Measuring Food Supply Chain Performance

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Slides prepared for presentation at the International Agricultural Trade Research Consortium's (IATRC's) 2013 Symposium: Productivity and Its Impacts on Global Trade, June 2-4, 2013, Seville, Spain

MEASURING FOOD SUPPLY CHAIN PERFORMANCE

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IATRC Symposium

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MOTIVATION

Food production is projected to increase to meet growing demand of food

Scarcity of natural resources and socio-economic costs derived from externalities of the intensification of agricultural production

Sustainable production of food has become a key concern and hence a requirement for trade

Proliferation of certification schemes (voluntary, regulatory, etc.)

MOTIVATION

Problems:

- Harmonization
- Recognition
- Market-access requirements
- Resources
- Insecurity

Major obstacle for trade of sustainable commodities

Therefore...

Need to develop a single metric of food supply chain performance towards sustainable development based on the Total Factor Productivity approach

WHY A TFP APPROACH?

TFP acknowledges the fact that a food supply chain is first a system of production

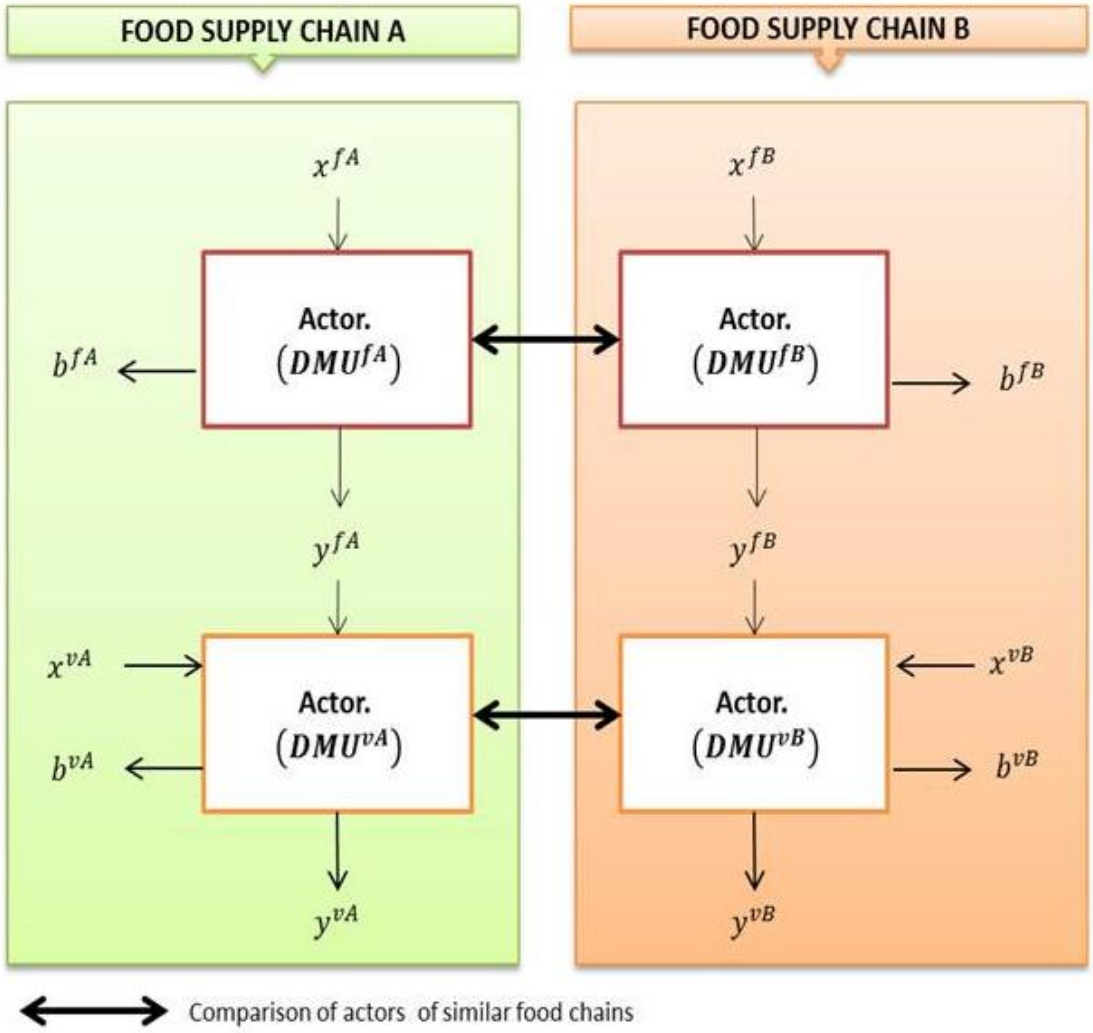
TFP measures are prompt to be adjusted to internalize externalities of agricultural commodity production

FOOD SUPPLY CHAIN SUSTAINABILITY

Actors $(DMUs)$ transforming inputs into outputs

Inputs $x^f\left(x_1^f, x_2^f, \ldots x_n^f\right)$ and outputs $y^f\left(y_1^f, y_2^f, \ldots y_m^f\right)$.

Undesirable outputs $b^f\ \left(b_1^f, b_2^f\ \ldots b_j^f\right)$.



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FOOD SUPPLY CHAIN SUSTAINABILITY

- Efficient
- Maintain the environmental quality
- Provide social rewards and produce a sufficient and accessible food supply

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ADJUSTED TFP INDICATORS

- TFP Indicators

$$TFP^{fA} = Q_0\left(y^{fA}, b^{fA}\right) - Q_i\left(x^{fA}\right)$$

$$TFP^{fAB} = Q_j\left(y^{fA}, y^{fB}, b^{fA}, b^{fB}\right) - Q_i\left(x^{fA}, x^{fB}\right)$$

Adjusted Bennet and Luenberger indicator

ADJUSTED BENNET INDICATOR (1)

- Output quantity indicator minus an input quantity indicator

$$B^{AB} =$$

$$\frac{1}{2}\left(\frac{p^A}{p^A g_y + w^A g_X + r^A g_b} + \frac{p^B}{p^B g_y + w^B g_x + r^B g_b}\right)(y^B - y^A) -$$

$$\frac{1}{2}\left(\frac{r^A}{p^A g_y + w^A g_X + r^A g_b} + \frac{r^B}{p^B g_y + w^B g_x + r^B g_b}\right)(r^B - r^A) -$$

$$\frac{1}{2}\left(\frac{w^A}{p^A g_y + w^A g_X + r^A g_b} + \frac{w^B}{p^B g_y + w^B g_x + r^B g_b}\right)(x^B - x^A)$$

- Where bad outputs b are aggregated using shadow prices r.

Bennet indicator > 0 productivity B higher than A

ADJUSTED BENNET INDICATOR (2)

- Measure of overall welfare.

Relative performance towards sustainability

Hypothetical DMU: Based on international standards, targets, sustainable reference values, scientific literature, etc.

- Adjusted Bennet indicator < 0 room for improvement
- Shadow prices for non-marketed outputs: WTP and WTA

ADJUSTED BENNET INDICATOR (3)

Advantages

- Few observations required
- Easy to construct and compute
- Regional perceptions and values about sustainability aspects are considered

Disadvantages:

- Precise economic calculation is often impossible. Some values cannot be adequately captured by monetary metrics
- Some values are non-fungible and subject to value incommensurabilities.

ADJUSTED LUENBERGER INDICATOR (1)

- Technology P: all feasible vectors (x, y, b) defined as:

$$P(x) = \{(y, b): x\ can\ produce\ (y, b)\}$$

- Two properties:
  1. Weak disposability
  3. Null-jointness

ADJUSTED LUENBERGER INDICATOR (2)

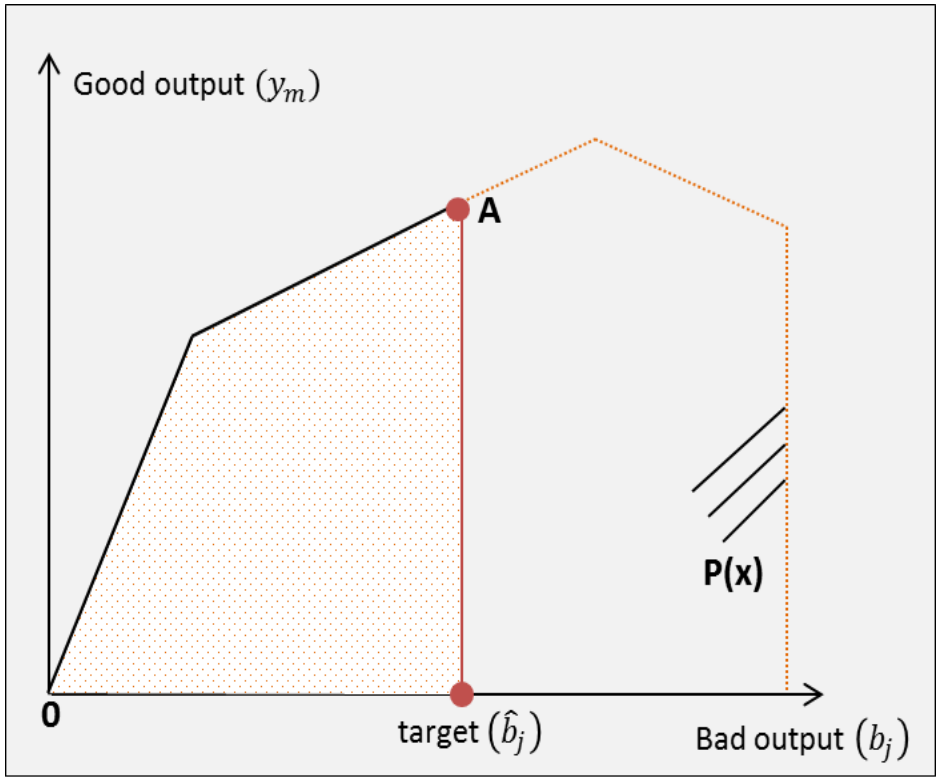
Limits to growth

↓

Imposition of maximum restrictions on bad outputs and inputs

↓

Efficient frontier regarded as an empirical standard of excellence performance towards sustainable development



HOW TO ESTIMATE THE PRODUCTION TECHNOLOGY FRONTIER?

- Once the frontier is established, we can compare a set of $DMUs$, to the frontier. Thus, it can be regarded as a benchmarking tool

- How to evaluate the economic, environmental and social performance of the observed $DMUs$.

PERFORMANCE EVALUATION

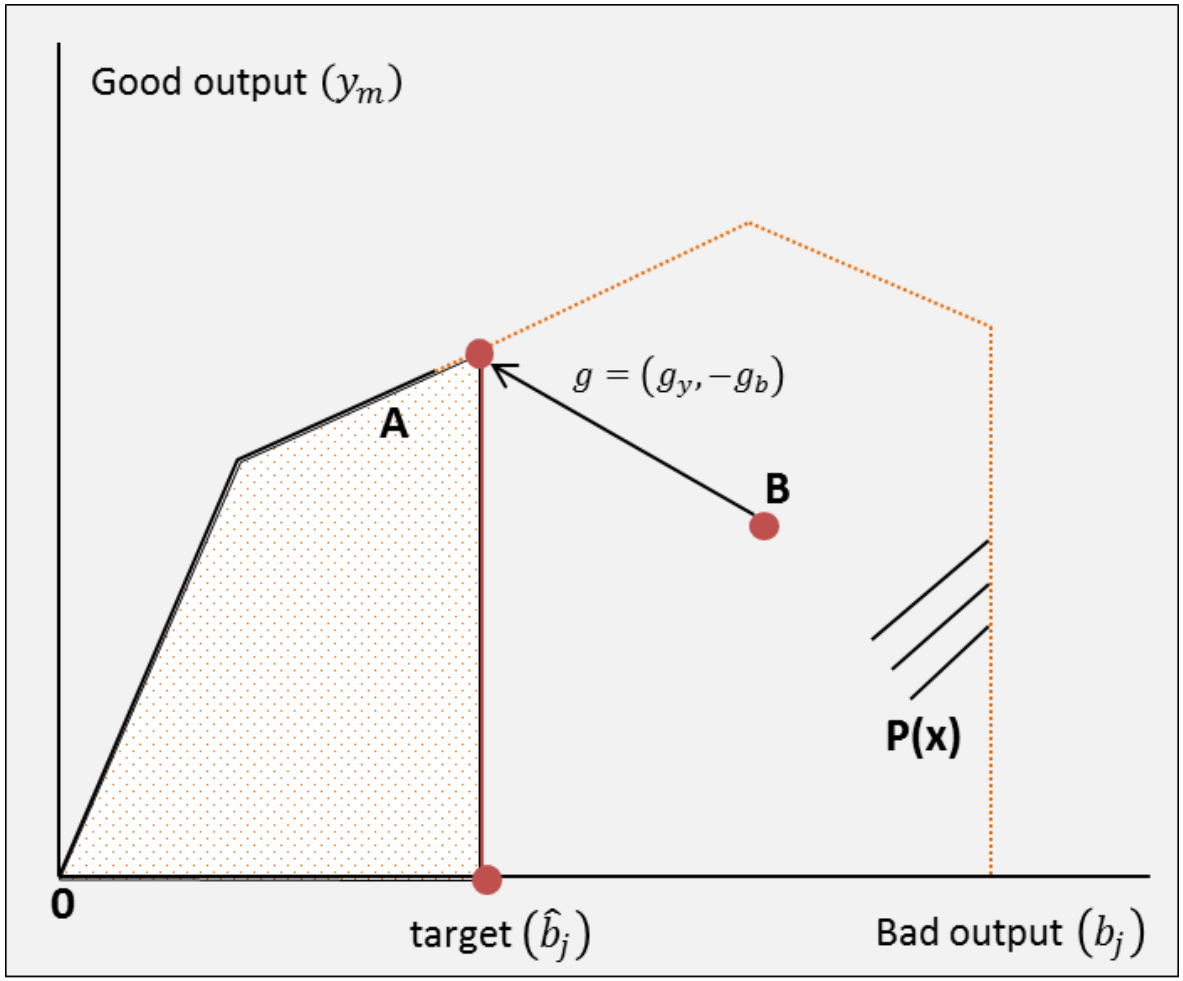
- Directional distance functions

In terms of $P(x)$, the directional output distance function is defined as

$$\vec{D}_0(x, y, b; g_y, g_b) = max\left\{\left(\beta : (y + \beta g_y, b - \beta g_b) \in P(x)\right)\right\}$$

- Directional vector used to include societal preferences with regard to sustainability aspects (Are the economic, social and environmental dimension of sustainability equally important?)

PERFORMANCE EVALUATION



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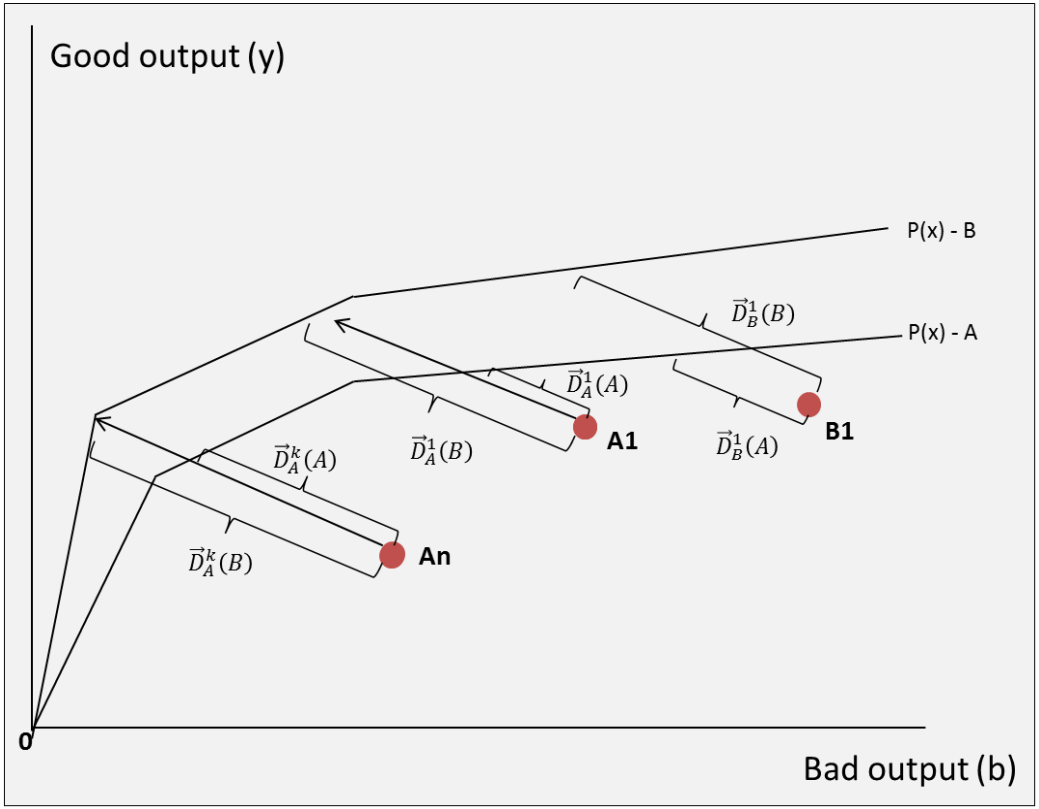
CROSS-COUNTRY PERFORMANCE ESTIMATION

Adjusted Luenberger indicator defined as

$$SL(.) = \frac{1}{2}\left\{\begin{array}{l}\left[D_B\left(x_A, y_A, b_A; g_y, g_b\right) - D_B\left(x_B, y_B, b_B; g_y, g_b\right)\right] + \\ \left[D_A\left(x_A, y_A, b_A; g_y, g_b\right) - D_A\left(x_B, y_B, b_B; g_y, g_b\right)\right]\end{array}\right\}$$



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ADJUSTED LUENBERGER INDICATOR

Advantages

- Does not require information
- Inputs, bad outputs and other social outputs can be changed according to institutional regulations, targets, sustainable use levels or relative importance of each sustainability aspect (directional vector)

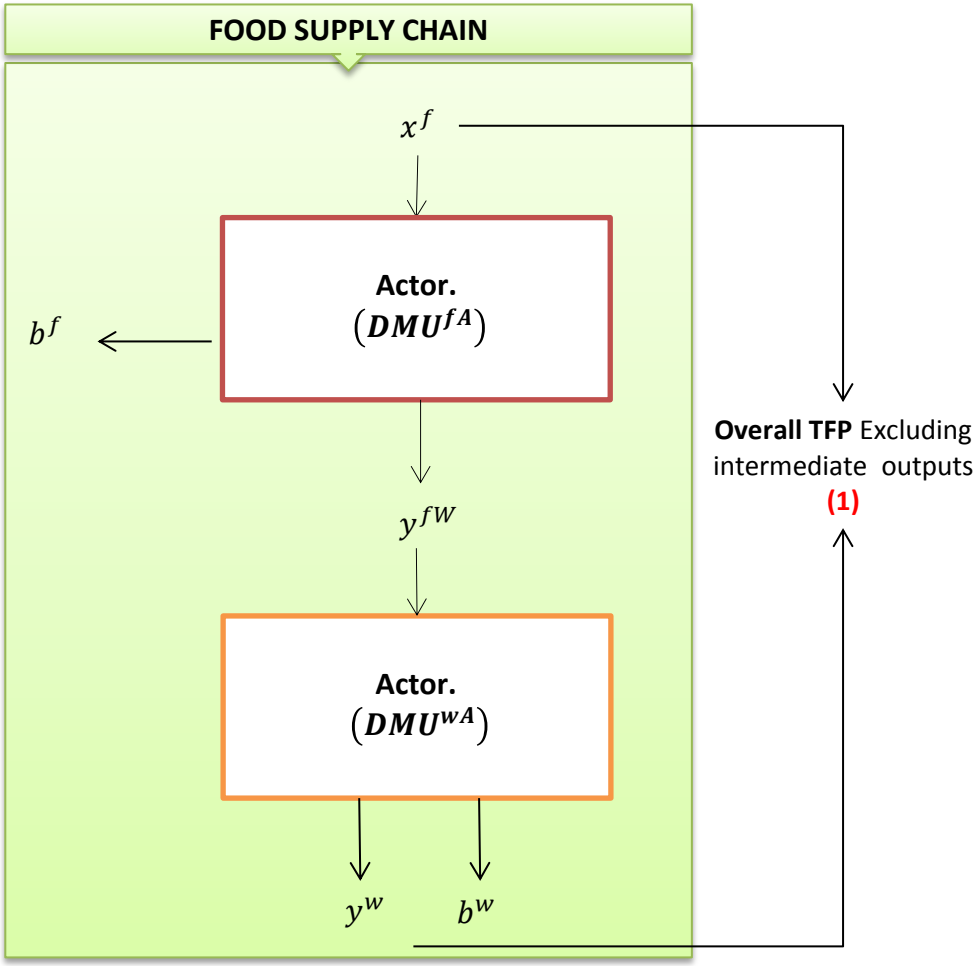
Disadvantages:

- Require extensive data
- Large number of input and output variables will affect the DEA results, implying higher probability of efficient $DMUs$
- The determination of the weights is problematic and has a high degree of subjectivity

OVERALL FOOD SUPPLY CHAIN PERFORMANCE

1) Bad outputs can be added since "bads" are not used as inputs through stages of the chain

Previous approach ignoring intermediate outputs y^f



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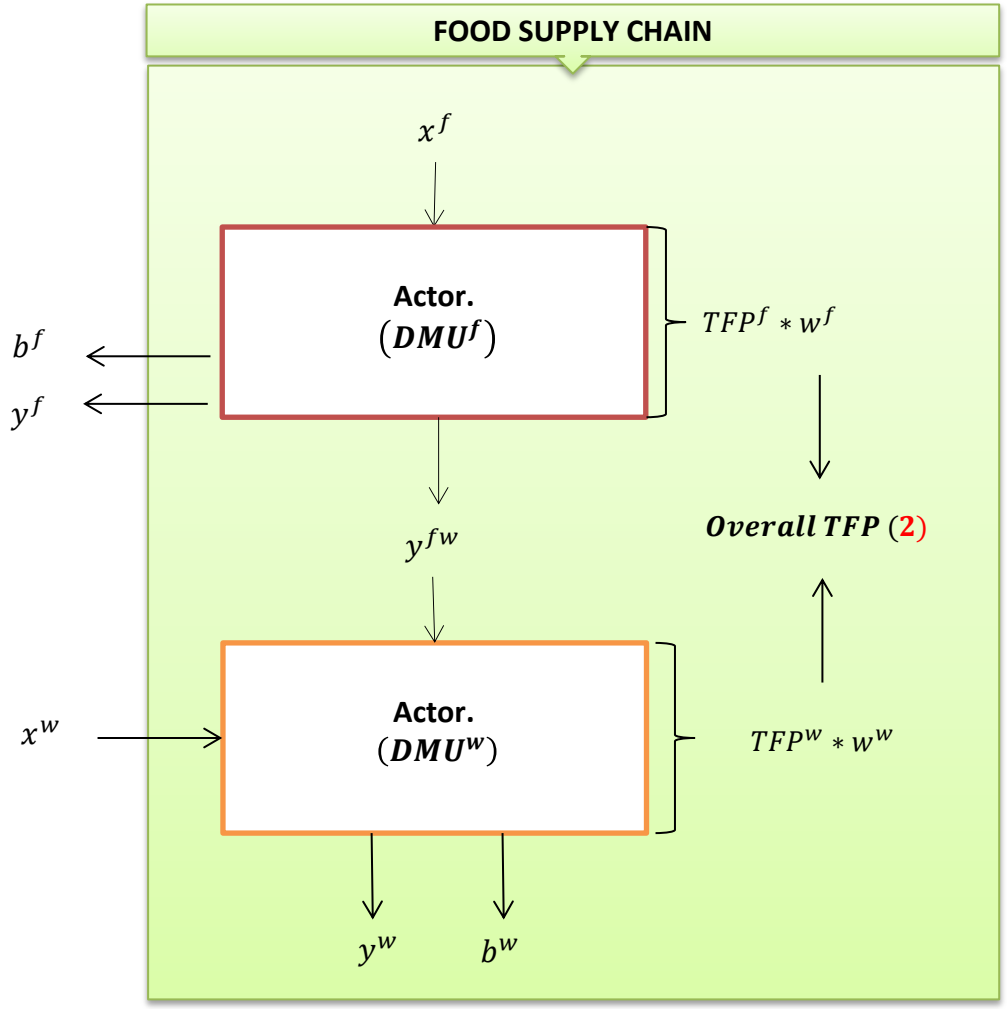
ADJUSTED INDICATORS IN A CHAIN CONTEXT

2) Weighted sum of individual TFP measures where weights (w^f and w^w) represent the relative importance of individual actors to the overall performance.

Proportion of the total input used at each stage of the chain

$w^k = (DMU^k input)$

/(Total input along the chain)



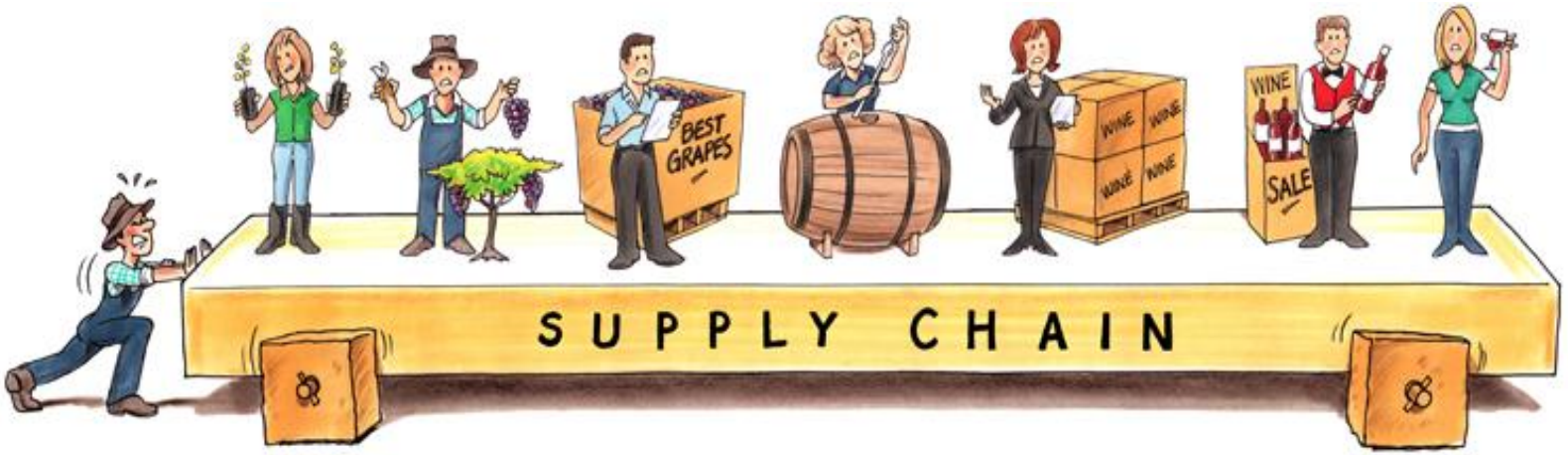
CONCLUSIONS

By providing reliable information about the extent to which commodities are sustainably produced

- Adequate solutions to disputes in the interest of the majority of stakeholders
- Avoiding costs, time and reputation damage
- Will allow imposing trade preferences for sustainable commodities
- Could be the base of Corporate Social Responsibility reporting

Further work...

- Selection of sustainability aspects and indicators
- Application of the adjusted Bennet indicator in conventional, organic and Genetically Modified soy chains in Brazil.
- Application of the adjusted Luenberger indicator in potato chains in the European context
- Comparison of both indicators based on data availability (data poor and data rich situations)



Traditional supply chain - supply push

THANK YOU FOR YOUR ATTENTION

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