Productivity and Efficiency Analysis

7) Productivity growth

d) Case: Green TFP growth

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Backgroung and motivation

- Measurement of Green TFP growth is a challenging topic: bad outputs do not have market prices
- The following industry-level study explores alternative approaches to measuring green TFP growth in the agricultural sector
- 13 OECD countries: AUT, DEN, FIN, FRA, GER, GRE, ITA, NED, NOR, POR, SPA, SWE, UK
- Years 1990 – 2004

- Reference: Kuosmanen (2013)

Variables

Economic inputs

- Labor
- Capital stock
- Land area

Economic outputs

- Value added

Environmental criteria

- Nitrogen
- Phosphorus
- Green-house gases (GHG)

Conceptual setting: ECON model

Economic inputs

- Labor
- Capital stock
- Land area

Economic outputs

- Value added

Environmental criteria

- Nitrogen
- Phosphorus
- Green-house gases (GHG)

Conceptual setting: ENV model

Economic inputs

- Labor
- Capital stock
- Land area

Economic outputs

- Value added

Environmental criteria

- Nitrogen
- Phosphorus
- Green-house gases (GHG)
- *Land area*

Conceptual setting: MIX model

Economic inputs

- Labor
- Capital stock
- Land area

Economic outputs

- Value added

Environmental criteria

- Nitrogen
- Phosphorus
- Green-house gases (GHG)

Semi-nonparametric StoNED models

ECON

$$\ln y_{it} = \ln f(K_{it}, L_{it}, LA_{it}) + Trend \cdot t + \varepsilon_{it}$$

ENV

$$\ln y_{it} = \ln g(GHG_{it}, N_{it}, P_{it}, LA_{it}) + Trend \cdot t + \varepsilon_{it}$$

MIX

$$\ln y_{it} = \ln h(K_{it}, L_{it}, LA_{it}, GHG_{it}, N_{it}, P_{it}) + Trend \cdot t + \varepsilon_{it}$$

Level of efficiency

Analogous to Schmidt & Sickles (1984) panel data SFA approach:

$$Eff_i = \frac{\sqrt[T]{\prod_{t=1}^{T} \exp(\varepsilon_{it})}}{\max_h \sqrt[T]{\prod_{t=1}^{T} \exp(\varepsilon_{ht})}}$$

Malmquist index and its components

TFP = ΔEff x Tech

$$\Delta Eff_i(t, t+1) = \frac{\exp(\varepsilon_{i,t+1})}{\exp(\varepsilon_{i,t})}$$

Tech = *Trend*

Note: technical change assumed Hicks neutral, and constant across all countries and years

Parametric Cobb-Douglas models (SFA)

ECON

$$\ln(y_{it} / LA_{it}) = \beta_0 + \beta_K \ln(K_{it} / LA_{it}) + \beta_L \ln(L_{it} / LA_{it}) + Trend \cdot t + \varepsilon_{it}$$

ENV

$$\ln(y_{it} / LA_{it}) = \beta_0 + \beta_{GHG} \ln(GHG_{it} / LA_{it}) + \beta_N \ln(N_{it} / LA_{it}) + \beta_P \ln(P_{it} / LA_{it}) + Trend \cdot t + \varepsilon_{it}$$

MIX

$$\ln(y_{it} / LA_{it}) = \beta_0 + \beta_K \ln(K_{it} / LA_{it}) + \beta_L \ln(L_{it} / LA_{it}) + \beta_{GHG} \ln(GHG_{it} / LA_{it}) + \beta_N \ln(N_{it} / LA_{it}) + \beta_P \ln(P_{it} / LA_{it}) + Trend \cdot t + \varepsilon_{it}$$

Panel-data DEA (Ruggiero, 2004)

Apply DEA to average inputs and output

Output: $\bar{y}_i = \frac{1}{T}\sum_{t=1}^{T} y_{it}$

Inputs (ECON): $\overline{LA}_i, \overline{K}_i, \overline{L}_i$

Rationale: random noise is averaged out (”stochastic DEA”)

However, TECH and EFF cannot be separated.

StoNED: Shadow prices and R^2

ECON	**Mean**	**St. Dev.**	**Min**	**Max**
K	0.1045	0.1429	0.0000	0.3190
L ($/pers.)	7 540.32	5 199.47	0.0000	34 546.00
LA ($/ha)	394.48	312.12	0.0000	2 249.34
R^2	0.855			
ENV	**Mean**	**St. Dev.**	**Min**	**Max**
GHG ($/ton)	194.54	167.39	0.00	348.71
N ($/ton)	1 364.99	1 746.38	0.00	5 838.43
P ($/ton)	1 785.50	4 572.35	0.00	34 941.61
LA ($/ha)	249.08	101.91	0.00	525.76
R^2	0.942			
MIX	**Mean**	**St. Dev.**	**Min**	**Max**
K	0.01936	0.03611	0.00	0.1957
L ($/pers.)	3 930.84	5 502.72	0.00	36 216.77
LA (€/ha)	103.60	135.04	0.00	563.97
GHG ($/ton)	148.64	127.20	0.00	362.78
N ($/ton)	1 101.25	1 132.41	0.00	5 394.99
P ($/ton)	2 133.24	4 242.54	0.00	35 401.12
R^2	0.948			

StoNED: Time trend

Model	Coefficient	St. error	*t* stat	*p*-value	lower 95%	upper 95%
ECON	0.0160	0.0070	2.2871	0.0233	0.0022	0.0299
ENV	0.0119	0.0044	2.6828	0.0079	0.0032	0.0206
MIX	0.0162	0.0042	3.8614	0.0002	0.0079	0.0244

StoNED: Efficiency and TFP: ECON model

	Eff level	*Rank*	*Eff change*	*Rank*	*TFP change*
AUT	31 %	9	1.060 %	1	2.695 %
DEN	64 %	2	0.852 %	3	2.484 %
FIN	20 %	13	0.396 %	6	2.021 %
FRA	45 %	3	0.440 %	5	2.065 %
GER	44 %	4	0.674 %	4	2.302 %
GRE	42 %	5	-1.279 %	12	0.318 %
ITA	41 %	6	0.915 %	2	2.548 %
NED	100 %	1	-0.138 %	7	1.477 %
NOR	23 %	12	-0.733 %	10	0.873 %
POR	26 %	10	-0.460 %	9	1.150 %
SPA	36 %	8	-0.927 %	11	0.676 %
SWE	25 %	11	-0.340 %	8	1.272 %
UK	37 %	7	-1.391 %	13	0.204 %

Note: Global technical change (TECH) is estimated as 1.618 % for all countries and years

StoNED: Efficiency and TFP: ENV model

	Eff level	*Rank*	*Eff change*	*Rank*	*TFP change*
AUT	72 %	4	0.750 %	4	1.955 %
DEN	70 %	5	1.130 %	2	2.341 %
FIN	43 %	12	0.637 %	6	1.841 %
FRA	64 %	7	0.787 %	3	1.994 %
GER	64 %	6	0.016 %	7	1.213 %
GRE	75 %	3	0.638 %	5	1.842 %
ITA	100 %	1	1.511 %	1	2.726 %
NED	88 %	2	-0.139 %	8	1.056 %
NOR	41 %	13	-1.676 %	13	-0.499 %
POR	61 %	9	-1.108 %	12	0.075 %
SPA	62 %	8	-0.668 %	11	0.521 %
SWE	50 %	10	-0.402 %	9	0.790 %
UK	45 %	11	-0.632 %	10	0.558 %

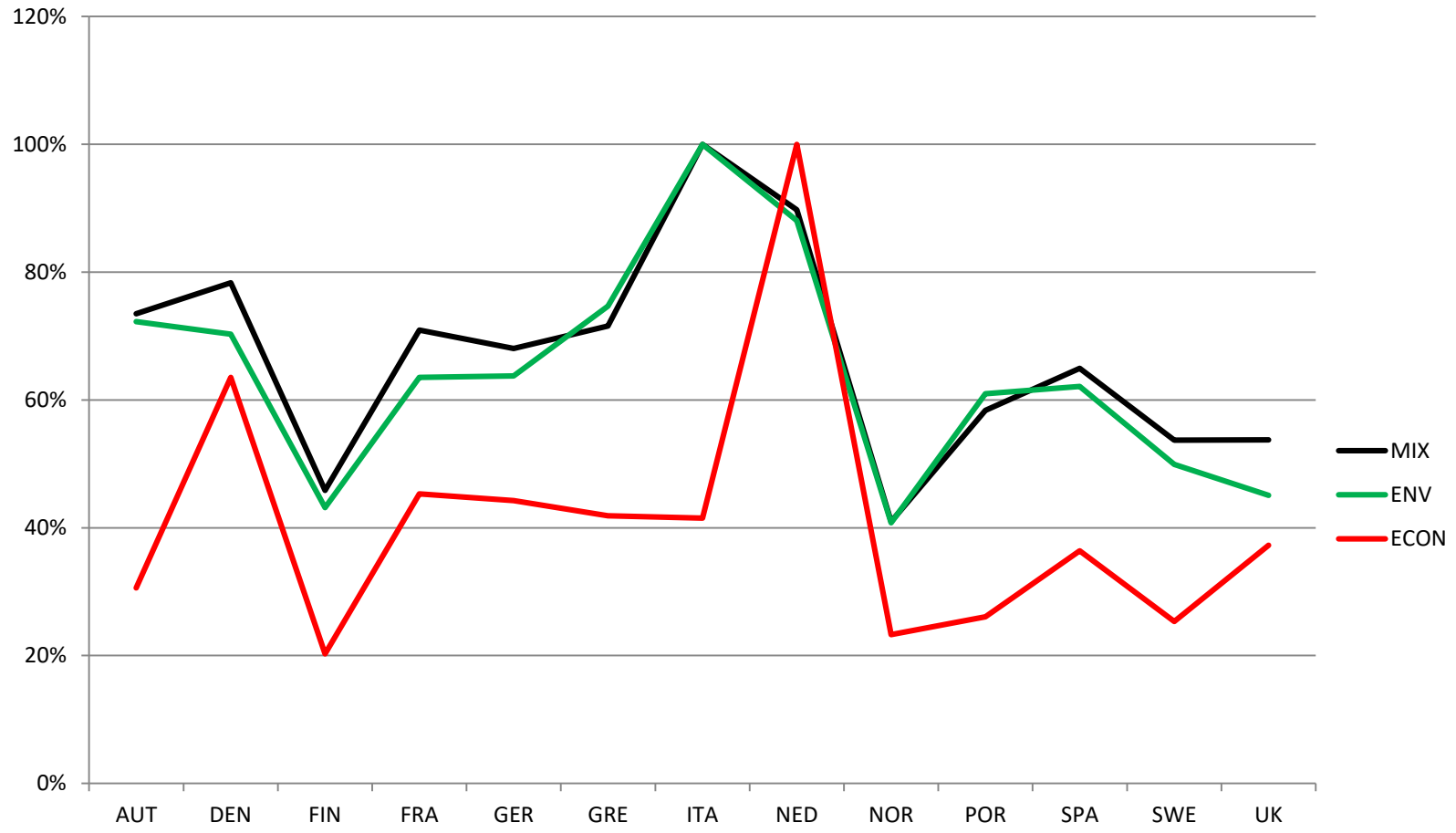
Note: Global technical change (TECH) is estimated as 1.197 % for all countries and years

StoNED: Efficiency and TFP: MIX model

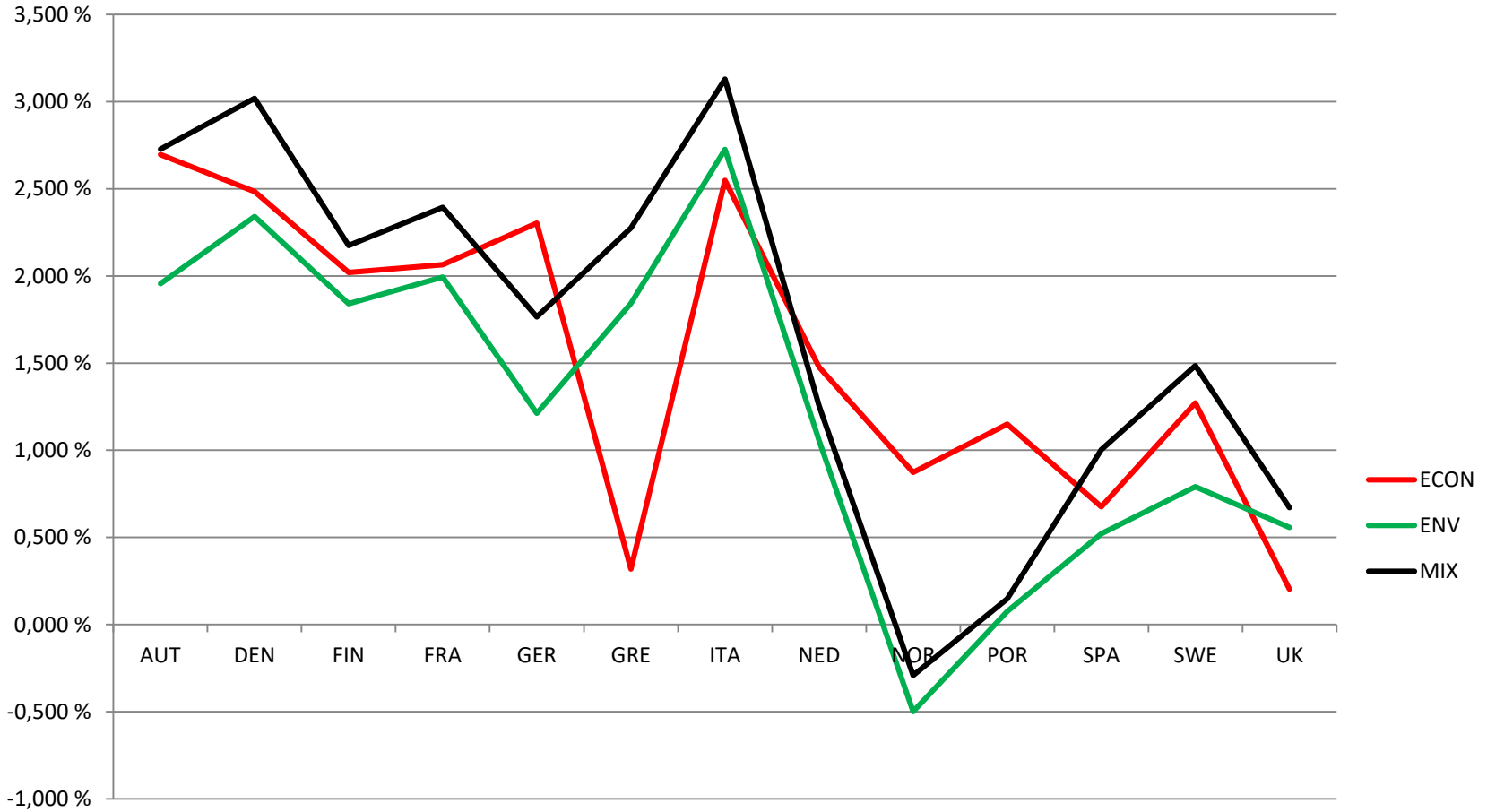
	Eff level	*Rank*	*Eff change*	*Rank*	*TFP change*
AUT	73 %	4	1.080 %	3	2.727 %
DEN	78 %	3	1.367 %	2	3.018 %
FIN	46 %	12	0.536 %	6	2.174 %
FRA	71 %	6	0.752 %	4	2.394 %
GER	68 %	7	0.134 %	7	1.765 %
GRE	72 %	5	0.635 %	5	2.274 %
ITA	100 %	1	1.475 %	1	3.129 %
NED	90 %	2	-0.369 %	9	1.255 %
NOR	41 %	13	-1.890 %	13	-0.291 %
POR	58 %	9	-1.457 %	12	0.148 %
SPA	65 %	8	-0.616 %	10	1.003 %
SWE	54 %	11	-0.141 %	8	1.486 %
UK	54 %	10	-0.943 %	11	0.671 %

Note: Global technical change (TECH) is estimated as 1.629 % for all countries and yea

StoNED: Mean efficiency LEVELS

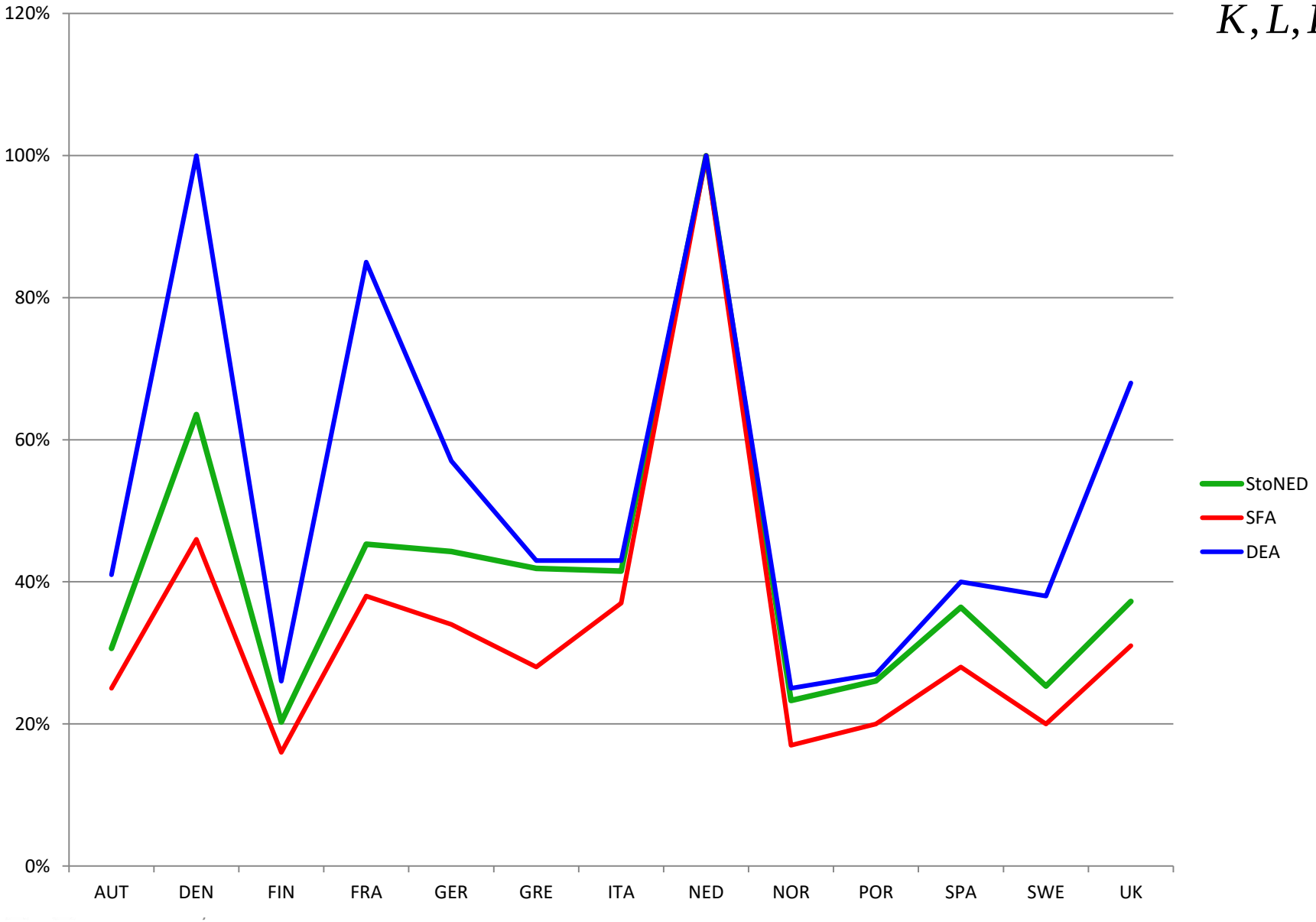


StoNED: Mean TFP change



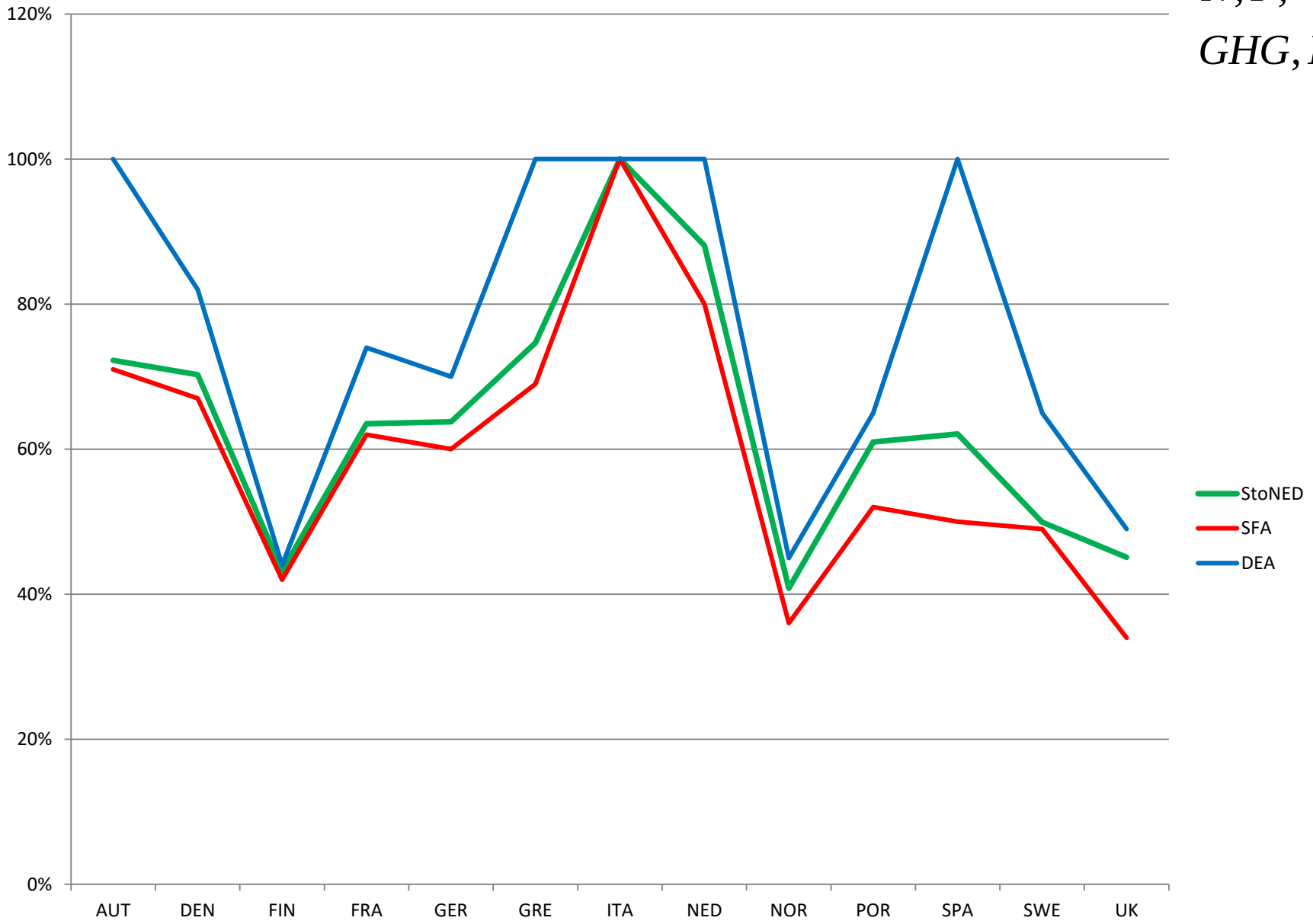
Mean efficiency levels - **ECON** model

$Inputs: K, L, LA$



Mean efficiency levels - ENV model

Inputs: N, P, GHG, LA

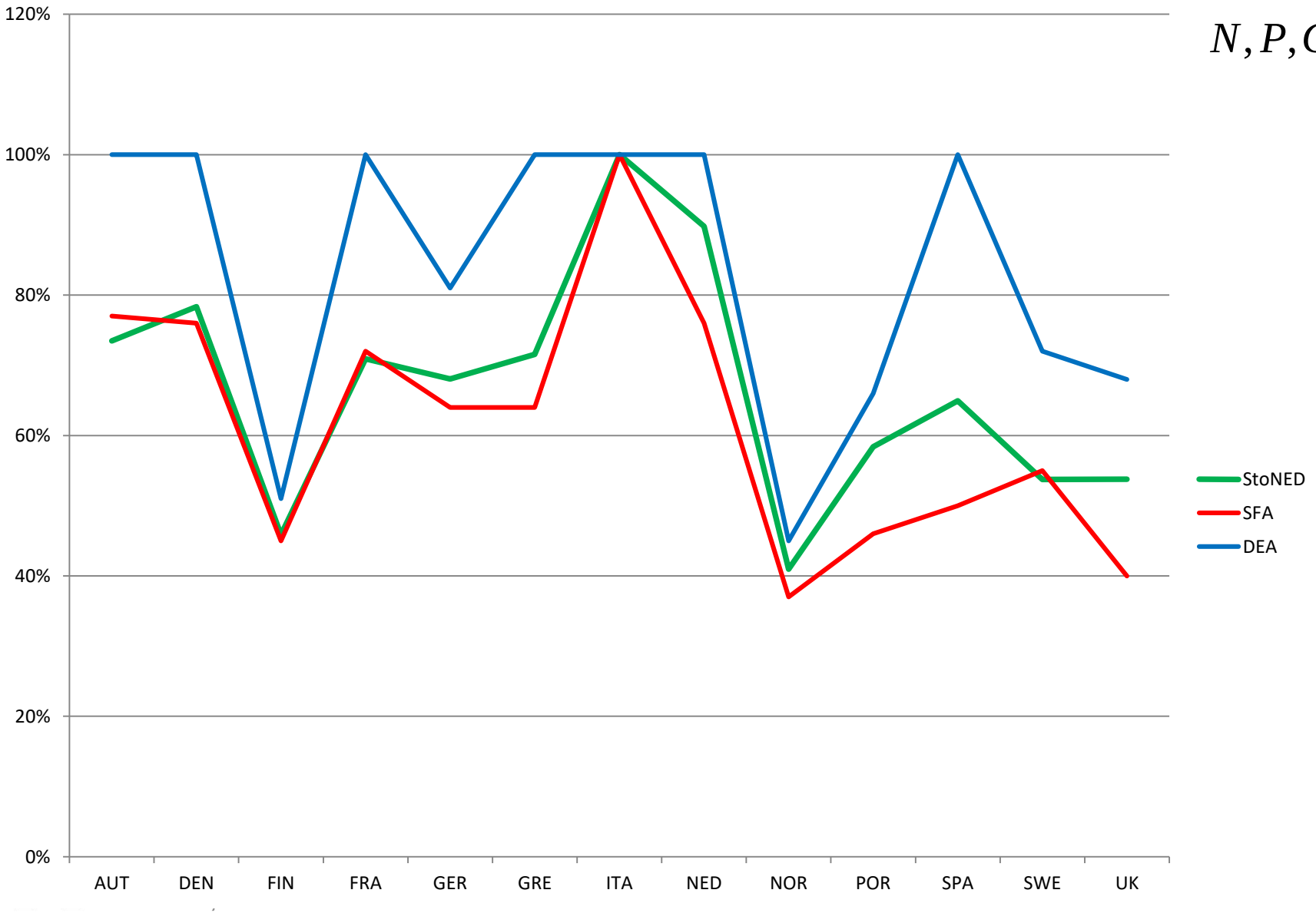


Mean efficiency levels - **MIX** model

$Inputs:$

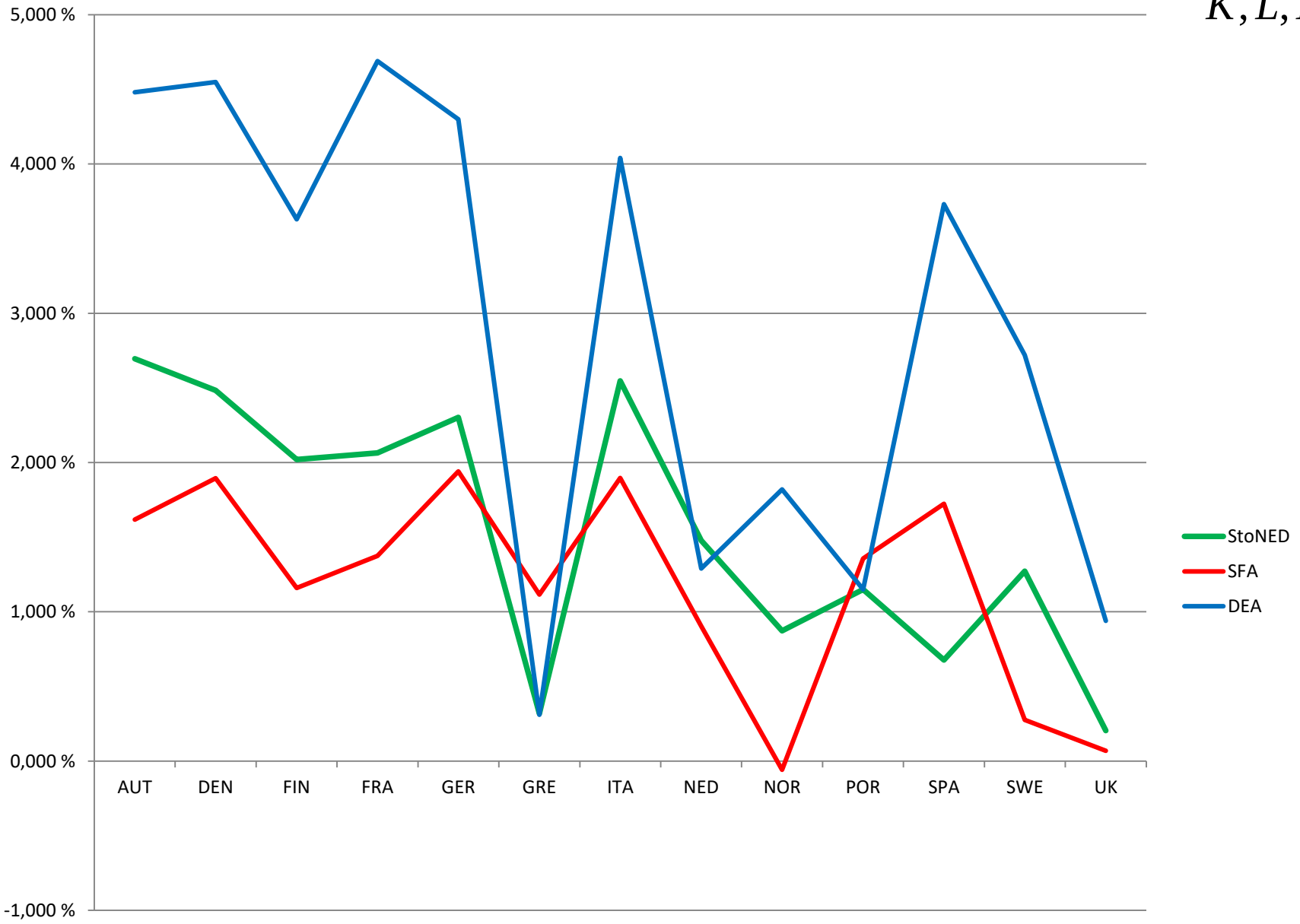
K, L, LA

N, P, GHG



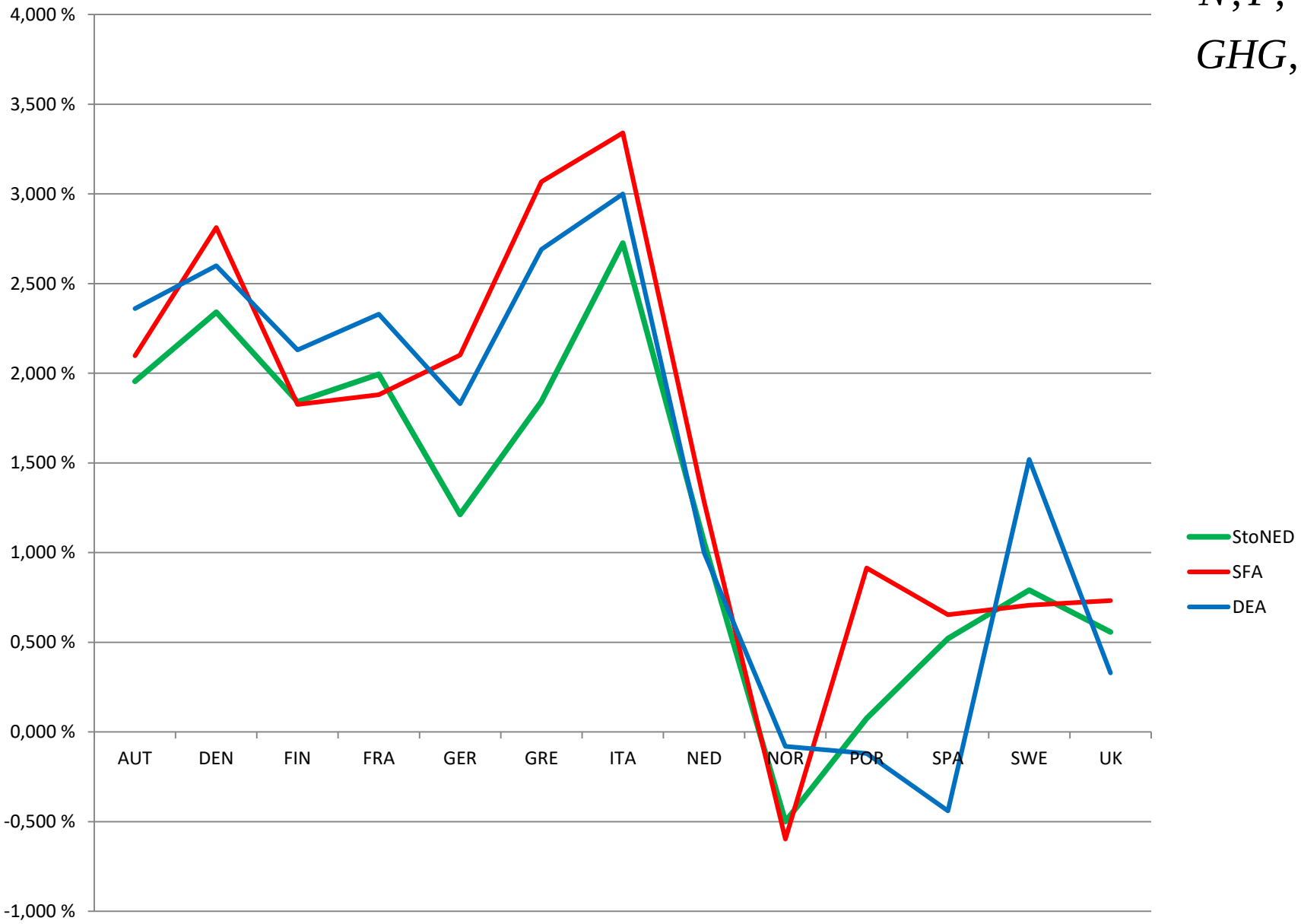
Mean TFP change - ECON model

$Inputs: K, L, LA$



Mean TFP change - ENV model

Inputs: N, P, GHG, LA

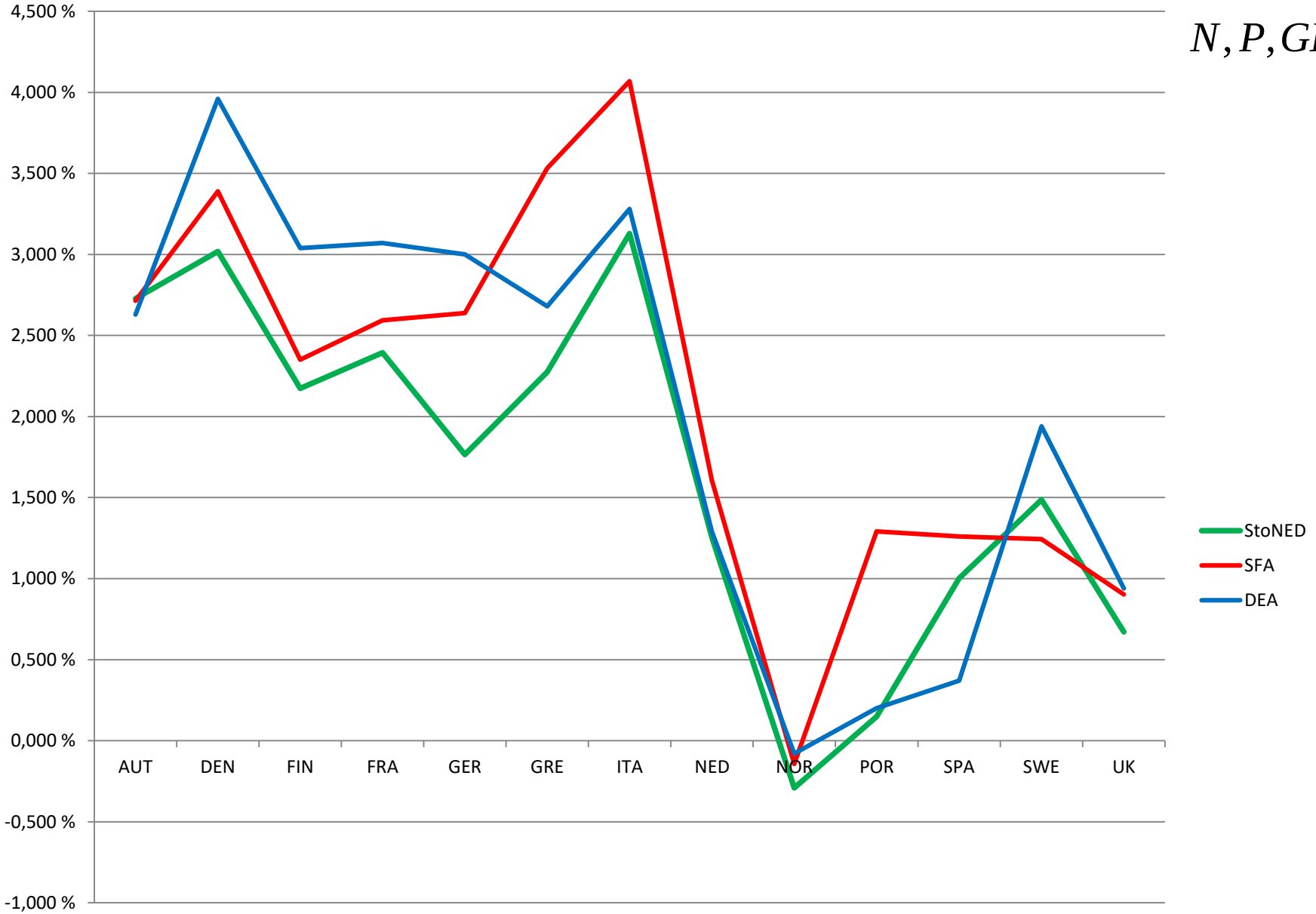


Mean TFP change - MIX model

$Inputs:$

K, L, LA

N, P, GHG



Next lesson

8) Structural change