Efficiency Analysis on Finnish Foodstuffs

FIN-MIPS Research Project

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- FIN-MIPS Research Project studied the Material Input (MI) of household consumption in Finland
- In this context the aim was to gather comparable MI-values for Finnish foodstuffs
  - MI-values for 24 groups of foodstuffs were acquired
- In my thesis methods of analysis for this data on foodstuffs are studied
  - DEA models come into play

Motivation

- Consumption of foodstuffs form 25-32% of total material requirement (TMR) of Finland
  - Over-consumption of material as 3rd world countries develop
- To avoid this scenario the total material requirement can be used as an indicator of progress made
  - Goal: decoupling of GDP growth and TMR

More Motivation

- Different methods of analysis are needed to identify main sources of material requirement
  - The results can be used as basis of discussion while forming policies
  - The goal is to lower the material requirement efficiently
    - That is, by lowering the heaviest material flows
    - This should not have an effect on the well-being of consumers
    - Restructuring (but not down-sizing) the economy

Contents of the thesis

- (Introduction)
- (brief Data Collection)
- **Data Analysis**
  - (Individual's Optimal Groceries (LP))
  - **DEA models**
- (Conclusion)

Contents of the presentation

- Data and rationale
  - DMUs
  - Input and Output variables
- DEA models used
  - Reasons for concentrating on Input-oriented CCR-AR models
- Some preliminary results
  - Efficiency Scores
  - Dominance Matrix (Salo, Kangaspunta et al.)

Material Inputs and DMUs

- MIPS (Material Input Per Service unit) method divides the material inputs to five different classes
  - Abiotic, biotic, water, air and erosion
  - TMR = abiotic + biotic + erosion
- Only Finnish foodstuffs were included as DMUs, with exception of Brasilian soy
  - Milk, butter, cheese and rape- and soyspreadables
  - Meat products: cattle-, pig-, poultry- and fishmeat
  - Lager, potato, sugar, rye-, wheat-, mixed- ja barleybread
  - Vegetables: tomato and cucumber
  - Fruits: apple, Berries: strawberry and cloudberry

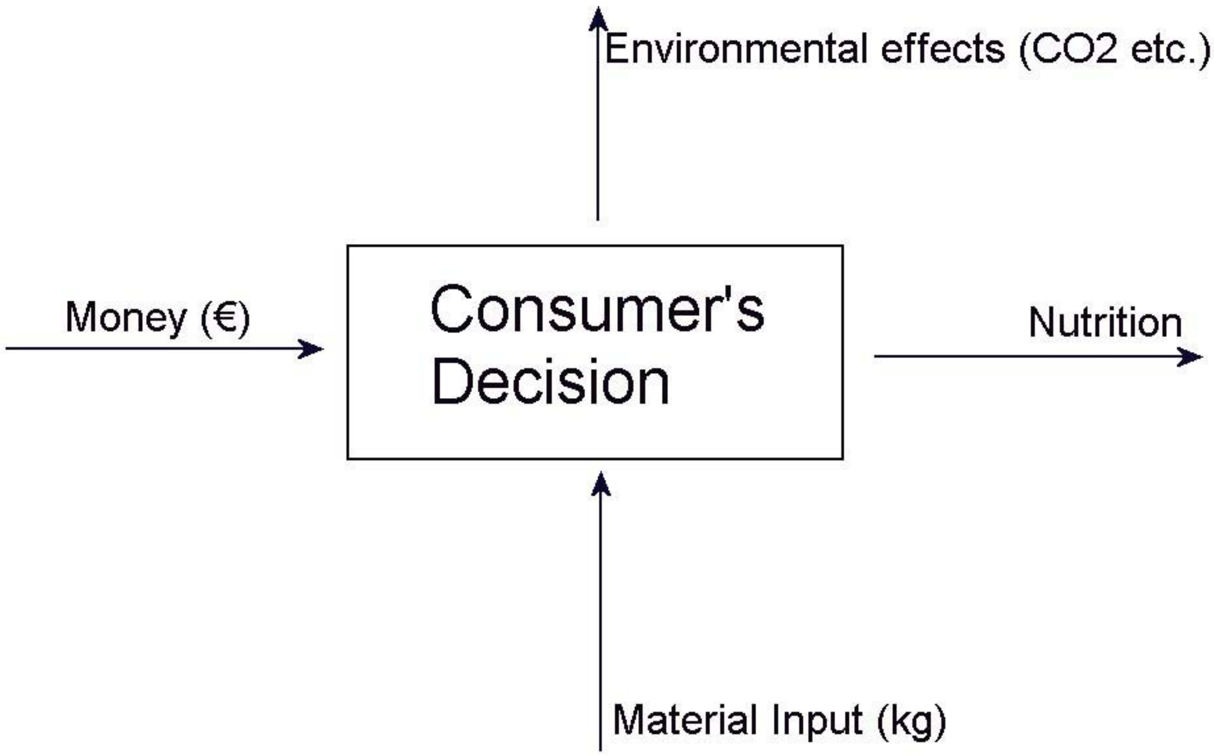
Material Inputs for the DMUs

Product group	MIPS abiotic (kg/kg)	biotic (kg/kg)	water (kg/kg)	air (kg/kg)	erosion (kg/kg)
Milk	1,1	3,0	30,8	0,1	0,3
Butter	9,8	25,1	208,1	0,7	2,6
Spreadables, rapeoil	7,6	19,2	162,3	0,7	2,0
Spreadables, soyoil	8,3	19,7	168,1	0,6	2,2
Cheese	11,3	28,9	260,5	1,1	3,0
Beef	12,0	30,6	438,6	1,0	3,2
Pigmeat	8,3	10,2	240,5	1,9	2,8
Fishmeat	2,8	4,7	271,0	0,8	0,2
Poultrymeat	7,0	4,6	227,7	1,5	1,2
Eggs	5,7	4,0	140,7	1,0	1,1
Soy	1,3	1,4	156,6	0,9	0,4
Lager	1,5	0,3	280,4	0,5	0,1
Potato	0,3	1,7	52,3	0,0	0,1
Sugar	3,1	1,6	24,4	0,8	0,4
Wheatbread	1,1	1,3	20,4	0,1	0,3
Ryebread	1,6	0,8	110,8	0,2	0,3
Mixedbread	1,3	1,1	98,8	0,2	0,3
Barleybread	1,1	1,4	21,0	0,1	0,4
Tomato	8,0	1,4	792,9	4,5	0,0
Cucumber (average)	7,0	1,4	569,9	4,1	0,0
Cucumber (around the year)	13,8	1,4	2481,3	7,0	0,0
Apple	0,7	1,0	6,8	0,0	0,3
Cloudberry	2,0	1,0	17,5	0,2	0,0
Strawberry	1,1	1,0	16,8	0,2	0,6

Nutritional values

- Nutritional values included as outputs (5 variables)
  - Energy contents (kJ)
  - proteins (g)
  - carbohydrates (g)
  - Total minerals and traces (g)
  - Total vitamins (g)
- Fat (g) was not included in the analysis, however
  - In the dominance matrix fat was put in as input variable

Input and Output Variables



(Happiness, individual ethics, religion etc… not included)

– Environmental effects are not included in the thesis

Selecting the DEA models used

- The nutritional values are not maximized, but material inputs (and money spent) minimized
  - The models used should all be input-oriented
- Recommendations are available for nutrition
  - Assurance Region can be used for the weigths given
- BCC models give a wider range of efficient foodstuffs, while CCR gives more clear results
- Hence BCC models are used only for comparison, while results given by CCR and especially CCR-AR models are seen as most useful for the purposes described

DEA models used (envelopment form)

- CCR

$$\min_{\theta,\lambda,s^-,s^+} \quad \theta$$
$$s.t.$$
$$\theta x_0 - X\lambda - s^- = 0$$
$$Y\lambda - s^+ = y_0$$
$$\lambda \geq 0, s^- \geq 0, s^+ \geq 0 \quad ,$$

where of course the $\theta^* = min\ \theta$, and θ^* are the efficiency scores provided in the results

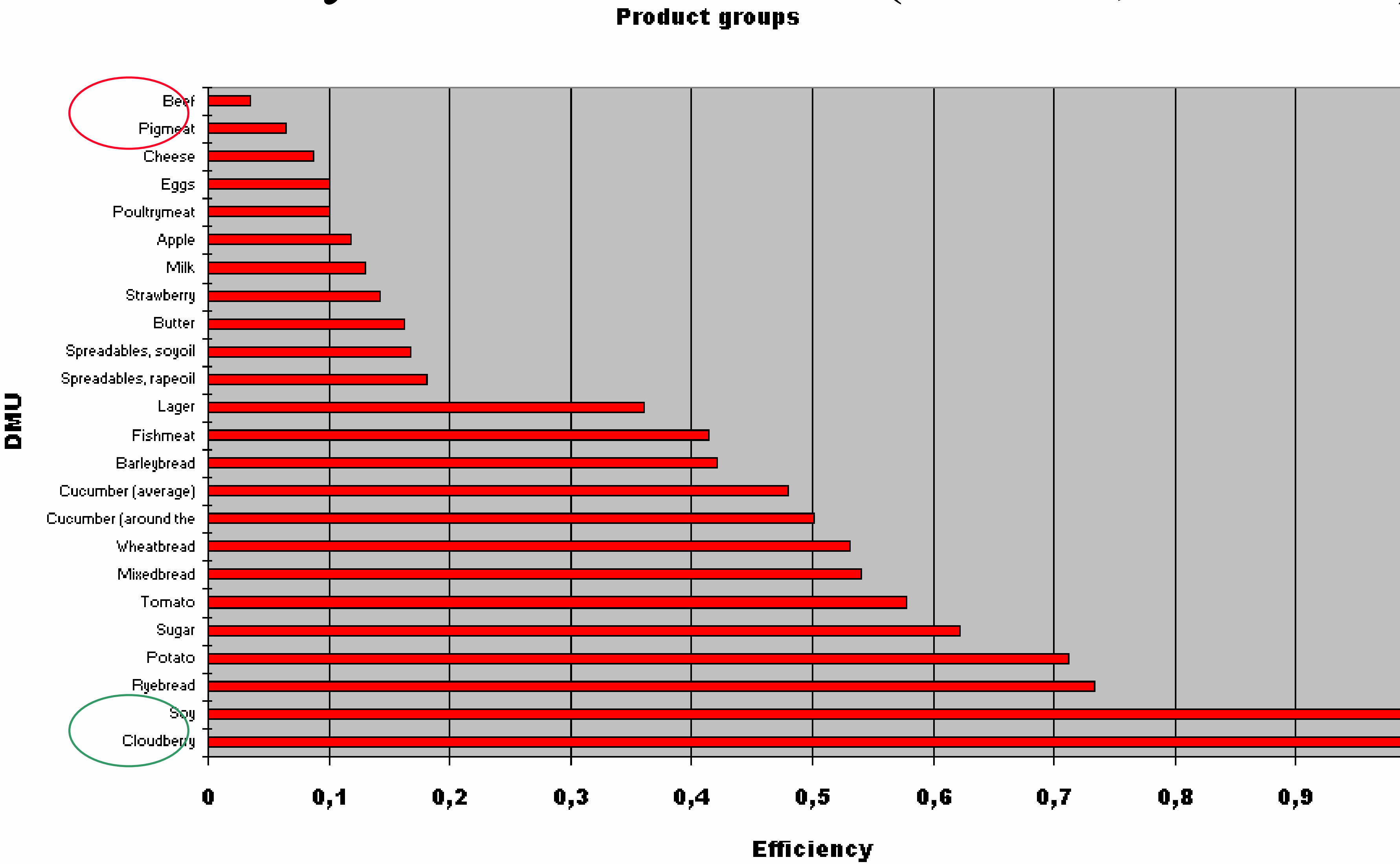
- CCR-AR

$$\min_{\theta,\lambda,\pi,\tau} \quad \theta$$
$$s.t.$$
$$\theta x_0 - X\lambda + P\pi \geq 0$$
$$Y\lambda - Q\tau \geq y_0$$
$$\lambda \geq 0, \pi \geq 0, \tau \geq 0 \quad .$$

Here P and Q matrices include information on nutritional recommendations given.

For formulation of matrices P and Q, see presentation 11.

Preliminary results:CCR-AR(w/o fat, w biotic)



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Dominance Matrix

- Due to degrees of freedom (e.g. Cooper et al. 2007:283), only some of the Material Input variables were included in each model
  - abiotic, erosion and ”one extra MI”
- Different models were analyzed with a dominance matrix
  - Inclusion or exclusion of fat on input side (2 options)
  - BCC, CCR or CCR-AR model (3 options)
  - ”one extra MI” varied (3 options)
- All different combinations included, N=2*3*3=18 models

Calculating the dominance matrix

- We make pairwise comparisons between DMUs k and l for all models n=1,…,N. If

$$\frac{E_k}{E_l} - 1 \geq 0$$

we say that DMU k dominates l in model n, and write

$$D_k^n(l) = 1 \,.$$

Otherwise $D_k^n(l) = 0$.

- By making the comparison between all DMUs k,l inside every model n, we receive the number of times k is dominated by l in all models n.
- This number can be divided by N, giving a percentage score

Dominance Matrix

	Milk	Butter	Spreadab	Spreadab	Cheese	Beef	Pigmeat	Fishmeat	Poultryme	Eggs	Soy	Lager	Potato	Sugar	Wheatbre	Ryebread	Mixedbre	Barleybre	Tomato	Cucumbe	Cucumbe	Apple	Cloudberr	Strawberr
Milk	100 %	56 %	56 %	50 %	0 %	0 %	0 %	44 %	6 %	0 %	100 %	72 %	100 %	100 %	94 %	78 %	78 %	78 %	72 %	83 %	78 %	78 %	100 %	83 %
Butter	56 %	100 %	100 %	78 %	0 %	0 %	0 %	67 %	0 %	0 %	100 %	83 %	100 %	100 %	100 %	89 %	67 %	78 %	78 %	83 %	78 %	94 %	100 %	89 %
Spreadables, rapeoil	56 %	33 %	100 %	11 %	0 %	0 %	0 %	67 %	0 %	0 %	100 %	83 %	100 %	100 %	100 %	89 %	67 %	78 %	78 %	78 %	78 %	94 %	100 %	83 %
Spreadables, soyoil	56 %	33 %	100 %	100 %	0 %	0 %	0 %	67 %	0 %	0 %	100 %	83 %	100 %	100 %	100 %	89 %	78 %	78 %	78 %	78 %	78 %	94 %	100 %	83 %
Cheese	100 %	100 %	100 %	100 %	100 %	0 %	0 %	100 %	33 %	33 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	78 %	100 %	100 %	100 %
Beef	100 %	100 %	100 %	100 %	100 %	100 %	78 %	100 %	78 %	78 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	94 %	100 %	100 %	100 %
Pigmeat	100 %	100 %	100 %	100 %	100 %	22 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	89 %	100 %	100 %	100 %
Fishmeat	56 %	33 %	33 %	33 %	0 %	0 %	0 %	100 %	0 %	0 %	100 %	72 %	100 %	100 %	100 %	100 %	100 %	100 %	78 %	78 %	78 %	83 %	100 %	72 %
Poultrymeat	94 %	100 %	100 %	100 %	67 %	22 %	0 %	100 %	100 %	78 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	83 %	100 %	100 %	100 %
Eggs	100 %	100 %	100 %	100 %	67 %	22 %	0 %	100 %	22 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	83 %	100 %	100 %	100 %
Soy	11 %	33 %	33 %	11 %	0 %	0 %	0 %	0 %	0 %	0 %	100 %	39 %	78 %	89 %	78 %	33 %	0 %	22 %	33 %	67 %	67 %	44 %	100 %	67 %
Lager	39 %	39 %	39 %	22 %	0 %	0 %	0 %	28 %	0 %	0 %	100 %	100 %	100 %	100 %	94 %	78 %	50 %	61 %	61 %	78 %	78 %	67 %	100 %	72 %
Potato	11 %	33 %	33 %	11 %	0 %	0 %	0 %	0 %	0 %	0 %	100 %	39 %	100 %	89 %	78 %	44 %	0 %	33 %	44 %	67 %	67 %	44 %	100 %	67 %
Sugar	11 %	33 %	33 %	11 %	0 %	0 %	0 %	0 %	0 %	0 %	100 %	39 %	83 %	100 %	83 %	44 %	0 %	22 %	33 %	67 %	67 %	44 %	100 %	67 %
Wheatbread	17 %	33 %	33 %	11 %	0 %	0 %	0 %	0 %	0 %	0 %	100 %	44 %	89 %	94 %	100 %	44 %	11 %	22 %	50 %	67 %	67 %	50 %	100 %	67 %
Ryebread	28 %	33 %	33 %	22 %	0 %	0 %	0 %	0 %	0 %	0 %	100 %	44 %	89 %	89 %	89 %	100 %	44 %	33 %	56 %	67 %	67 %	61 %	100 %	67 %
Mixedbread	22 %	33 %	33 %	22 %	0 %	0 %	0 %	0 %	0 %	0 %	100 %	50 %	100 %	100 %	89 %	56 %	100 %	39 %	56 %	67 %	67 %	61 %	100 %	67 %
Barleybread	28 %	33 %	33 %	22 %	0 %	0 %	0 %	0 %	0 %	0 %	100 %	50 %	89 %	100 %	100 %	67 %	61 %	100 %	67 %	78 %	78 %	50 %	100 %	67 %
Tomato	39 %	56 %	56 %	33 %	0 %	0 %	0 %	22 %	0 %	0 %	100 %	61 %	89 %	100 %	83 %	67 %	44 %	44 %	100 %	78 %	72 %	72 %	100 %	72 %
Cucumber (average)	28 %	50 %	56 %	33 %	0 %	0 %	0 %	22 %	0 %	0 %	100 %	61 %	89 %	100 %	89 %	61 %	33 %	39 %	56 %	100 %	78 %	61 %	100 %	72 %
Cucumber (around the year)	33 %	56 %	56 %	33 %	22 %	6 %	11 %	22 %	17 %	17 %	100 %	61 %	89 %	100 %	89 %	61 %	33 %	39 %	61 %	89 %	100 %	61 %	100 %	78 %
Apple	33 %	39 %	39 %	17 %	0 %	0 %	0 %	17 %	0 %	0 %	100 %	61 %	100 %	100 %	94 %	61 %	39 %	61 %	61 %	78 %	78 %	100 %	100 %	72 %
Cloudberry	11 %	33 %	33 %	11 %	0 %	0 %	0 %	0 %	0 %	0 %	100 %	39 %	78 %	89 %	78 %	33 %	0 %	22 %	33 %	67 %	67 %	44 %	100 %	67 %
Strawberry	28 %	44 %	50 %	28 %	0 %	0 %	0 %	28 %	0 %	0 %	100 %	67 %	100 %	100 %	100 %	67 %	33 %	56 %	61 %	78 %	72 %	72 %	100 %	100 %
average	0,48	0,54	0,60	0,44	0,19	0,07	0,08	0,41	0,15	0,17	1,00	0,69	0,95	0,98	0,93	0,73	0,56	0,63	0,69	0,81	0,77	0,74	1,00	0,80

Some points considering the results

- Foodstuffs seem to receive roughly the same results using the CCR-AR model and dominance matrix
  - Beef, pigmeat, cheese, poultrymeat and eggs are worst off in both results
  - Soy and cloudberry, potato and sugar are best off in both results (discounting ryebread)
- There are also some clear variations between the results
  - Lager is clearly better off in the dominance matrix than in the CCR-AR model

Conclusion

- DEA modelling can be used to provide efficiency scores for different foodstuffs
- CCR-AR model which takes into account the nutritional recommendations seems promising when compared on the results given by the dominance matrix
- Taking fats into account by DEA modelling seems somewhat problematic

Homework

- Give your own view on DEA modelling concerning foodstuffs
  - What could be in your opinion the best model in taking into account all relevant factors in the I/O situation of consumer's decision (slide 10)?
    - A DEA model (2 points)
    - Needed Variables (3 points)
    - Some reasons for arriving to this particular model, max half a page (5points)