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Technical & Efficiency Change in the French Food Industries

Christophe Bontemps, Céline Nauges, Vincent Réquillart, and Michel Simioni

Toulouse School of Economics (INRA-GREMAQ) and (INRA-LERNA)

Efficiency measurement

Toulouse, June 2011

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- ▶ To propose a methodology to identify periods of technical progress (TP) and/or technical regress (TR)
- ▶ Once periods of TP or TR have been identified, to measure and decompose TFP into several interpretable components using panel data.

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 - ▶ -0.1 % in the dairy industry, (17 % of the total turnover of food industries)

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 - ▶ Private standards (retailers)

- ▶ A set of articles on food industry performance: Morrison (AJAE, 1997), Buccola et al. (AJAE, 2000) etc. mainly from the US, Gopinath (CJAE, 2003) and Fischer and Schornberg (Agribusiness, 2007) on a set of countries including France

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- ▶ No comprehensive study of the French food industry

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- ▶ For each period, measure and decompose TFP into several interpretable components

We observe firms inputs and outputs $(X_i, Y_i)_{t=1, \dots, T}$ over the period $t = 1, \dots, T$. We define two sequential empirical production sets to compute efficiency scores of a sample of observations:

- ▶ The **Forward Increasing** Production Set (FIPS):

$$P_t^{FIPS} = \left\{ (X, Y) \mid Y \leq \sum_{\tau=1}^t \sum_{j=1}^n Y_{j\tau} \lambda_{j\tau}, X \geq \sum_{\tau=1}^t \sum_{j=1}^n X_{j\tau} \lambda_{j\tau}, \text{ all } \lambda_{j\tau} \geq 0 \right\}.$$

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FIPS are used to detect periods with technical progress,
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BIPS are used to detect period with technical regress.

Stage 1: FIPS and BIPS

- ▶ We simulate technical regress on 100 observations over 3 periods.

$$y_t = x_t^{0.5} \times \exp\{-0.25 \times (t - 1)\} / (1 + u_t) \quad (1)$$

with $x_t \sim U[0, 1]$ and $u_t \sim \mathcal{N}^+(0.2, 0.25)$.

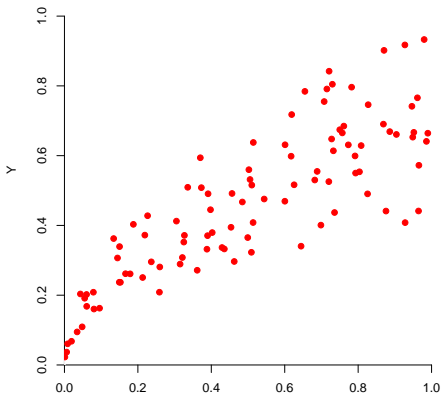
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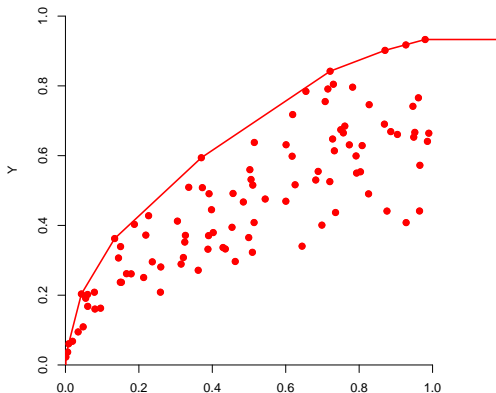
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- ▶ We estimate output-oriented efficiency using DEA (VRS).

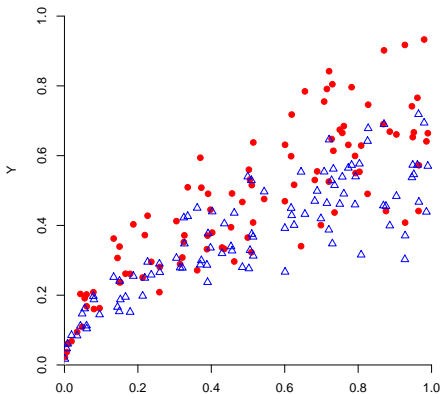
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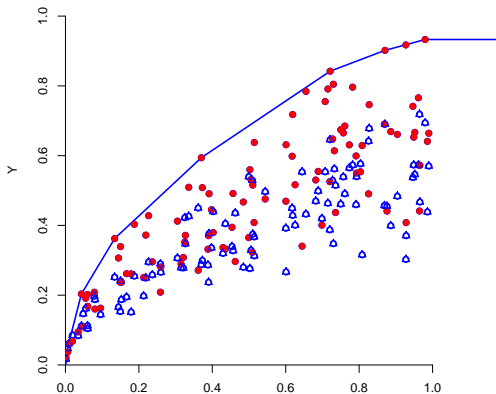
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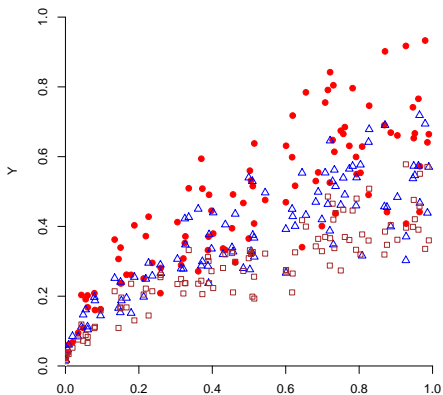
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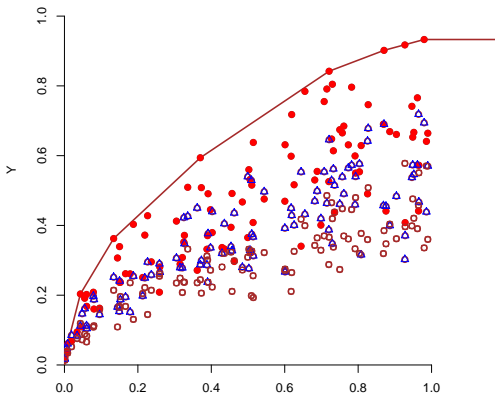
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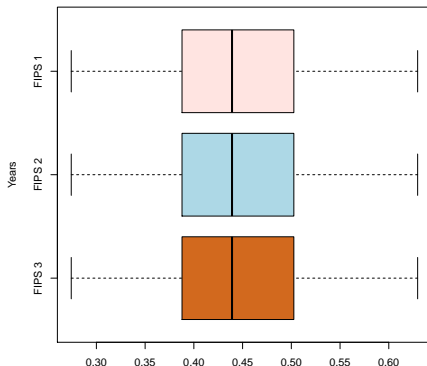
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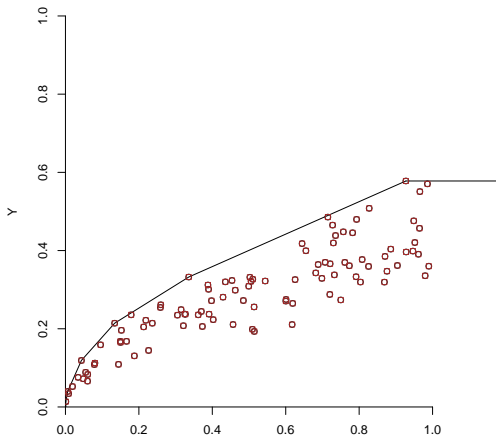
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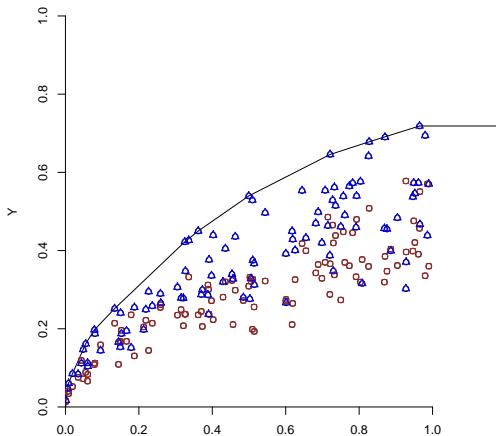
The distribution of efficiency for a sample of observations using the productions sets P_t^{FIPS} , $t = 1, 2, 3$. Here we use firms in 2006, but any sample taken as reference would lead to the same result.



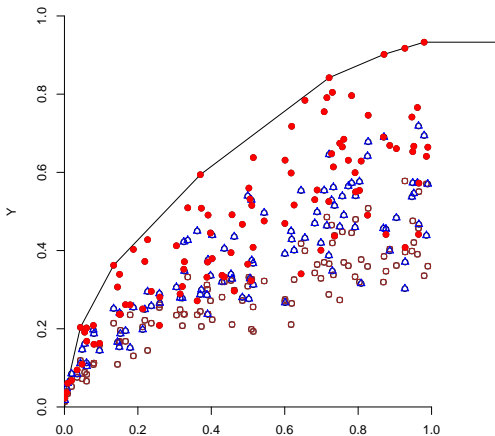
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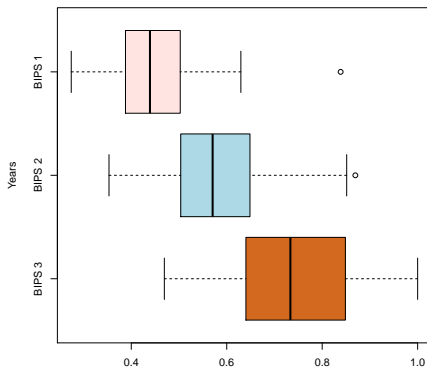
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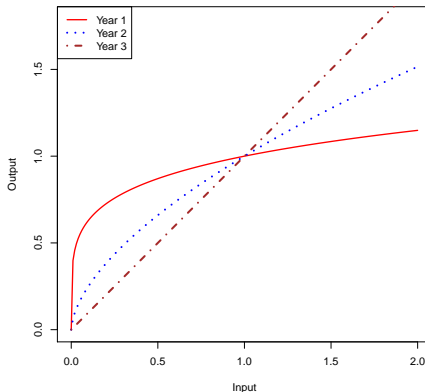
The distribution of efficiency of firms for the productions sets

$$P_t^{BIPS}, t = 1, 2, 3$$



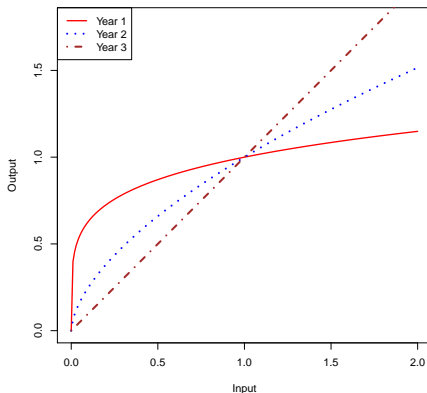
What happens if we simulate simultaneously

- ▶ technical progress (for large firms)



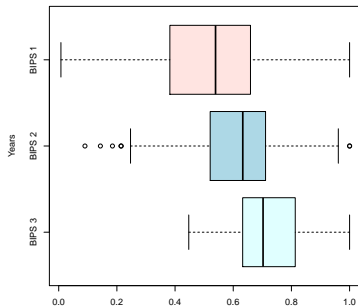
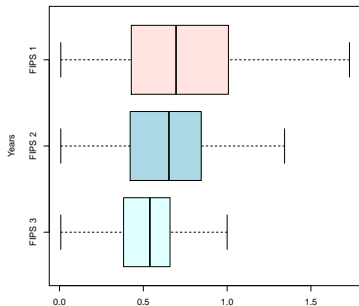
What happens if we simulate simultaneously

- ▶ technical progress (for large firms)
- ▶ technical regress (for small firms)



Stage 1: FIPS and BIPS

We get the following efficiency for FIPS and BIPS:



Stage 2: Decomposition of productivity change

For each subperiod $[t_1, t_2]$, we compute the Malmquist Index (MI) on a balanced panel using $(X_i, Y_i)_{t=t_1; t_2}$. We decompose MI into different elements following Simar and Wilson (1999).

$$\begin{aligned}
 MI &= \text{Pure efficiency change} \times \text{Change in the scale efficiency} \\
 &\times \text{Pure change in technology} \\
 &\times \text{Change in the scale of the technology}
 \end{aligned}$$

$$\begin{aligned}
 MI &= \left(\frac{D_{t_2}^{VRS}(x_{t_2}, y_{t_2})}{D_{t_1}^{VRS}(x_{t_1}, y_{t_1})} \right) \times \left(\frac{D_{t_2}^{CRS}(x_{t_2}, y_{t_2}) / D_{t_2}^{VRS}(x_{t_2}, y_{t_2})}{D_{t_1}^{CRS}(x_{t_1}, y_{t_1}) / D_{t_1}^{VRS}(x_{t_1}, y_{t_1})} \right) \\
 &\times \left(\frac{D_{t_2}^{VRS}(x_{t_2}, y_{t_2})}{D_{t_2}^{VRS}(x_{t_2}, y_{t_2})} \times \frac{D_{t_1}^{VRS}(x_{t_1}, y_{t_1})}{D_{t_2}^{VRS}(x_{t_1}, y_{t_1})} \right)^{0.5} \\
 &\times \left(\frac{D_{t_1}^{CRS}(x_{t_2}, y_{t_2}) / D_{t_1}^{VRS}(x_{t_2}, y_{t_2})}{D_{t_2}^{CRS}(x_{t_2}, y_{t_2}) / D_{t_2}^{VRS}(x_{t_2}, y_{t_2})} \times \frac{D_{t_1}^{CRS}(x_{t_1}, y_{t_1}) / D_{t_1}^{VRS}(x_{t_1}, y_{t_1})}{D_{t_2}^{CRS}(x_{t_1}, y_{t_1}) / D_{t_2}^{VRS}(x_{t_1}, y_{t_1})} \right)
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- ▶ Firms are classified with respect to their main production, using a four digit classification level → 41 sectors.

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- ▶ Implemented using R-packages Benchmarking (Bogetoft & Otto 2010) and NP (Hayfield and Racine, 2008).

Poultry Industry in 2006 (5% of food industry sales)

Variable	Mean	Std dev	Min	1st quart.	3rd quart.	Max	N
Y	33,854	66,402	1,190	5,660	33,710	486,890	151
Y/K	8.3	31.3	0.4	1.9	5.1	342.0	151
Y/L	239.8	436.4	41.0	118.2	201.8	4,585.6	151
Y/M	1.4	0.4	1.0	1.2	1.4	2.9	151

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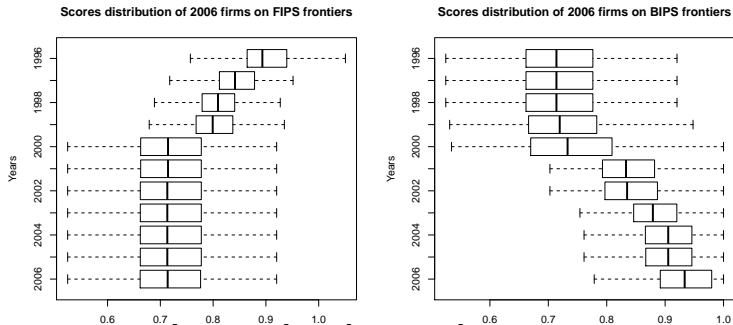
- ▶ 1960 observations, 282 different firms, 118 outliers
- ▶ Lower dispersion of Y/M compared to Y/K and Y/L (Y/M is strongly constrained by the technology)

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Y/L	239.8	436.4	41.0	118.2	201.8	4,585.6	151
Y/M	1.4	0.4	1.0	1.2	1.4	2.9	151

- ▶ 1960 observations, 282 different firms, 118 outliers
- ▶ Lower dispersion of Y/M compared to Y/K and Y/L (Y/M is strongly constrained by the technology)
- ▶ Technical efficiency in 2006 (contemporaneous frontier): 0.93 (0.06)

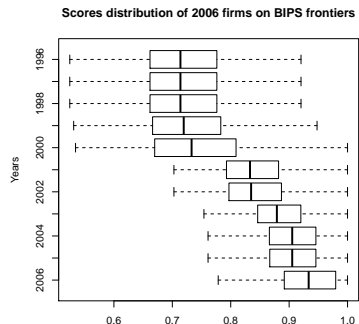
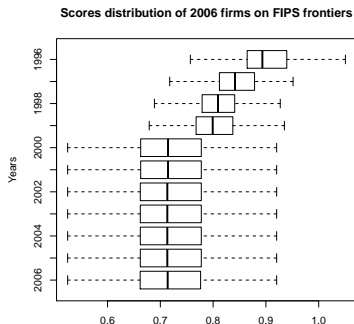
Distribution of DEA-based efficiency scores - Scores of firms in 2006 on FIPS and BIPS frontiers



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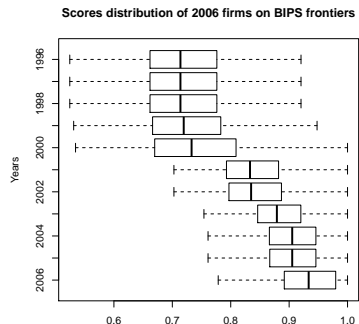
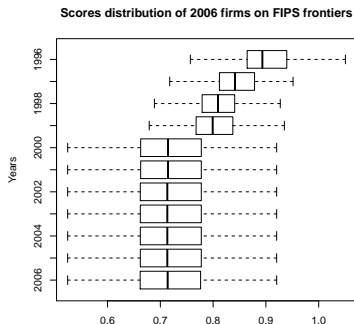
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Nonparametric test for equality of distributions (Li, 1996)

FIPS frontiers

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1996	.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	.	.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	.	.	.	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	1.00	0.98	0.98	0.98	0.97	0.85
2001	0.98	0.98	0.98	0.97	0.85
2002	1.00	1.00	1.00	0.91
2003	1.00	1.00	0.91
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Nonparametric test for equality of distributions

BIPS frontiers

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1996	.	1.00	1.00	1.00	0.56	0.00	0.00	0.00	0.00	0.00	0.00
1997	.	.	1.00	1.00	0.56	0.00	0.00	0.00	0.00	0.00	0.00
1998	.	.	.	1.00	0.56	0.00	0.00	0.00	0.00	0.00	0.00
1999	0.66	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.96	0.00	0.00	0.00	0.00
2002	0.00	0.00	0.00	0.00
2003	0.00	0.00	0.00
2004	1.00	0.00
2005	0.00

Stage 2: Malmquist decomposition on the two identified sub-period [1996-2000] and [2000-2006]

t_1	t_2	MI	Δ Pure Eff.	Δ Scale Eff.	Δ Tech.	Δ Scale Tech.
1996	2000	1.02	0.83	0.96	1.25	1.04
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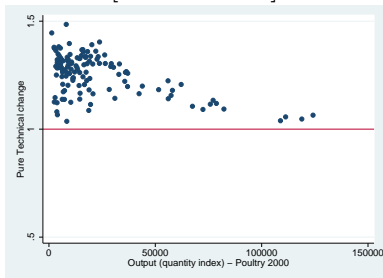
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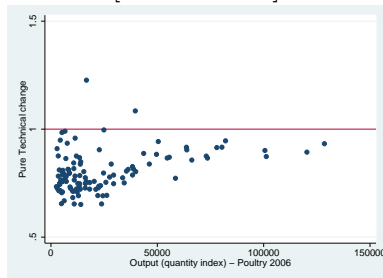
t_1	t_2	MI	Δ Pure Eff.	Δ Scale Eff.	Δ Tech.	Δ Scale Tech.
1996	2006	0.96	1	0.98	0.97	1.01

Pure Technical efficiency as a function of size (Poultry)

[1996 – 2000]



[2000 – 2006]



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Cheese Industry in 2006 (8% of food industry sales)

Variable	Mean	Std dev	Min	1st quart.	3rd quart.	Max	N
Y	50,135	112,714	223	6,599	47,402	1e+06	182
Y/K	158.0	1,916.7	0.1	1.3	4.6	23,943	156
Y/L	463.8	1,426.4	9.3	177.4	357.9	18,051	182
Y/M	1.3	0.2	0.6	1.2	1.3	2.9	182

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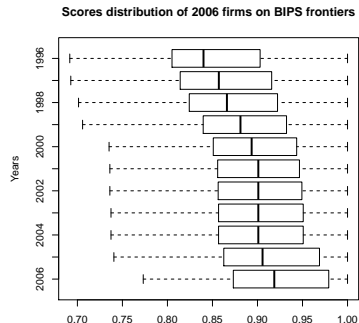
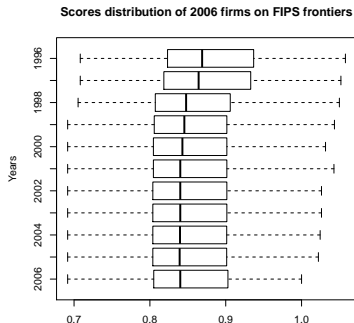
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- ▶ Technical efficiency in 2006: 0.92 (0.07)

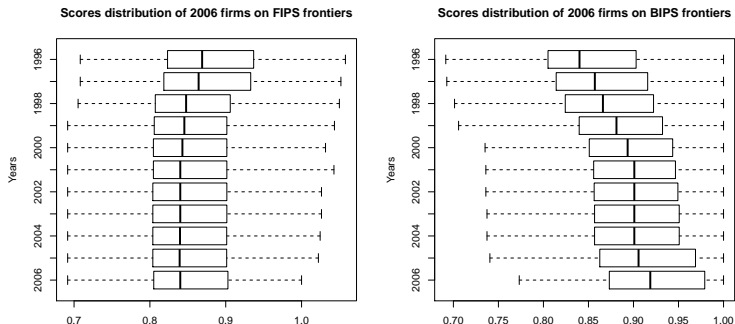
Distribution of DEA-based efficiency scores - Scores of firms in 2006 on FIPS and BIPS frontiers



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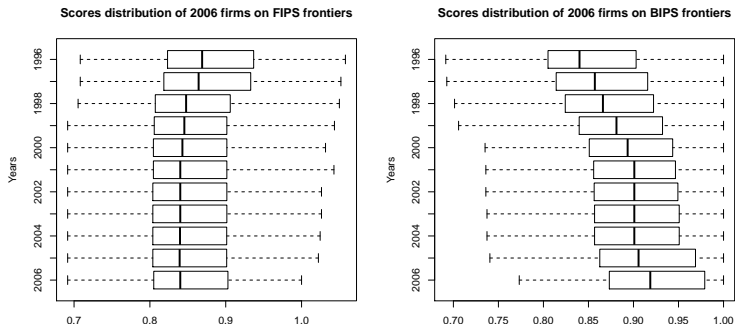
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Malmquist decomposition on the two identified sub-period [1996-1998] and [1998-2006]

Year 1	Year 2	MI	Δ Pure Eff.	Δ Scale Eff.	Δ Tech.	Δ Scale Tech.
1996	1998	0.99	0.99	0.99	1.00	1.01
1998	2006	0.99	1.01	0.99	0.98	1.01
1996	2006	0.96	1.00	0.97	0.97	1.02

- ▶ [1996 – 1998] : Technical progress and technical regress

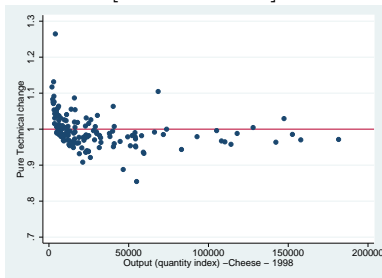
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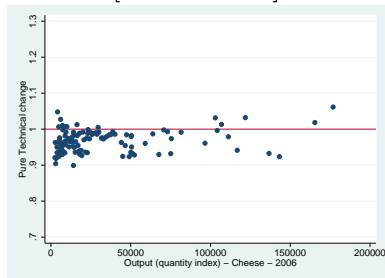
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Question to the audience !

On the same sample (poultry), and on the same two periods we compute :

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Year 1	Year 2	MI	Δ Eff.	Δ Tech.	HM	Δ Eff.	Δ Tech.
1996	2000	1.02	0.79	1.30	1.03	1.07	0.96
2000	2006	0.97	1.28	0.76	0.97	1.01	0.96

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- ▶ Index are equivalent but leads to completely different decomposition with HM values less extreme but not in accordance with the conclusion from FIPS and BIPS.

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Thank you for your attention