Technical & efficiency change in the french food industries

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

Efficiency measurement

Toulouse, June 2011

TSE

- To provide evidence on the dynamics of productivity in the French food industry (at a disaggregated level) using panel data over the years 1996-2006.

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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)

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- Technical efficiency of French cheese manufacturers: 0.82 on average during the 1985-2000 years (Chaban *et al.*, 2005)
- A variety of methods (cost function approach, value added function, index-based approaches). Mainly with aggregate data.
- No comprehensive study of the French food industry

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→ Two-stage procedure:

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

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

- The Forward Increasing Production Set (FIPS):

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

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BIPS are used to detect period with technical regress.

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

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

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

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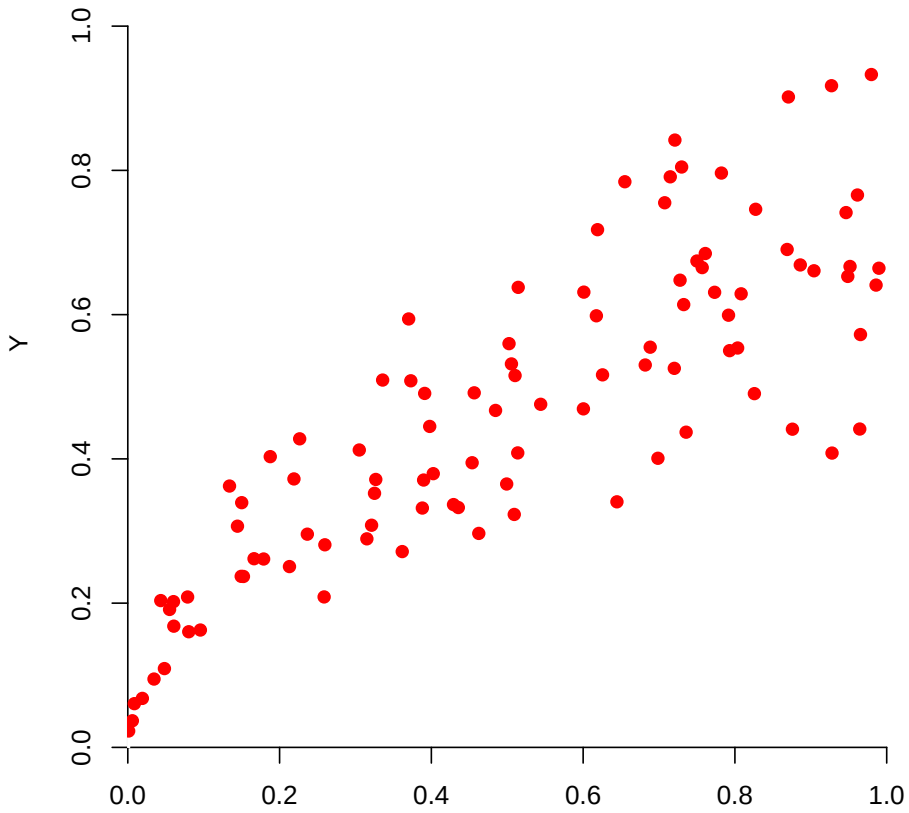

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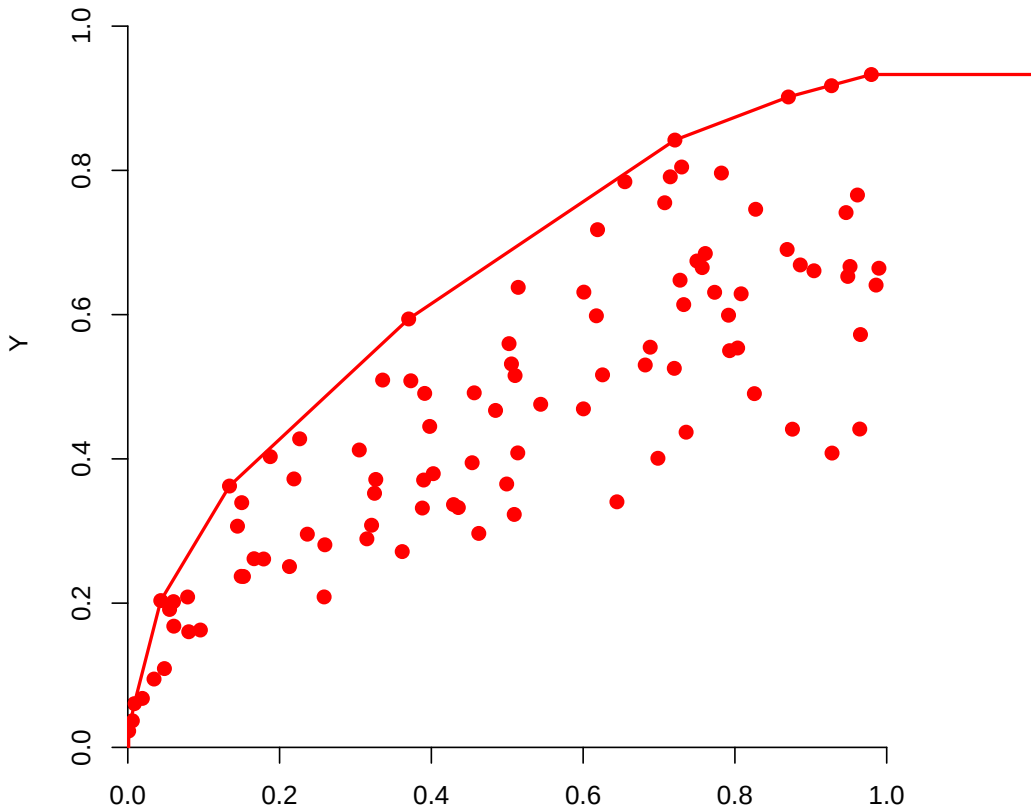
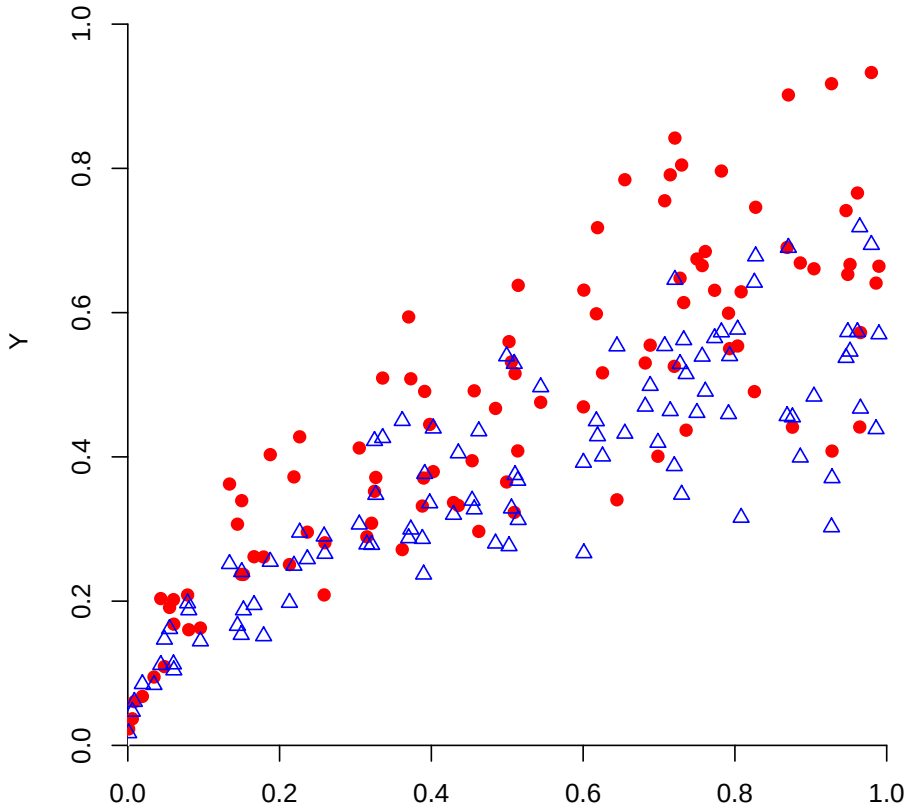


P_2^{FIPS}



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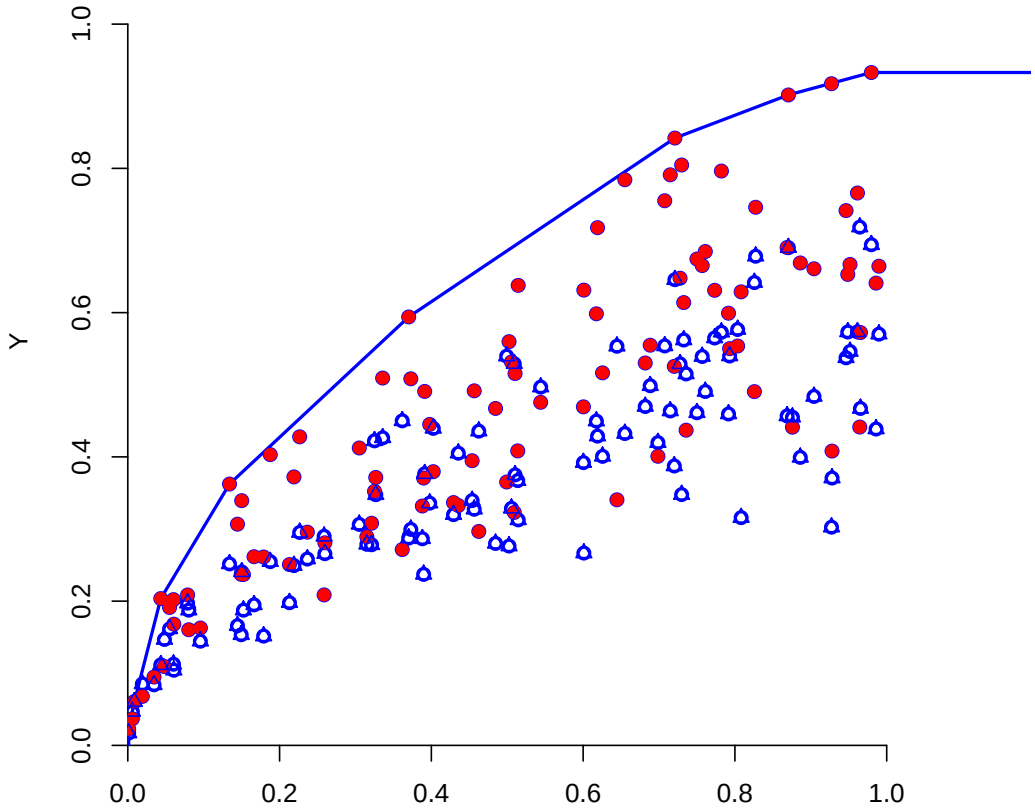

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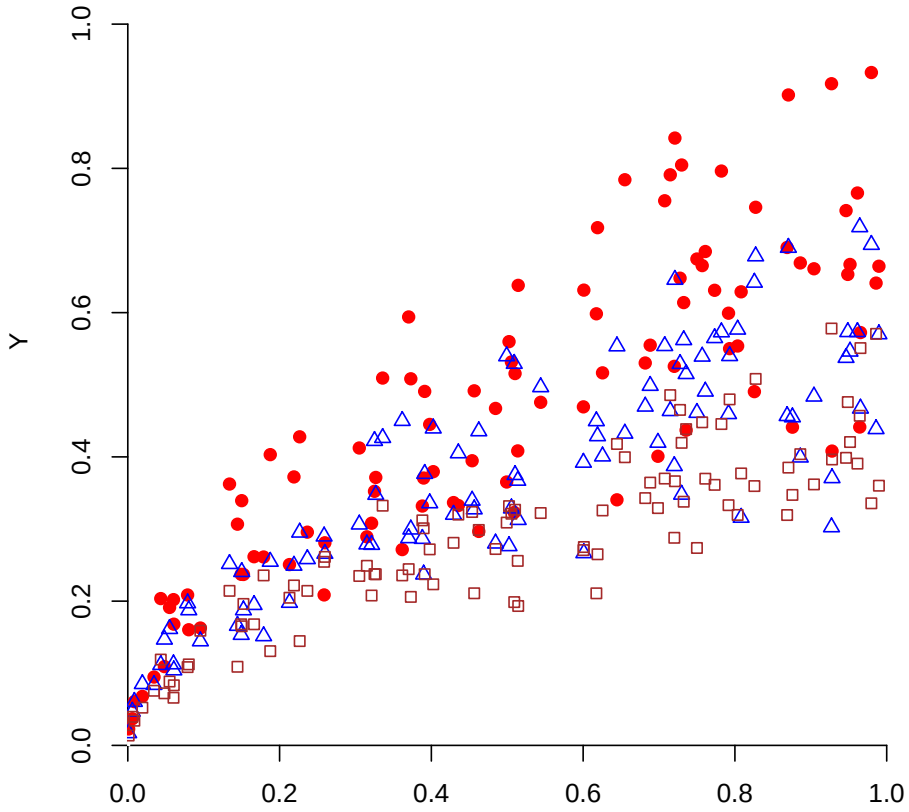

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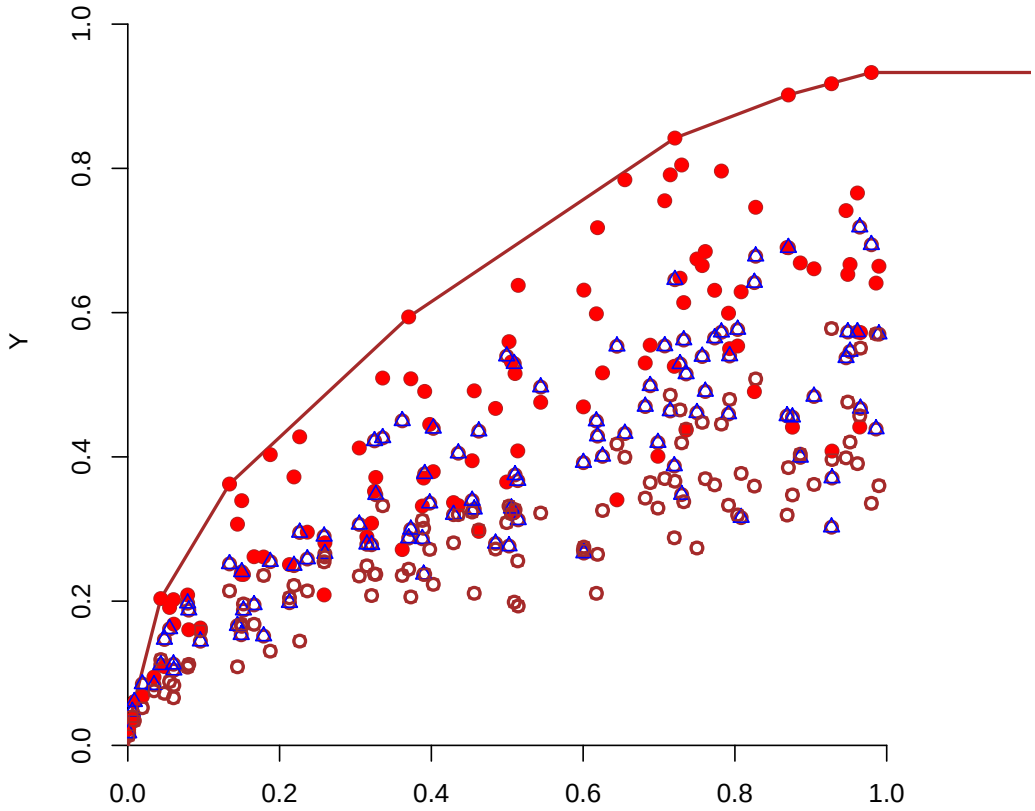
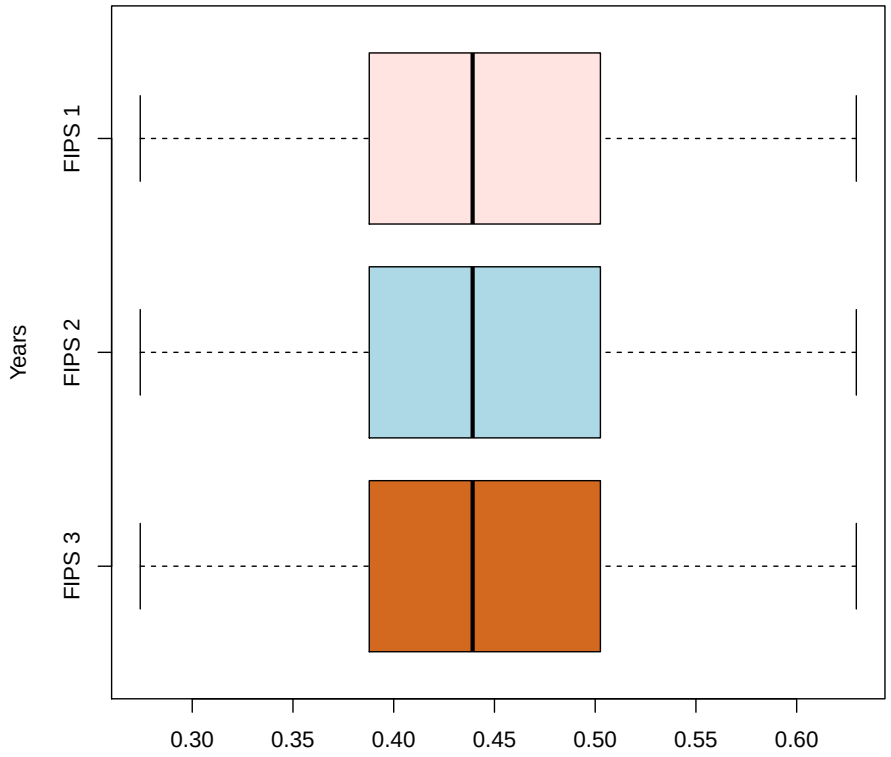
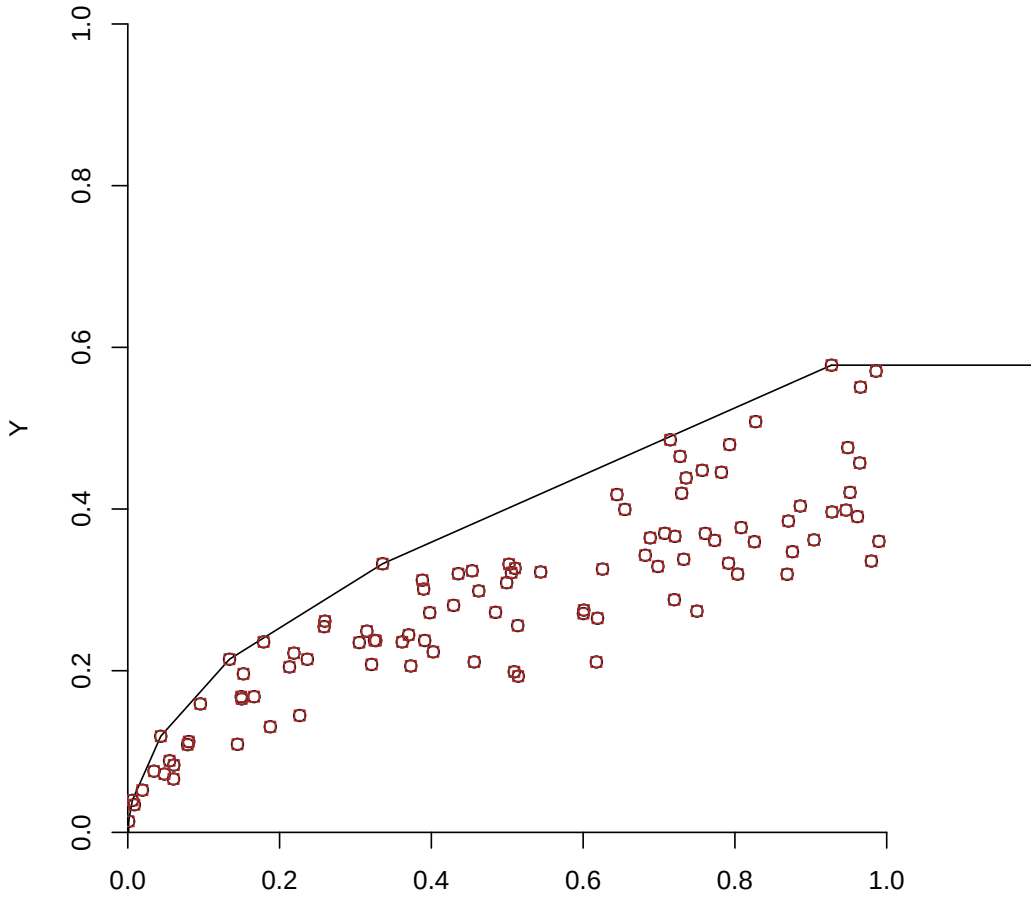


The distribution of efficiency for a sample of observations using the productions sets $P_t^{FIPS}, t = 1, 2, 3$. Here we use firms in 2006, but any sample taken as reference would lead to the same result.



P_3^{BIPS}



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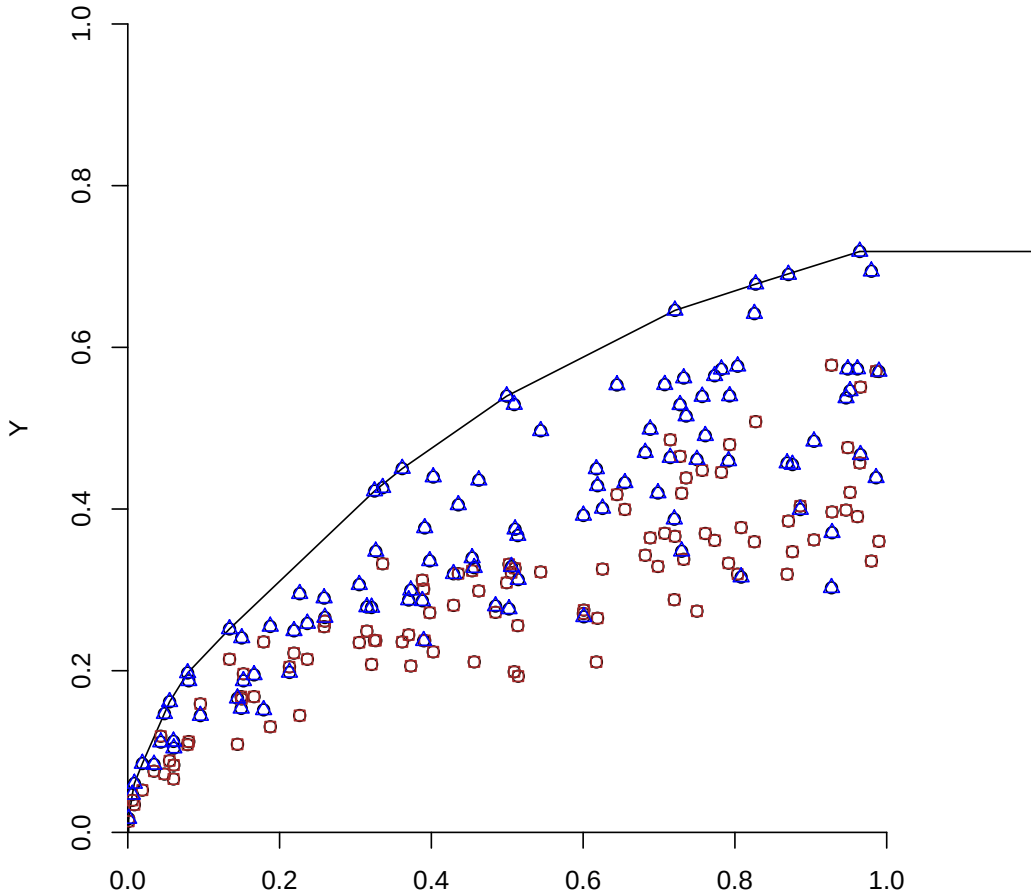
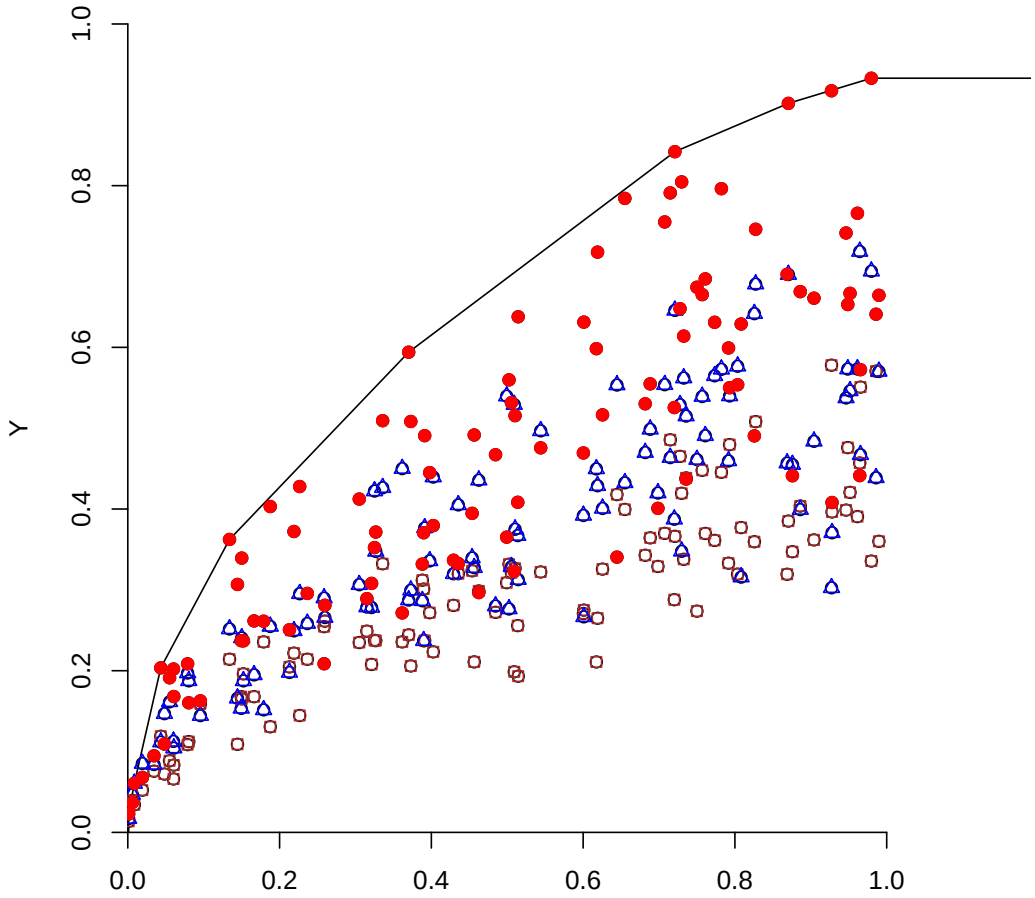
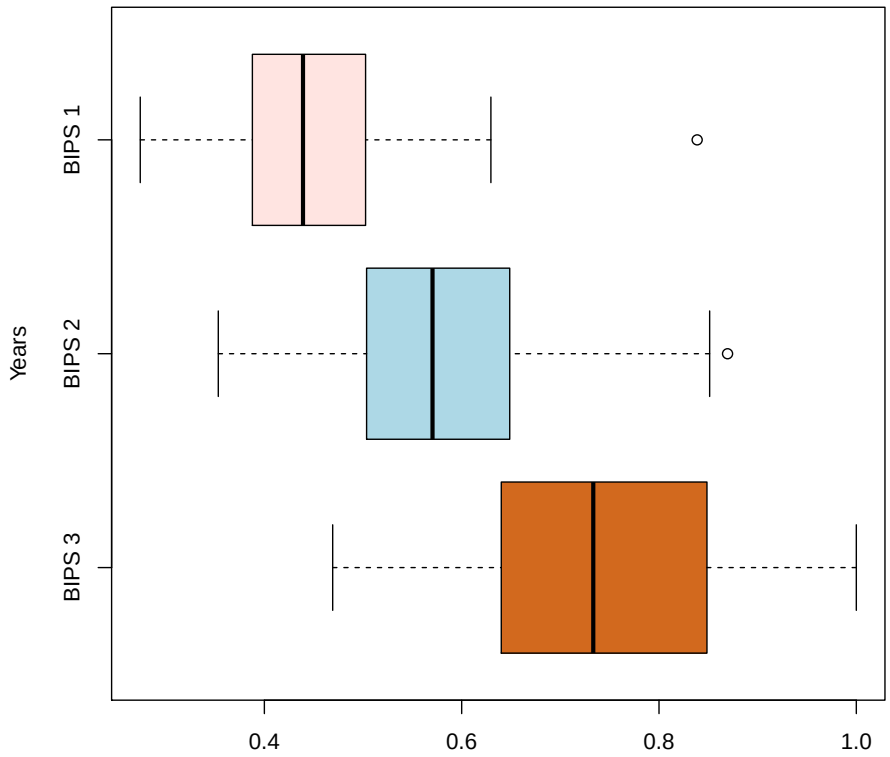


P_1^{BIPS}



The distribution of efficiency of firms for the productions sets $P_t^{BIPS}, t = 1, 2, 3$



What happens if we simulate simultaneously

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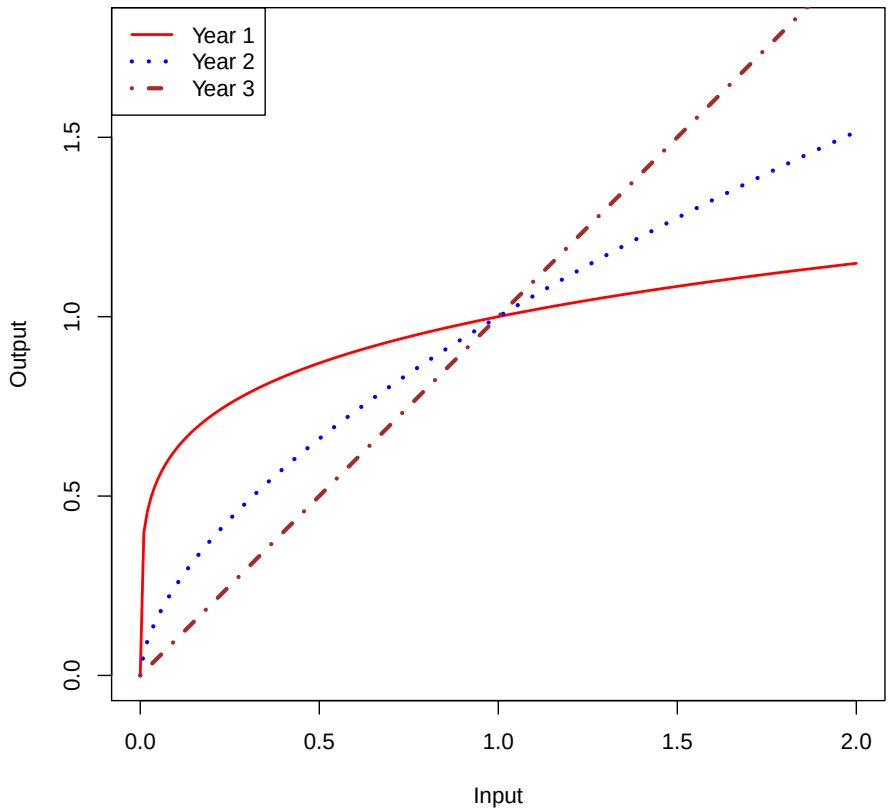
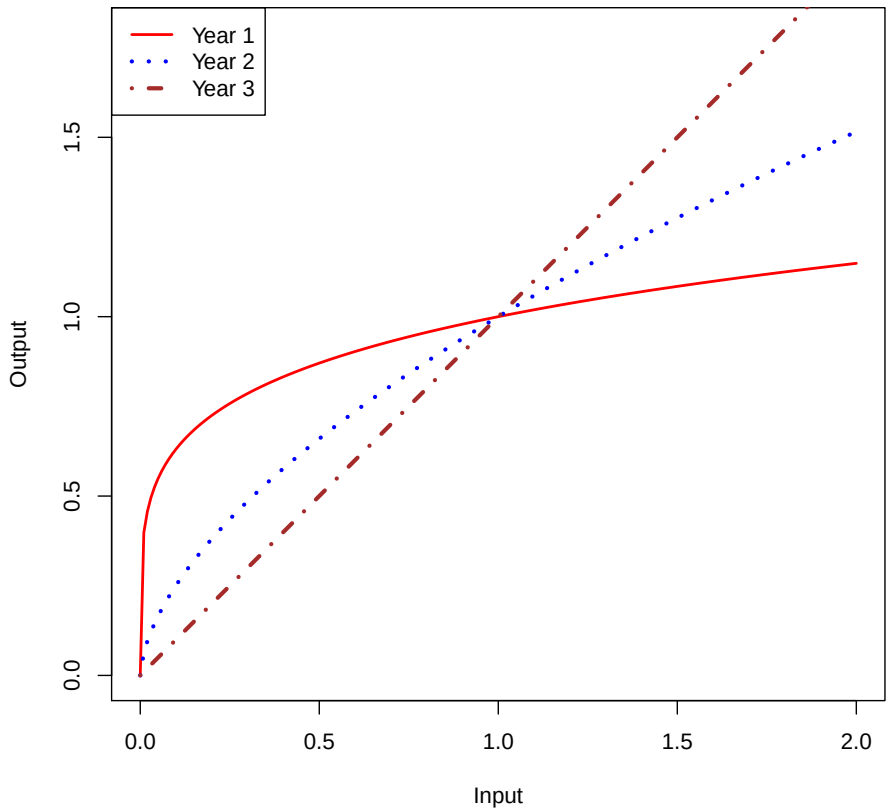
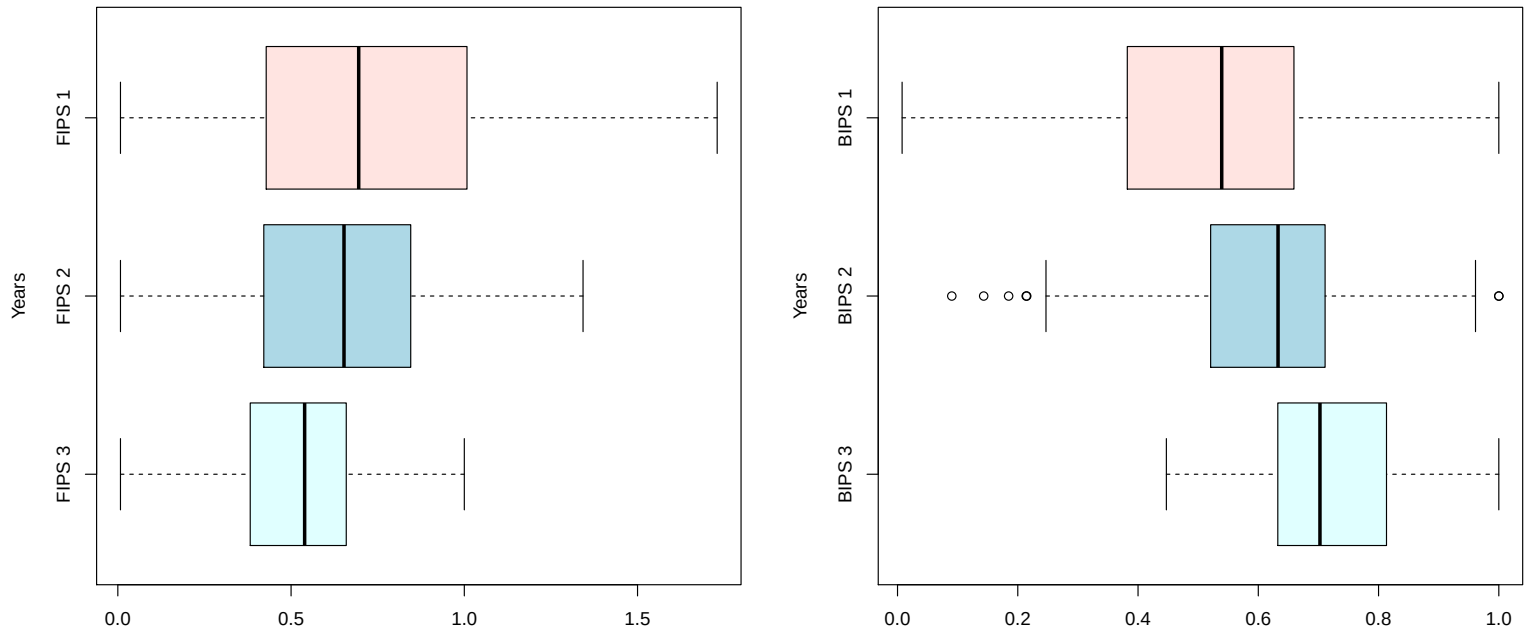


What happens if we simulate simultaneously

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



We get the following efficiency for FIPS and BIPS:



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).

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

$$\begin{aligned} MI &= \left(\frac{D^{VRS}_{\mathbf{t_2}}(x_{\mathbf{t_2}}, y_{\mathbf{t_2}})}{D^{VRS}_{\mathbf{t_1}}(x_{\mathbf{t_1}}, y_{\mathbf{t_1}})}\right) \times \left(\frac{D^{CRS}_{\mathbf{t_2}}(x_{\mathbf{t_2}}, y_{\mathbf{t_2}}) \,/\, D^{VRS}_{\mathbf{t_2}}(x_{\mathbf{c}}, y_{\mathbf{t_2}})}{D^{CRS}_{\mathbf{t_1}}(x_{\mathbf{t_1}}, y_{\mathbf{t_1}}) \,/\, D^{VRS}_{\mathbf{t_1}}(x_{\mathbf{t_1}}, y_{\mathbf{t_1}})}\right) \\ &\times \left(\frac{D^{VRS}_{\mathbf{t_1}}(x_{\mathbf{t_2}}, y_{\mathbf{t_2}})}{D^{VRS}_{\mathbf{t_2}}(x_{\mathbf{t_2}}, y_{\mathbf{t_2}})} \times \frac{D^{VRS}_{\mathbf{b}}(x_{\mathbf{t_1}}, y_{\mathbf{t_1}})}{D^{VRS}_{\mathbf{t_2}}(x_{\mathbf{t_1}}, y_{\mathbf{t_1}})}\right)^{0.5} \\ &\times \left(\frac{D^{CRS}_{\mathbf{t_1}}(x_{\mathbf{t_2}}, y_{\mathbf{t_2}}) \,/\, D^{VRS}_{\mathbf{t_1}}(x_{\mathbf{t_2}}, y_{\mathbf{t_2}})}{D^{CRS}_{\mathbf{t_2}}(x_{\mathbf{t_2}}, y_{\mathbf{t_2}}) \,/\, D^{VRS}_{\mathbf{t_2}}(x_{\mathbf{t_2}}, y_{\mathbf{t_2}})} \times \frac{D^{CRS}_{\mathbf{t_1}}(x_{\mathbf{t_1}}, y_{\mathbf{t_1}}) \,/\, D^{VRS}_{\mathbf{t_1}}(x_{\mathbf{t_1}}, y_{\mathbf{t_1}})}{D^{CRS}_{\mathbf{t_2}}(x_{\mathbf{t_1}}, y_{\mathbf{t_1}}) \,/\, D^{VRS}_{\mathbf{t_2}}(x_{\mathbf{t_1}}, y_{\mathbf{t_1}})}\right) \end{aligned}$$

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- Firms are classified with respect to their main production, using a four digit classification level $\rightarrow$ 41 sectors.

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  1. DEA with VRS assumption using FIPS and BIPS and bootstrapped test of equality of probability density functions $\rightarrow$ identification of sub-periods
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- Implemented using R-packages Benchmarking (Bogetoft & Otto 2010) and NP (Hayfield and Racine, 2008).

TSE

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
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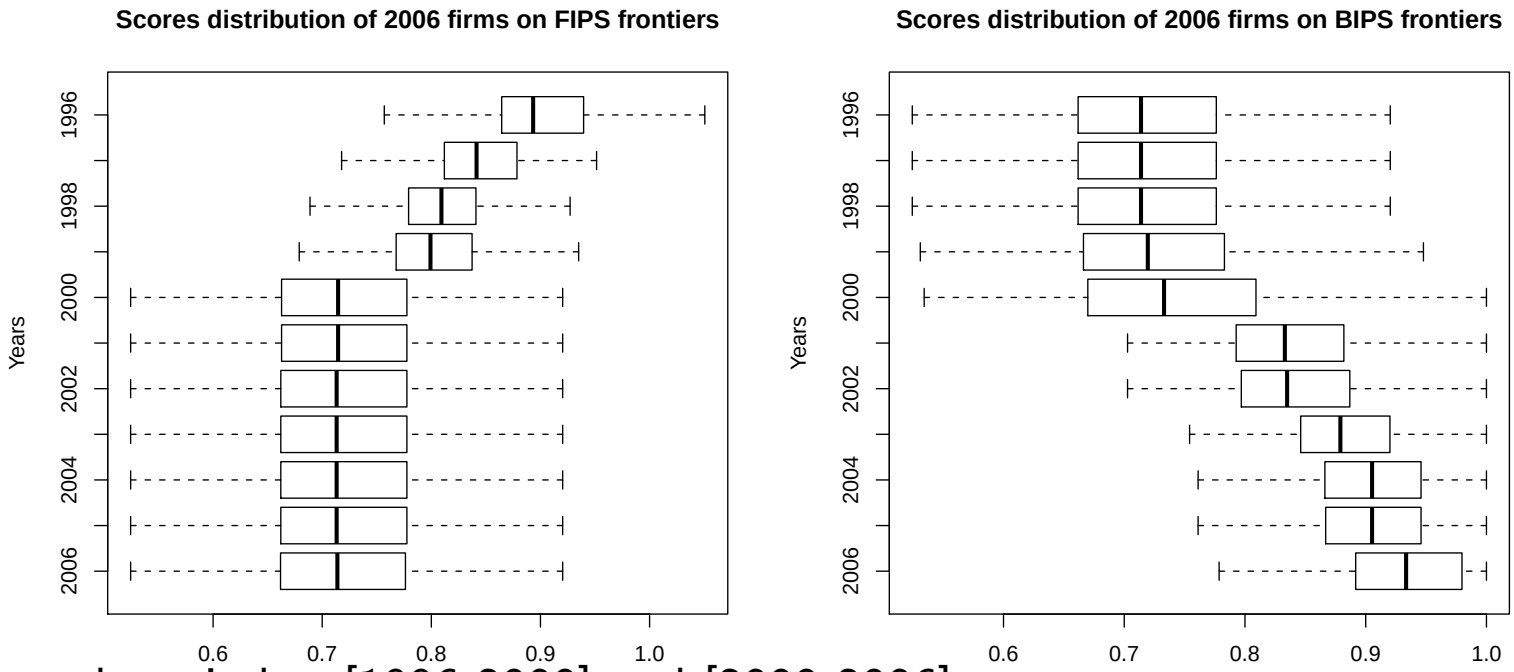
- Technical efficiency in 2006 (contemporaneous frontier): 0.93 (*0.06*)

TSE

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



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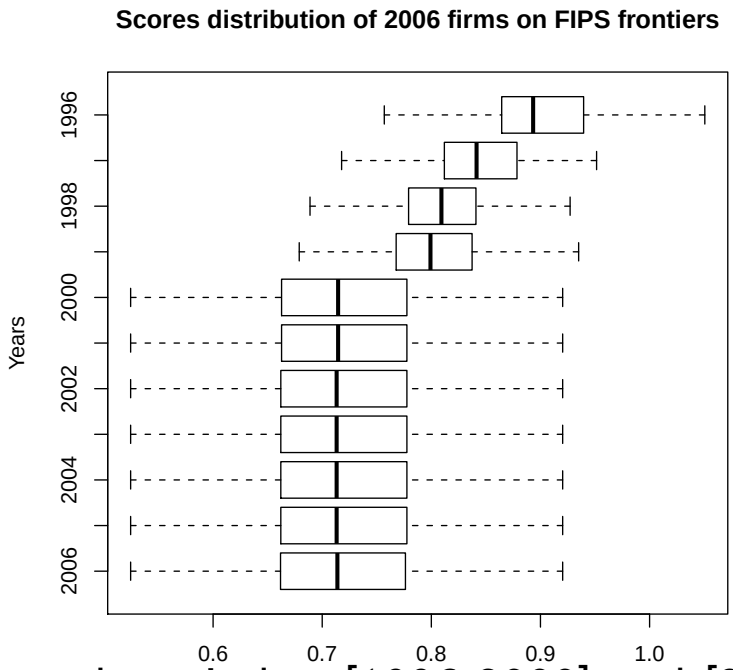

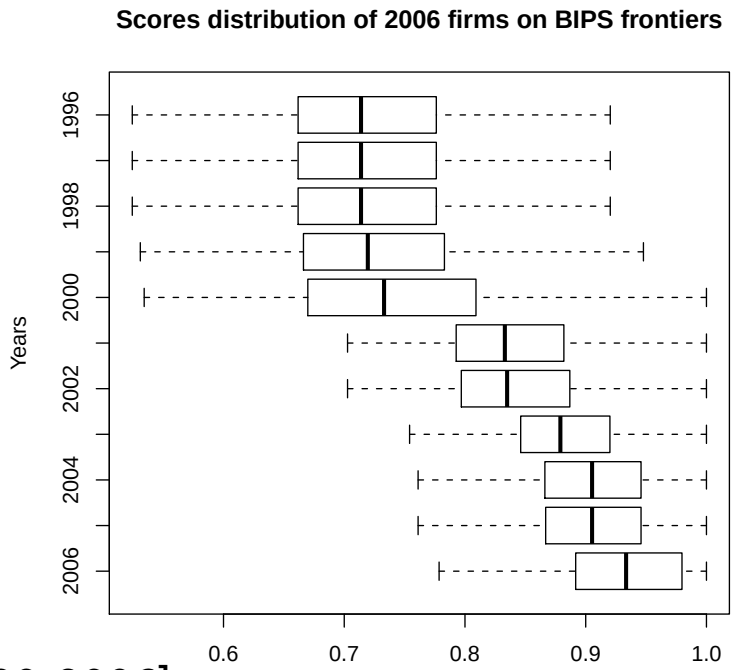

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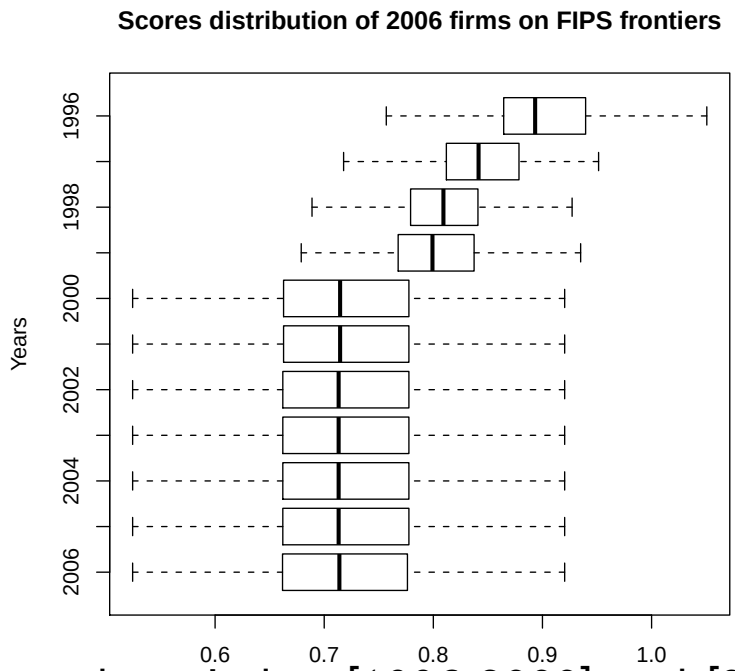

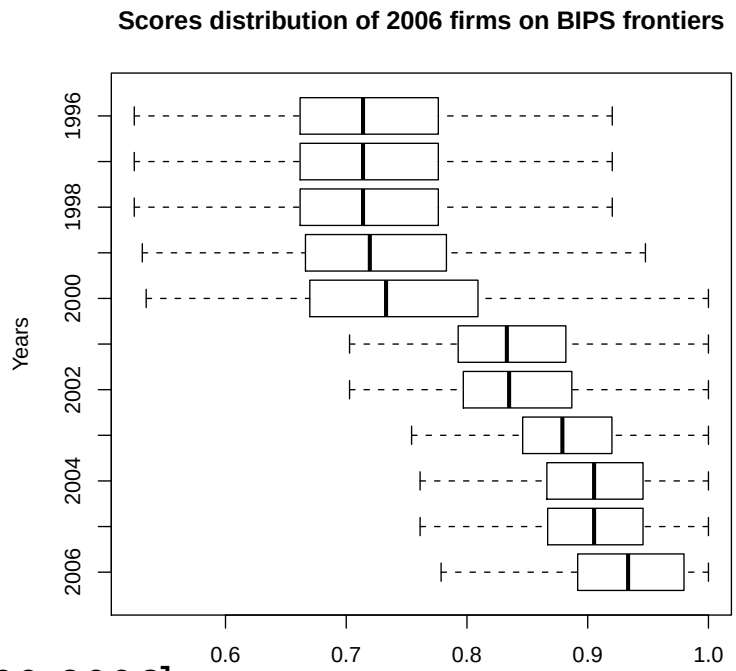

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Nonparametric test for equality of distributions (Li, 1996)
FIPS frontiers

	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
2004	.	.	.	.	.	.	.	.	.	1.00	0.91
2005	.	.	.	.	.	.	.	.	.	.	0.93

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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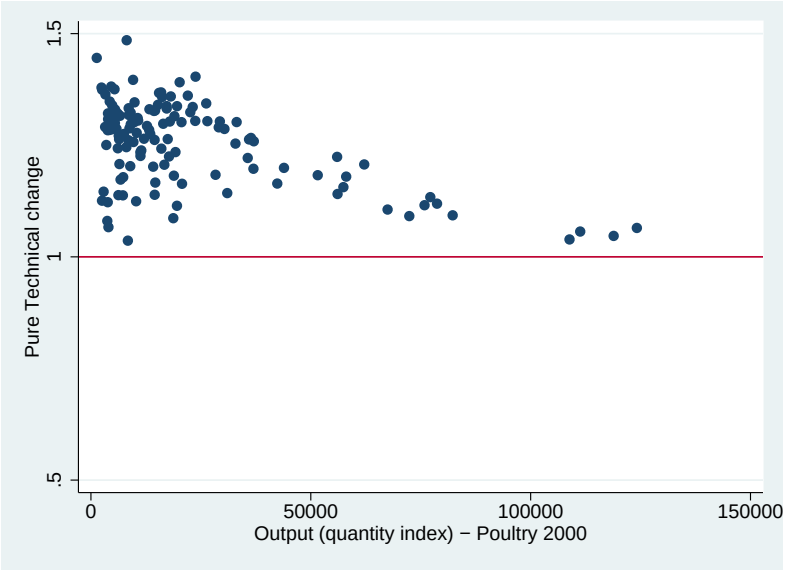
TSE

Pure Technical efficiency as a function of size (Poultry)

$[1996 - 2000]$



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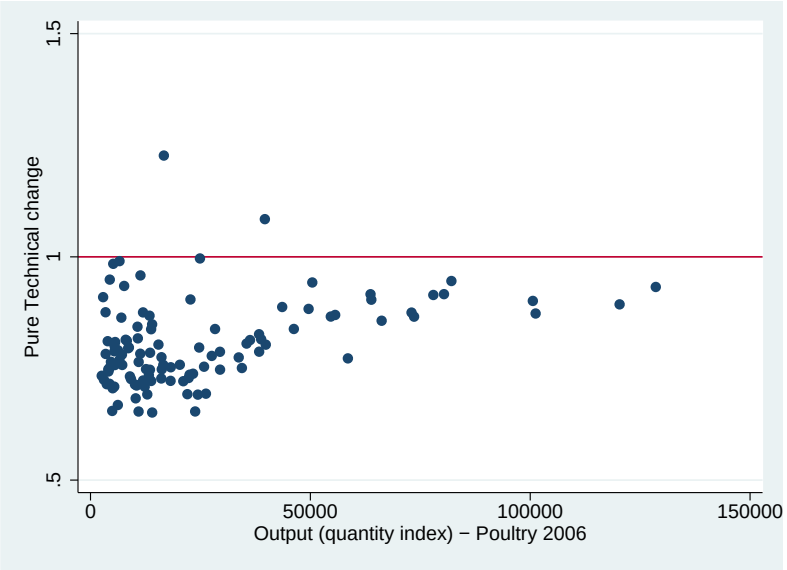

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  - Came progressively into force in the 2000's

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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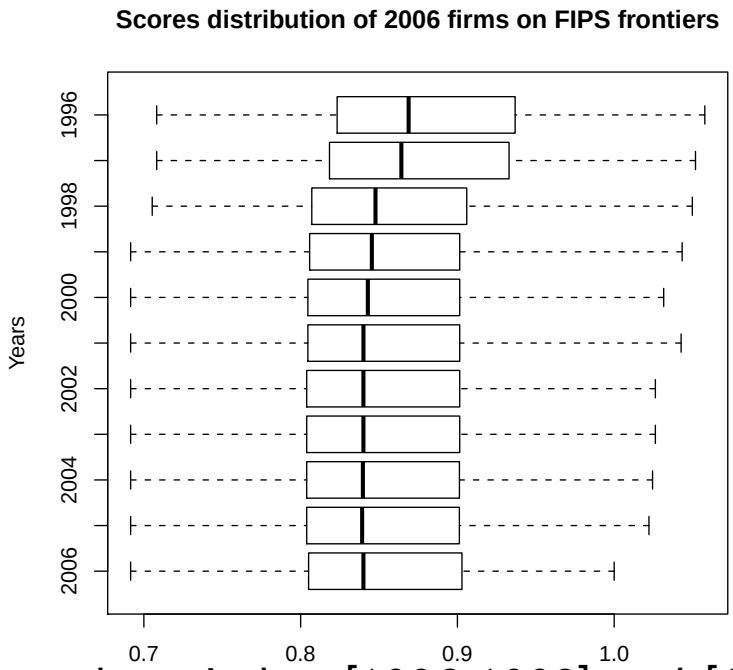

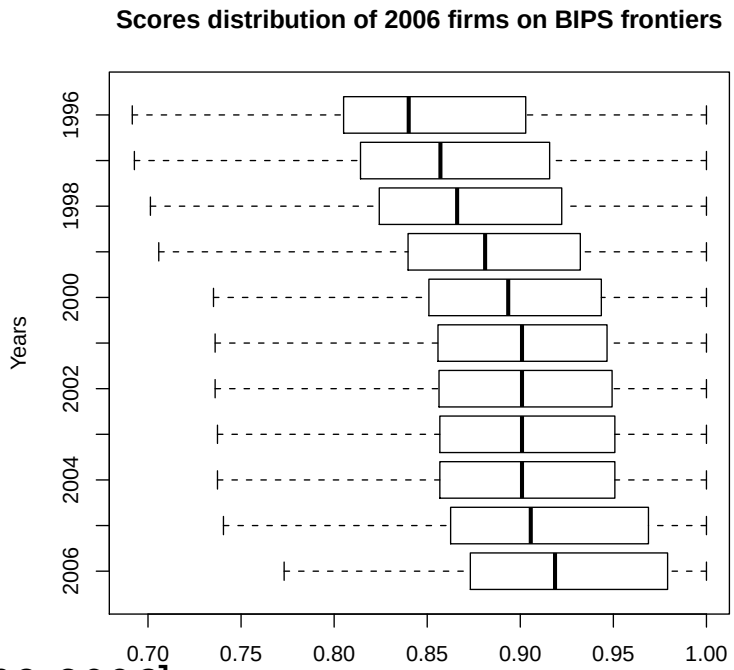

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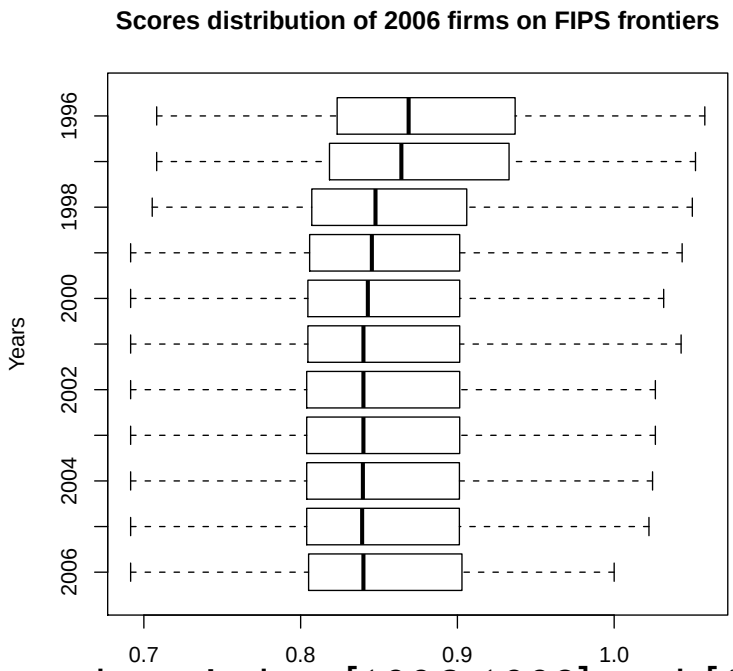

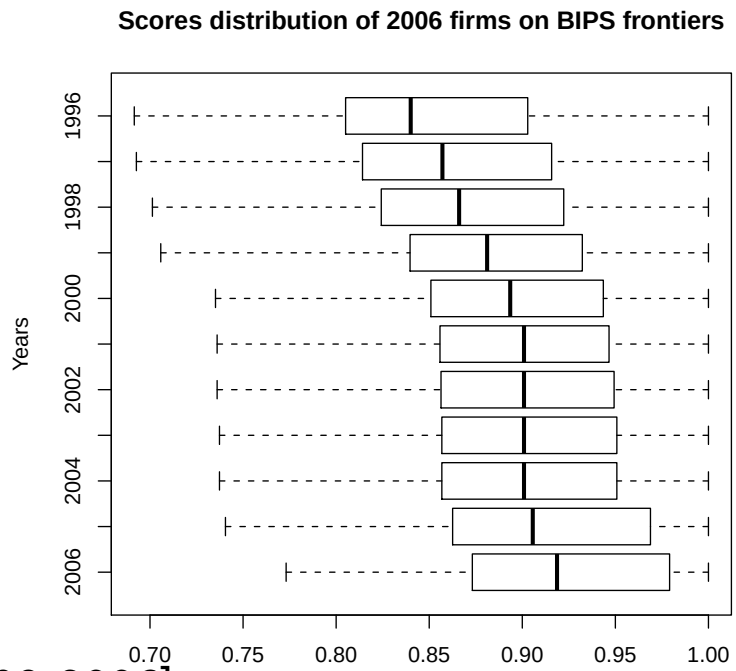

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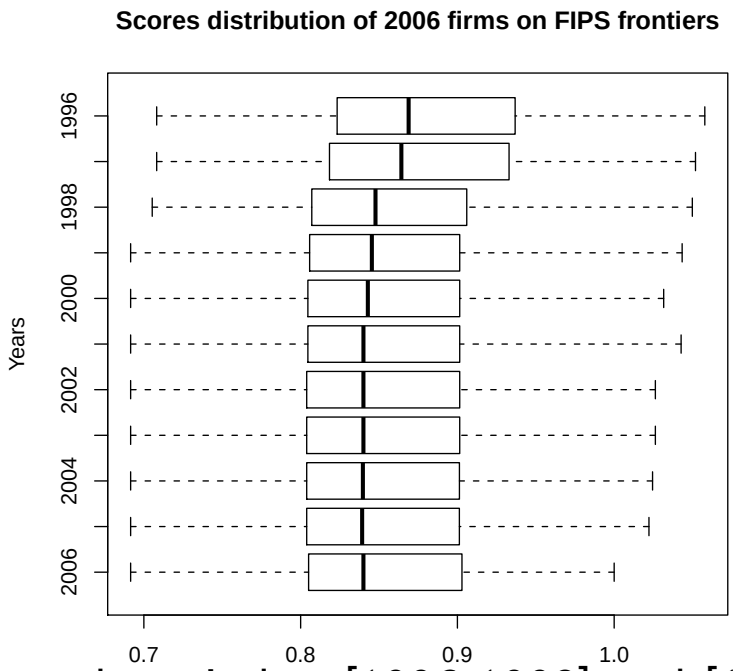

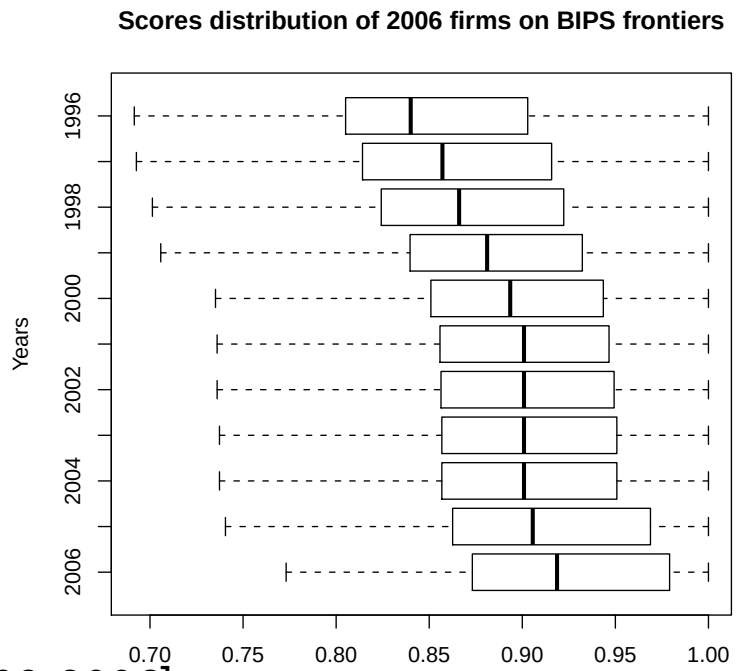

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Malmquist decomposition on the two identified sub-period [1996-1998] and [1998-2006]

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

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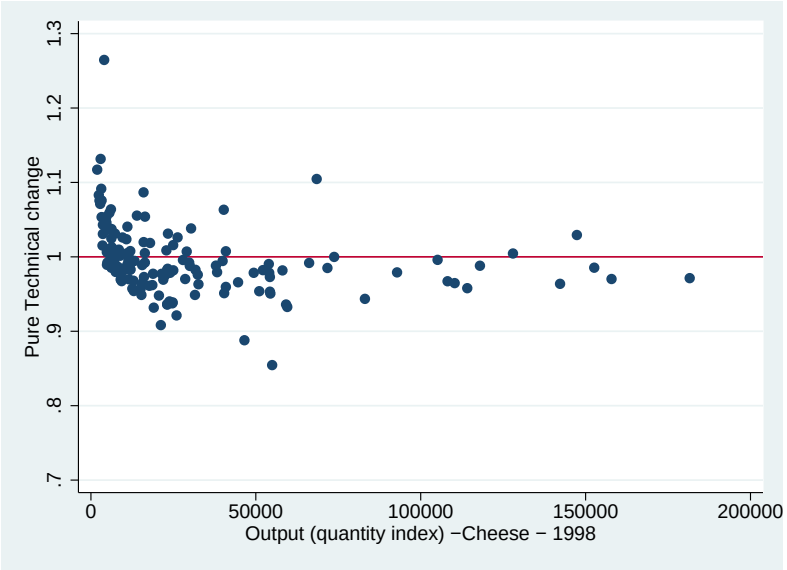

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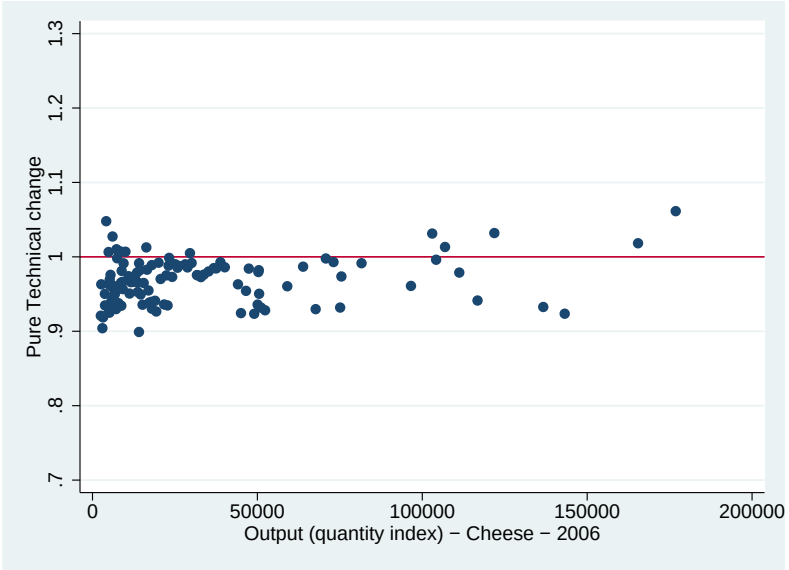

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Year 1	Year 2	MI	Δ Eff.	Δ Tech.	HM	Δ Eff.	Δ Tech.
1996	2000	1.02	0.79	1.30	1.03	1.07	0.96
2000	2006	0.97	1.28	0.76	0.97	1.01	0.96

TSE

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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

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

TSE

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- Puzzle: Malmquist vs Hicks-Moorsteen index decompositions

Thank you for your attention