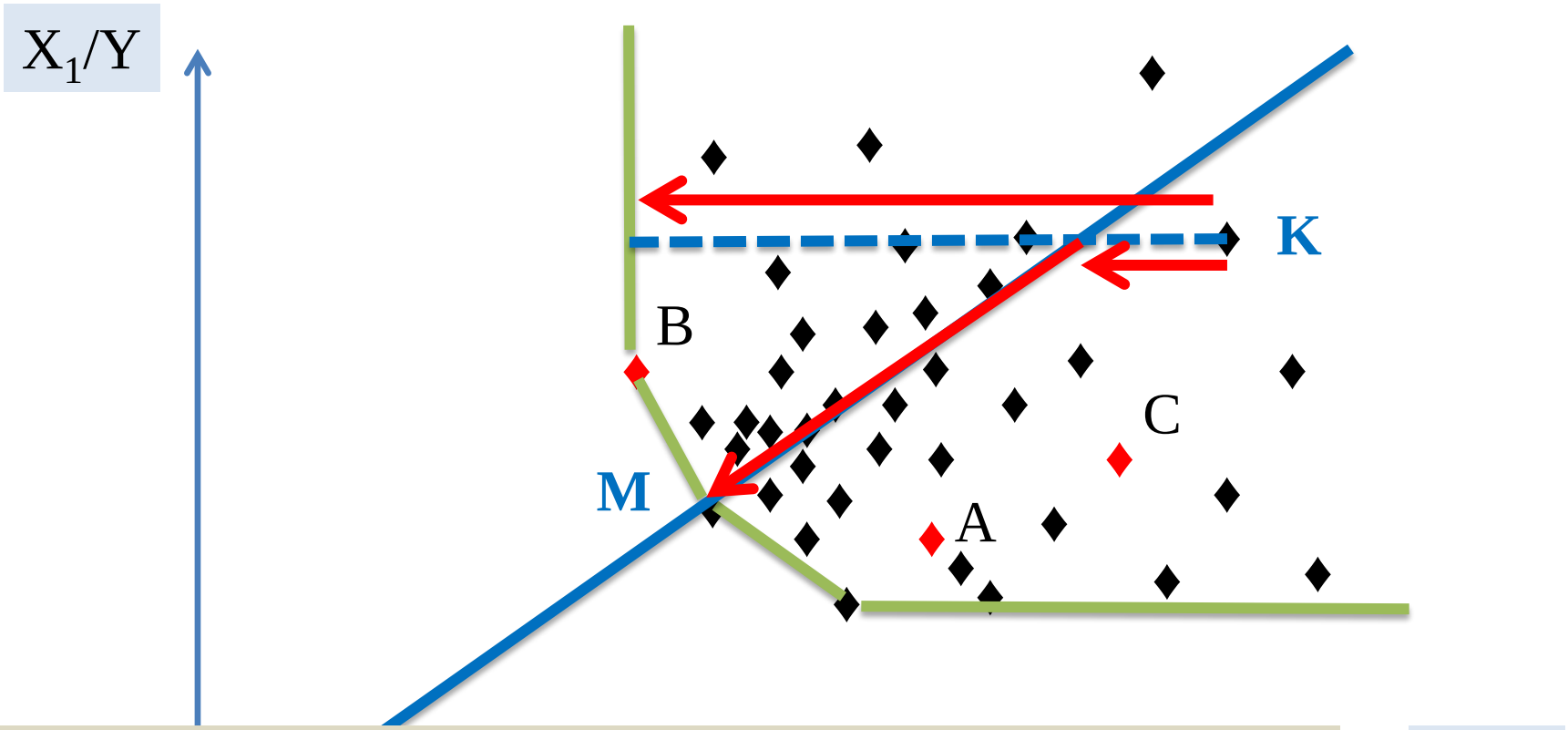
- Source : Reinhard S, Knox Lovell CA, Thijssen G., 2000. Environmental efficiency with multiple environmentally detrimental variables estimated with SFA and DEA. European Journal of Operational Research 121, 287-303

# Resource use and pollution inefficiency

## LITERATURE


- Speelman, S., M. D'Haese, J. Buysse, and L. D'Haese. 2008. A measure for the efficiency of water use and its determinants, study at small scale irrigation schemes in North-West Province, South Africa. Agric. Sys. 98:31–39
- Oude Lansink, A., Silva, E., 2003. CO2 and energy efficiency of different heating technologies in Dutch Glasshouse Industry. Environmental and Resource Economics 24, 395–407.
- Oude Lansink, A., Silva, E., 2004. Non-parametric production analysis of pesticides use in the Netherlands. Journal of Productivity Analysis 21, 49–65.
- Asmild M, Hougaard JL, Kronborg D et al. 2003. Measuring inefficiency via potential improvements. Journal Of Productivity Analysis 19(1) 59-76
- Fernandez C, Koop G, Steel MFJ, 2002. Multiple-output production with undesirable outputs: An application to nitrogen surplus in agriculture. Journal Of The American Statistical Association 97(458) 432-442

# Some fundamental drawbacks



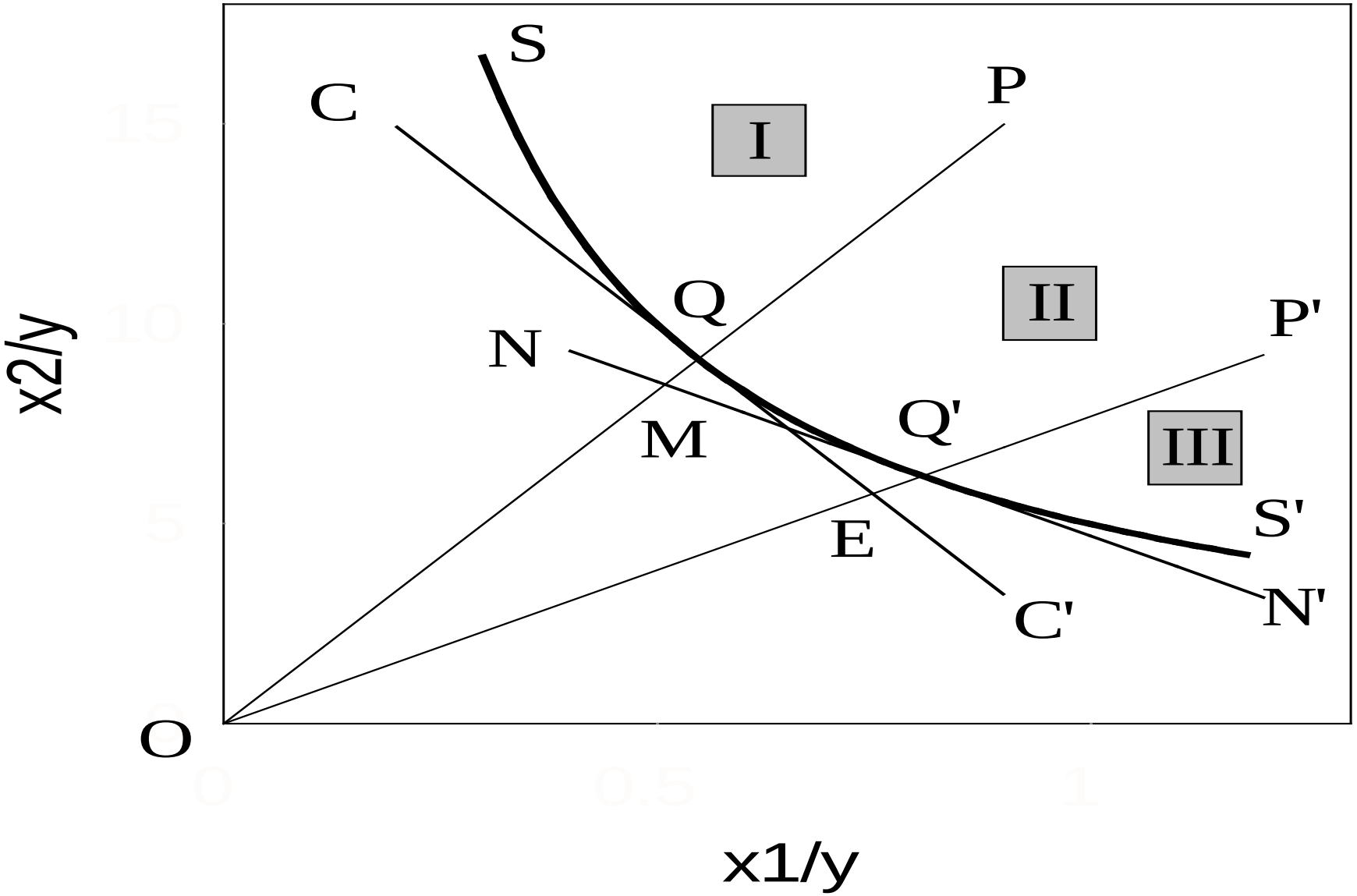

- Relative figures are context specific
- Subvector efficiency in conflict with allocative thinking
- When environmental outcome is function of inputs and outputs, considering it as an input is redundant

# MBB adjustments of the efficiency

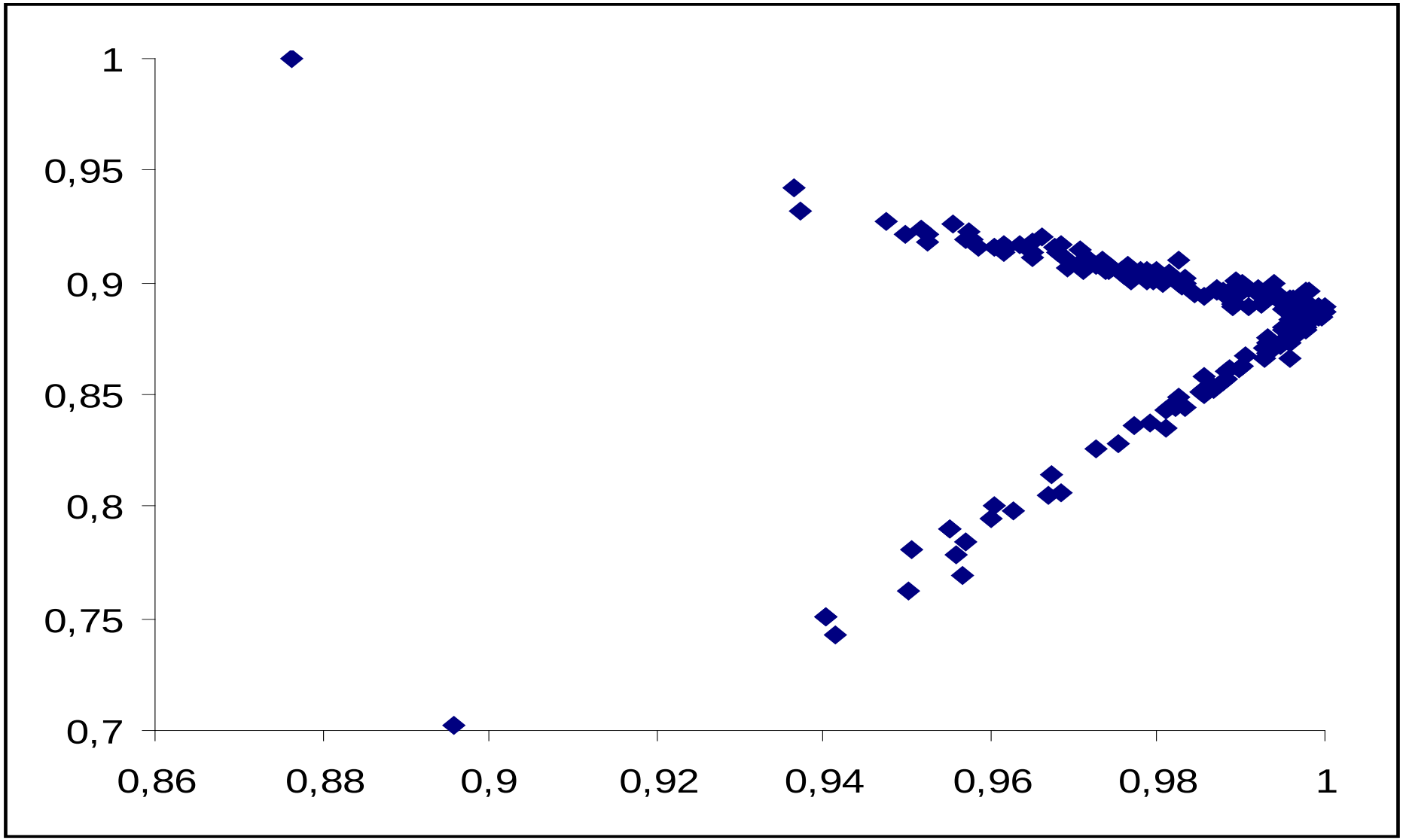
## PRINCIPLES

- MBB, materials-balance-based: what goes in must go out
- Exploits nutrient contents in X and Y similar to price information
- Measures an ecological outcome
- Allows for deriving trade-offs between economic (efficiency) and emission (efficiency)

# Various allocative optima



# Positive and negative trade-offs



# A glance on ongoing research

## DIAGNOSIS AND OPTIMISATION

- *Is low input farming input efficient?*
  SOLID project (EU FP7)
- *Does stocking density influence rabbit performance?*
  (national), IWT
- *Is this improved diagnosis applicable in current advisory?*
  Pigs2win (national, IWT)
- *Helminths infections and efficiency : cause-effects relationship?*
  ECOWORM (national)
- *Helminths infections and efficiency: farm-specific advisory?*
  ECOWORM (national)

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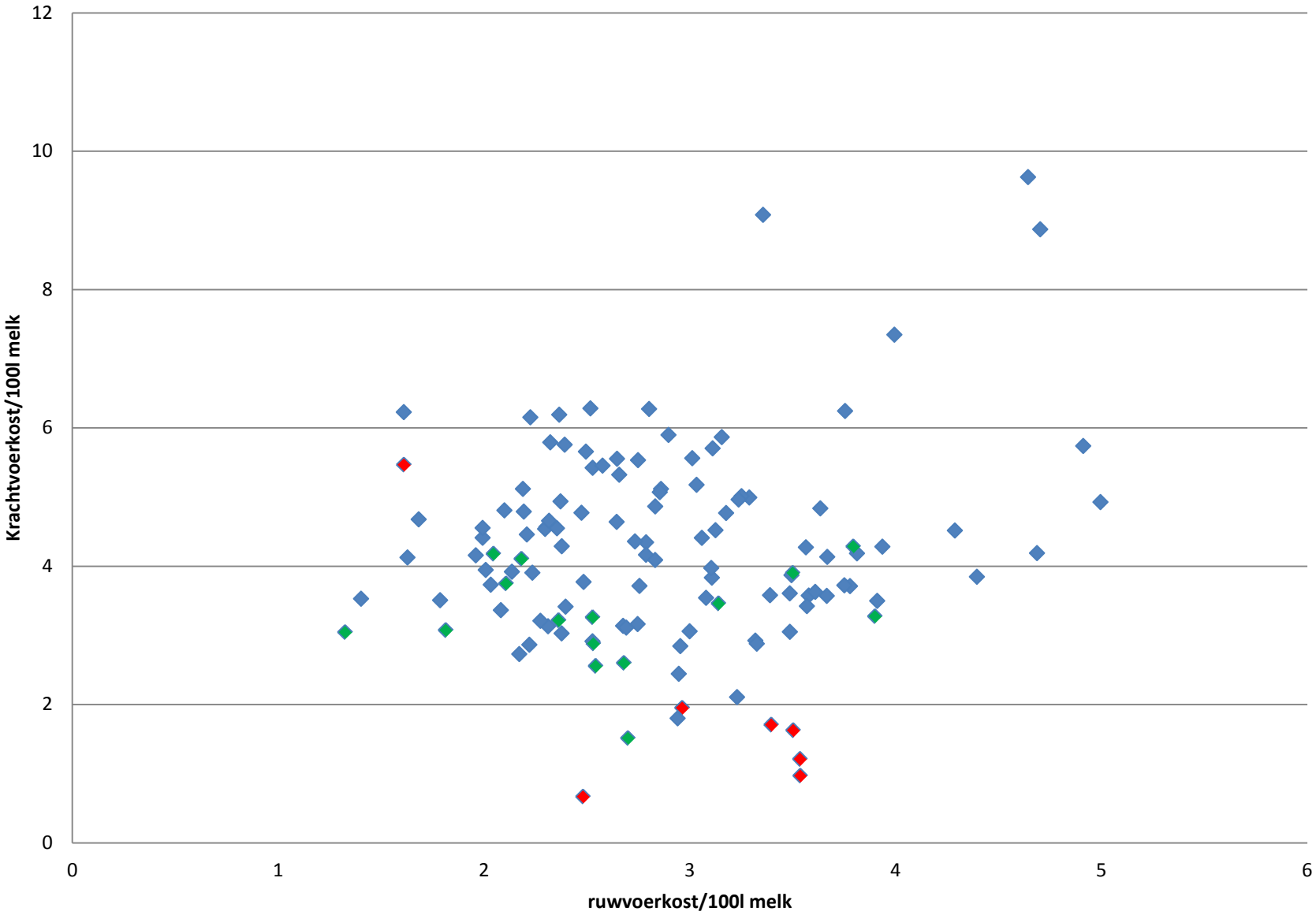
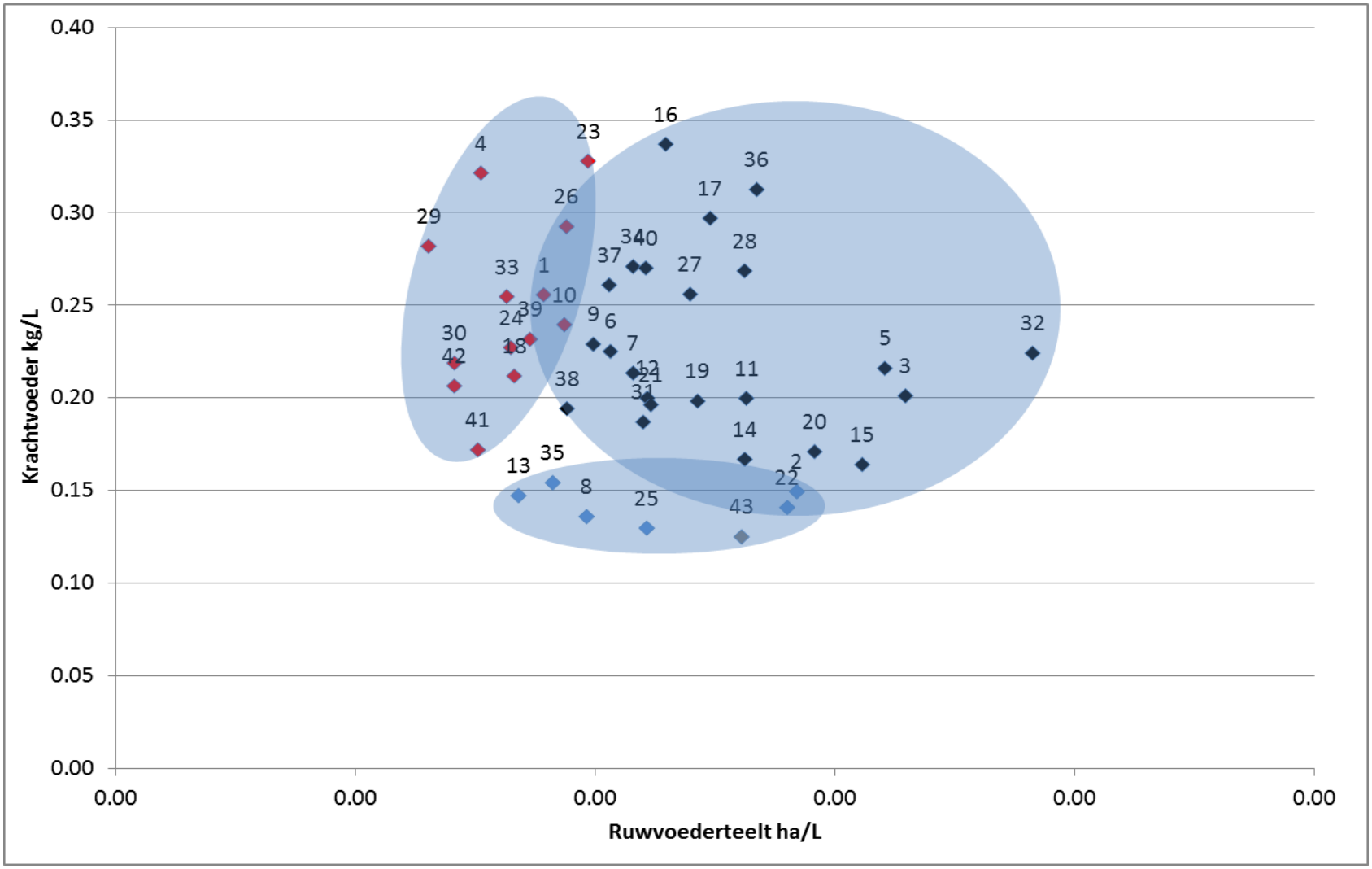
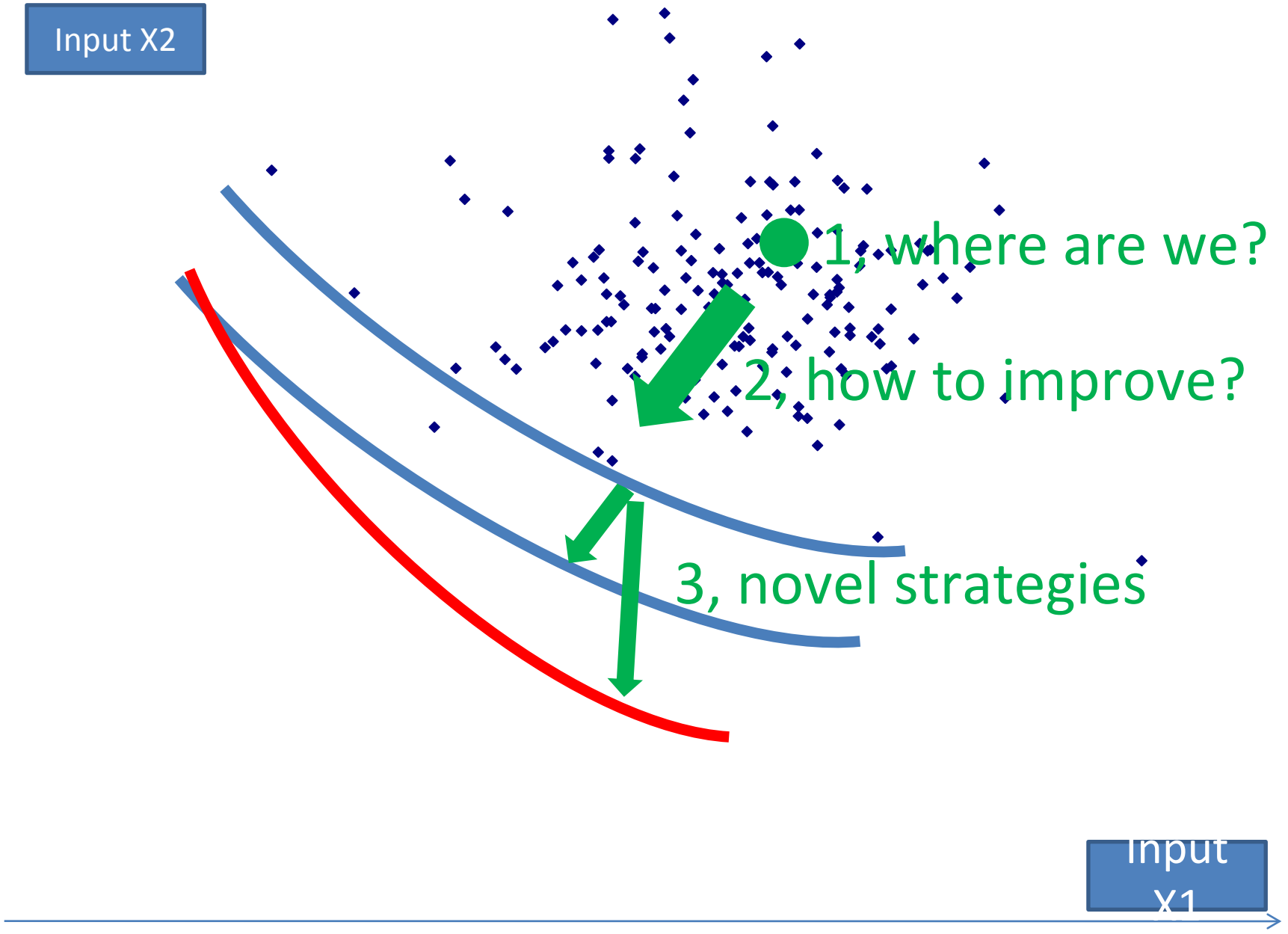
# Low input dairy farming



# Clusters of low-input dairy




Input X2
1, where are we?
2, how to improve?
3, novel strategies
Input X1

# The MBB adjusted method

## LITERATURE

- Method elaboration, with pig production as illustrative case:
  - Coelli et al. (2007) . The DEA method
  - Lauwers (2009); The principles
  - Van Meensel et al. (2010, 2011, 2012). Applications and theory of trade-offs
- Use in agriculture:
  - Graham M. (2009). Environmentally adjusted productivity changes in dairy farming
  - Hoang & Rao (2010) , Hoang (2011). OECD agriculture
  - Hoang & Coelli (2011). Nutrients balance OECD countries
  - Hoang & Alauddin (2012). OECD agriculture (profit, nutrient, exergy)
  - Ramilan et al. (2011). A metric for the New Zealand farming context
- Other use
  - Welch & Barnum (2009). Environmental and cost analysis of electricity production

# A glance on further research

## FOOTPRINTING AND CONSTANT CAPITAL

- Footprinting efficiency
  - Exergy efficiency
  - LCA
- Sustainable value
  - Added value over resource use
  - Capital preservation
    - -> economic capital
    - -> environmental capital
    - -> social capital
- Integrating various efficiency concepts

# Sustainable Value: a simple calculus

| Type of capital form | Capital form | Measurement unit (m.u.) | Example farm | *Average* Productivity (€/m.u.) | | Value contribution (€) | Sustainable value (€) |
|---|---|---|---|---|---|---|---|
| | | | | Farm | Benchmark | | |
| | | | A | B | C | D=(B-C) x A | E=ΣD/7 |
| Environmental | Water | $m^3$ | 1,770.00 | 67.15 | 161.49 | -166,981.80 | |
| | $CO_2$-emission | tonne $CO_2$-eq. | 499.21 | 238.10 | 255.08 | -8,476.59 | |
| | N-excretion | kg/ha | 121.33 | 979.64 | 757.18 | 26,991.07 | |
| | Land | ha | 50.36 | 2,360.21 | 1,923.33 | 22,001.28 | |
| Social | Labour | hours | 5,074.00 | 23.43 | 19.03 | 22,325.60 | |
| Manufactured | Farm capital | € | 21,429.00 | 5.55 | 4.77 | 16,714.62 | |
| | Concentrates | tonne | 290.94 | 408.54 | 479.57 | -20,665.47 | |
| | | | | | | | -15,441.61 |

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# Sustainable Value

## FURTHER READING

– Figge & Hahn, 2004
– Discussion in Ecological Economics, issue 69
– EUROCHOICE, 2011, 10 (2)

Sustainable Value Analysis: Sustainability in a New Light

*Results of the EU SVAPPAS Project*

Analyse de la valeur durable : Le projet SVAPPAS de l'Union européenne éclaire la durabilité sous un jour nouveau

Sustainable-Value-Analyse: Nachhaltigkeit in einem neuen Licht als Ergebnis des SVAPPAS-Projekts der EU

**Koen Mondelaers, Guido Van Huylenbroeck and Ludwig Lauwers**

In agriculture, as in many other industries, sustainability is a recurring issue – but one where agreement on a way forward has been difficult to achieve. According to the influential Brundtland Commission definition of 1987, sustainable production can be defined as production that meets the present needs without compromising the ability of future generations to meet their own needs. A core question for sustainability assessment is then: how to best fulfil these needs with a minimum of resources, or how to create maximum value with the resources used? Either way, it is not easy to quantify or measure sustainability performance. Methods have to be theoretically sound, easy to implement and understandable to stakeholders. Various assessment and monitoring methods have been developed, but few of them are used in practice for policy evaluation and design. The reason for this is that most methods are only burden oriented. This means that they aim at measuring the undesired impact of production, or burden, on the environment but do not look at the value created by the resource base. The Sustainable Value (SV) method, recently developed by Figge and Hahn (2004), starts from a different perspective and tries to assess sustainability performance based on the value that is created by resources used in alternative production processes. The method has already been applied to industry, as illustrated for 65 European manufacturing companies in the ADVANCE project.

The objective of the 2007 FP6 STREP EU-project SVAPPAS (Sustainable Value Analysis of Policy and Performance in the Agricultural Sector) was to test, elaborate and apply this new method in the agricultural context. Another goal of the project was to evaluate the suitability of EU Farm Accountancy Data Network (FADN) data for SV analysis. This project brought Figge and Hahn, the original developers of the SV method, together with a multidisciplinary group of agricultural and ecological economists. This article summarises the main findings of the SVAPPAS project.

"L'agriculture est un domaine auquel la méthode d'analyse de la Valeur Durable s'applique de manière satisfaisante."

**The Sustainable Value approach: from burden to value oriented**

The SV method offers two new perspectives with respect to conventional burden-oriented approaches. First, the method applies a value-oriented approach, which assesses and aggregates resource use

**Potential nitrate leaching to adjacent river streams**

EuroChoices 10(2) • 09



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# Livestock and resource use efficiency

## TAKE-HOME MESSAGE

- Inefficiency can be measured
- Use DEA (or SFA) context-specific
- Relative measures will give an indication of improvement margins but not of absolute resource efficiency
- Need for enlarging towards a system analysis => constant capital stocks of resources

# Livestock and resource use efficiency

## TAKE-HOME REFERENCES FROM AUTHORS


- Coelli, T., Lauwers, L. & Van Huylenbroeck, G. (2007). Environmental efficiency measurement and the materials balance condition. Journal of Productivity Analysis, **28**, 3-12.
- D'Haese M., Speelman S., Alary V., Lecomte P., 2009. Efficiency In Milk Production On Reunion Island: Dealing With Land Scarcity. J. Dairy science. 92 (8) 3676-3683
- Lauwers, L. (2009). Justifying the incorporation of the materials balance principle into frontier-based eco-efficiency models. Ecological Economics, **68**(6), 1605-1614.
- Mondelaers, K., Van Huylenbroeck, G., Lauwers, L. (2011).Sustainable Value Analysis: sustainability in a new light. Eurochoices, **10**(2), 9-15.
- Speelman, S., M. D'Haese, J. Buysse, and L. D'Haese. 2008. A measure for the efficiency of water use and its determinants, study at small scale irrigation schemes in North-West Province, South Africa. Agric. Sys. 98:31–39
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- Van Meensel, J., Kanora, A., Lauwers, L., Jourquin, J., Goossens, L., Van Huylenbroeck, G. (2010). From research to farm: ex ante evaluation of strategic deworming in pig finishing. Veterinarni Medicina, **55**(10), 483–493.
- Van Meensel, J., Lauwers, L. Van Huylenbroeck, G. (2010). Communicative diagnosis of cost-saving options for reducing nitrogen emission from pig finishing. Journal of Environmental Management, **91**(11), 2370-2377.
- Van Passel, S., Van Huylenbroeck, G., Lauwers, L., Mathijs, E. (2009). Sustainable value assessment of farms using frontier efficiency benchmarks. Journal of Environmental Management, **90(10),** 3057-3069.


# Thank you for your attention!
# Questions?