OECD WORK ON PRODUCTIVITY AND SUSTAINABILITY BENCHMARKING - USING EXISTING TFP AND AEIs

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Motivation and approach

- Lack of widely accepted and practicable approach for environmentally-adjusted TFP
- From this context, we use simple methods to answer following research questions:
  1. To what extent has TFP growth been coincided with improved GHG outcomes?
  2. Has countries' performance with respect to sustainable agricultural productivity improved over time?

Approach 1

Decomposing changes in GHGs into changes in TFP & other components

Description of the TFP index

- TFP index calculated using growth accounting method and published by the USDA.

- TFP is defined as the ratio of total output to total inputs. Let total output be given by ***Y*** and total inputs by ***X***. Then TFP is simply:

$$TFP = Y/X$$

- Changes in TFP over time expressed in logarithms:

$$\frac{d \ln TFP}{dt} = \frac{d \ln Y}{dt} - \frac{d \ln X}{dt}$$

- Defining $g(\cdot)$ as the annual growth ratethe above can be expressed:

$$\mathbf{g}(\boldsymbol{TFP}) = \mathbf{g}(\boldsymbol{Y}) - \mathbf{g}(\boldsymbol{X})$$

Decomposing changes in emissions

Consider an environmental variable, E, associated with production can be expressed as:

$$E = Y \frac{E/X}{Y/X}$$

..if we define E/X as the emission factor (EF) of input use this simplifies to:

$$E = Y \frac{EF}{TFP}$$

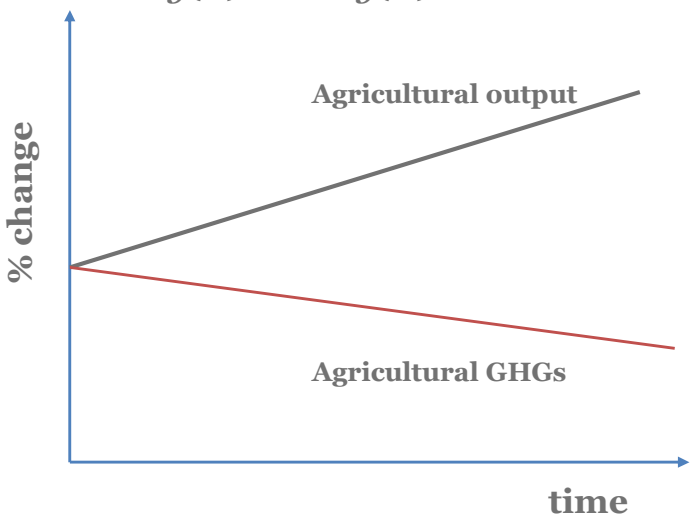
...which can be expressed in annual growth form as follows

$$\boldsymbol{g(E) = g(Y) - g(TFP) + g(EF)}$$

Decoupling of output growth from environmental emissions

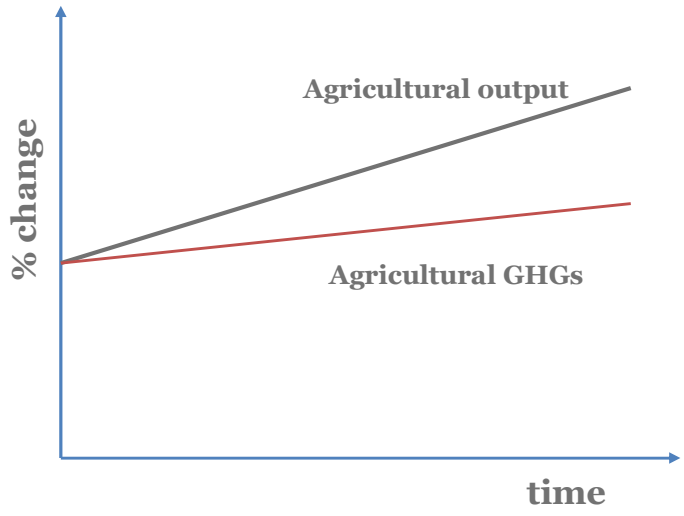
Absolute decoupling

$g(Y) > 0 > g(E)$



Relative decoupling

$g(Y) > g(E) > 0$



The decomposition **g(E) = g(Y) – g(TFP) + g (EF)**, can be used to define the decoupling of output growth and emissions, with respect to TFP growth:

Absolute decoupling

$g(TFP) > g(EF) + g(Y)$

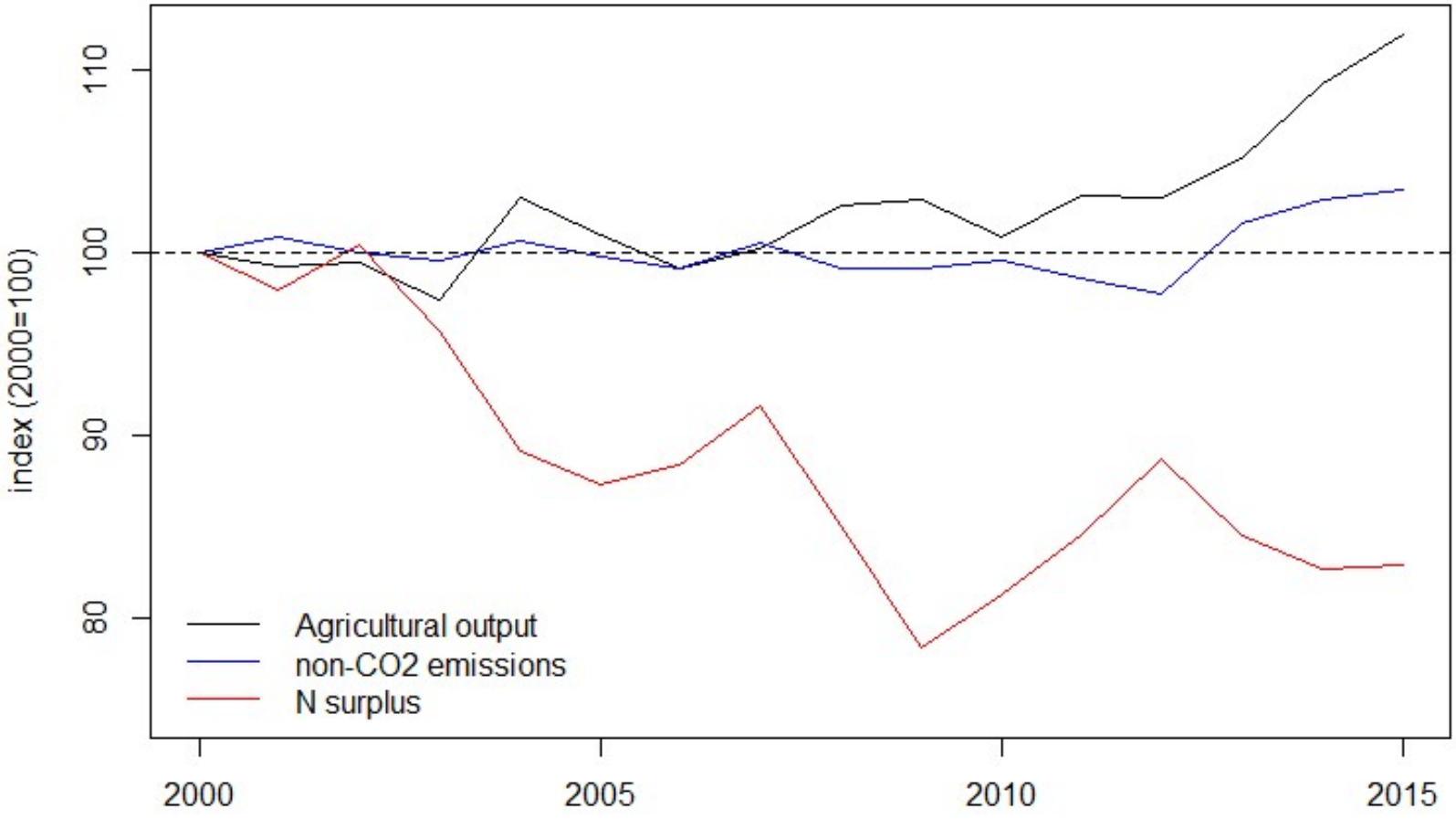
Relative decoupling

$g(EF) + g(Y) > g(TFP) > g(EF)$

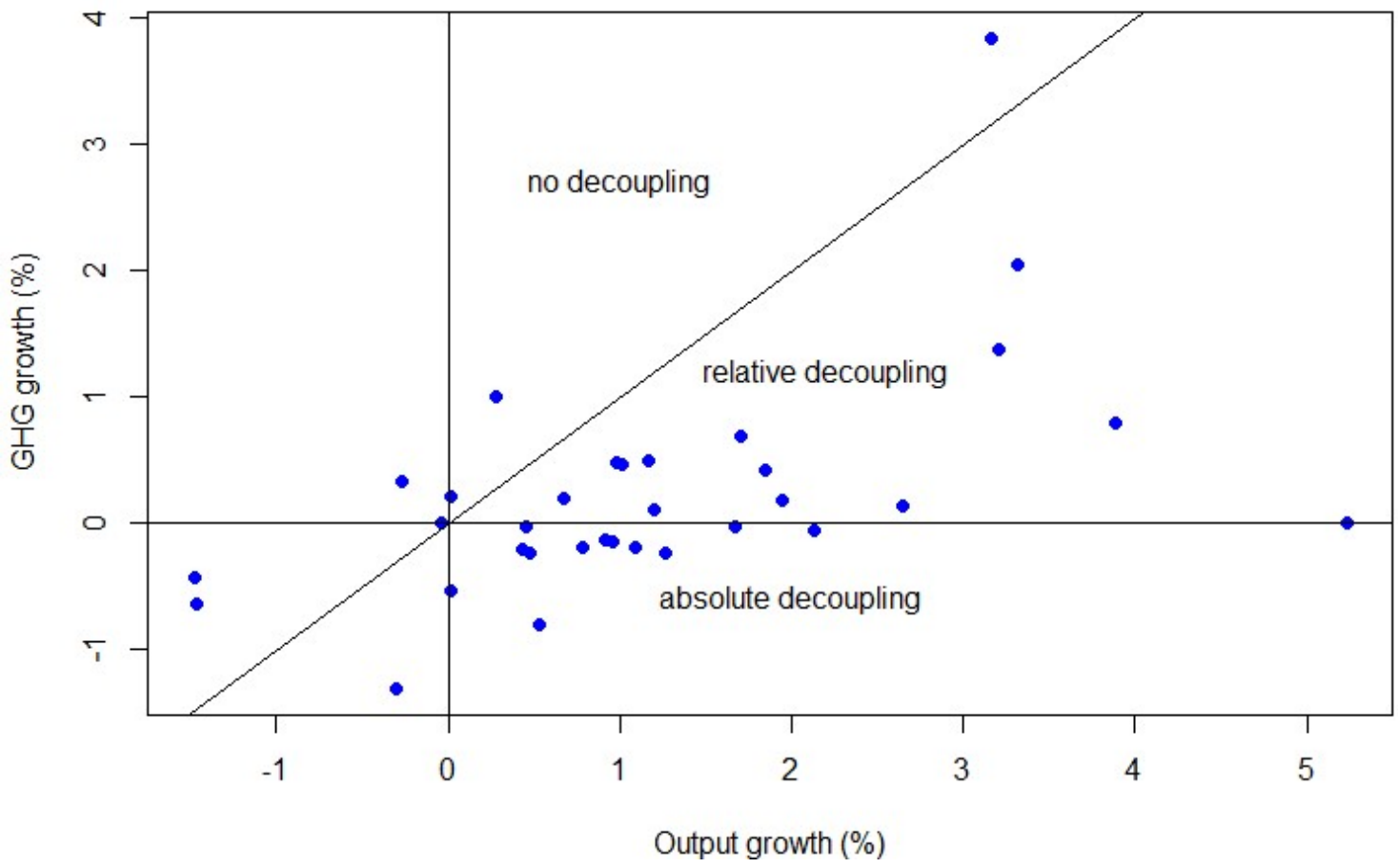
Results 1

Has TFP growth coincided with improved environmental outcomes?

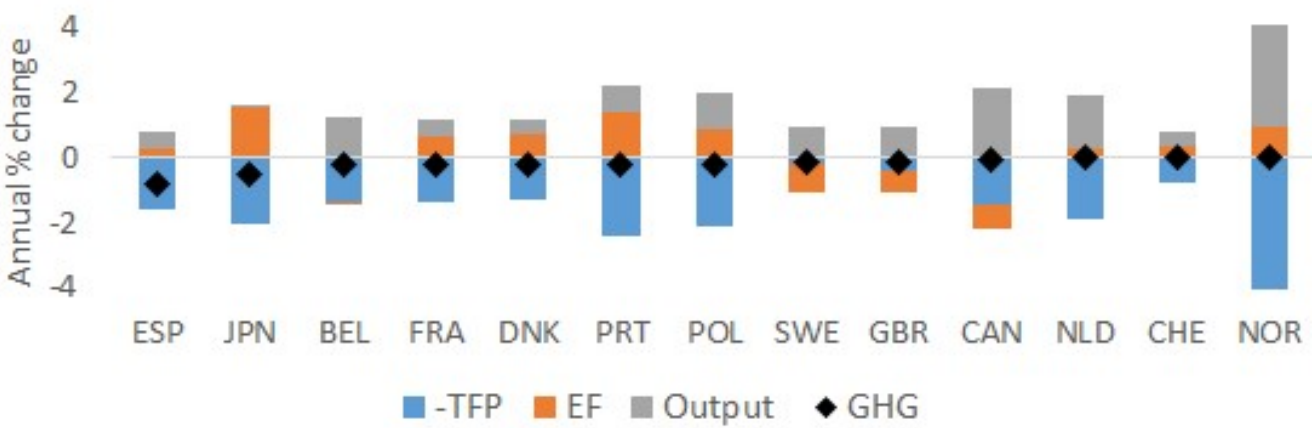
Is there evidence of decoupling output growth and GHG emissions?



Annual growth in production and GHG emissions (2006-2015)



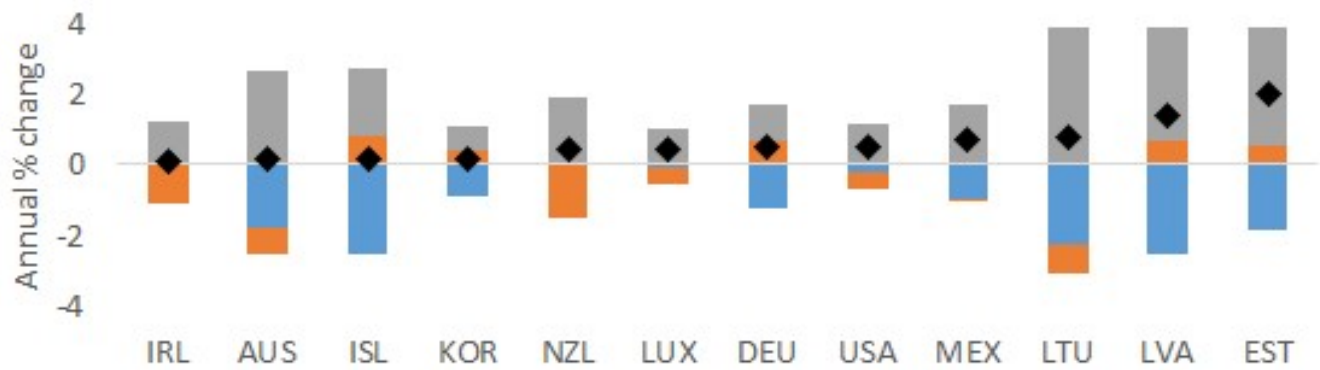
Aggregate decomposition of changes in GHGs (2006-2015)



$$g(TFP) > g(EF) + g(Y)$$

For countries with **absolute decoupling**

- **TFP growth** also tends to be **input-saving** (10 countries, 77%)

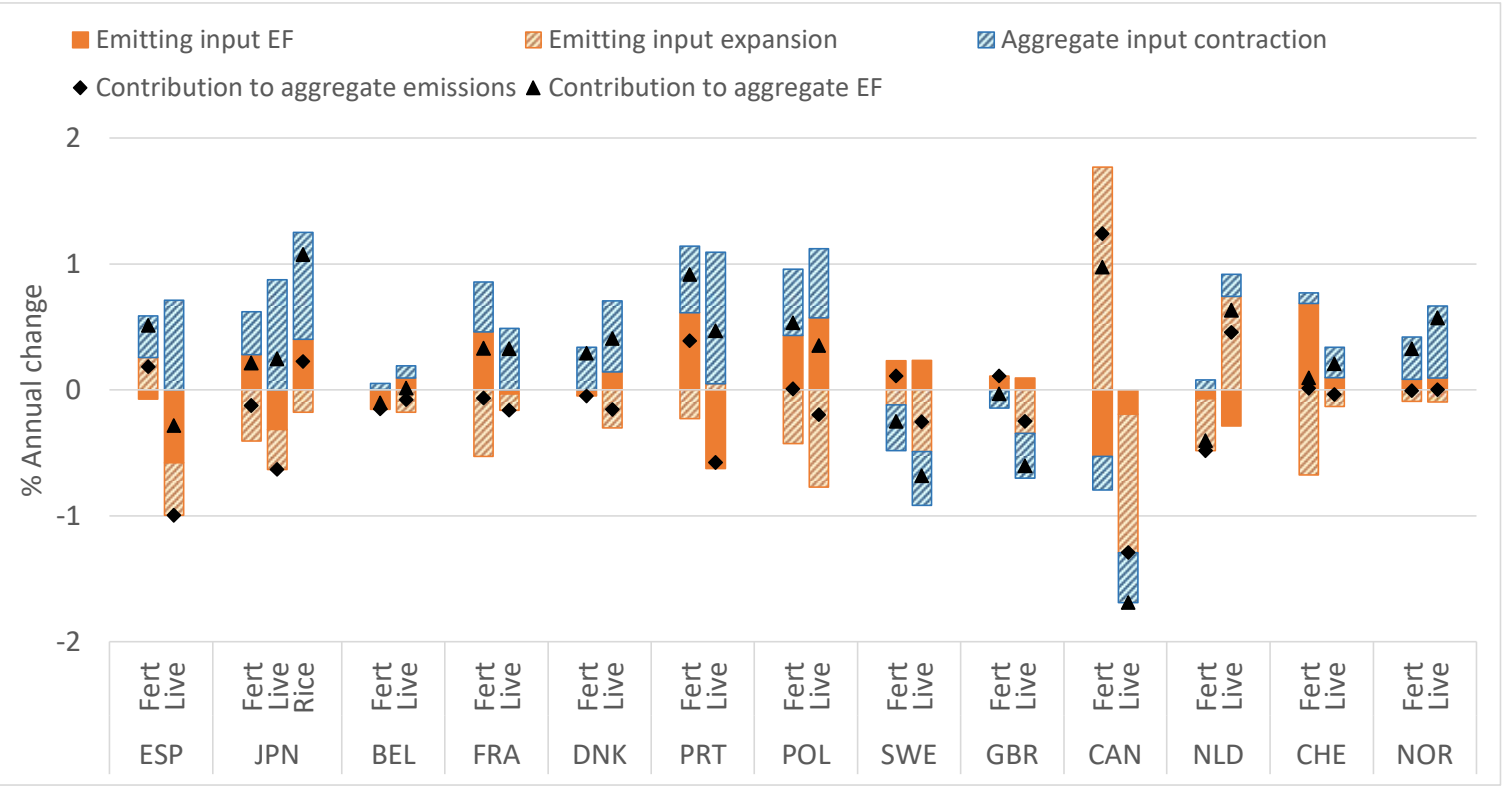


$$g(EF) + g(Y) > g(TFP) > g(EF)$$

For countries with **partial decoupling**

- **TFP growth** tends **not** to be **input-saving** (3 countries, 25%)

Further decomposition of changes in GHGs (**absolute decoupling**)



Absolute decoupling tends to be accompanied by reduced:

- **livestock** numbers & emissions
  - **11** countries (85%)

Fertiliser less important role

- use fell for **9** countries
- emissions fell for **6** countries

2. composite indicators of sustainable productivity growth

Aggregation rules for composite indicators

- **Theoretical basis**: a strong and a weak conceptions of sustainability, that is, the limited versus full substitutability of natural capital
- **Aggregation rules** for single indicators of productivity growth and environmental sustainability growth rates for different composite indicators (Lankoski & Thiem 2020):
  - Strong sustainable productivity (SSP): no substitution allowed between elements, that is, MIN(g(TFP), g(E))
  - Weak sustainable productivity (WSP): full substitution allowed by combining average of values; AVERAGE(g(TFP)-g(E))
- For comparison purposes of country performance based on growth rates vs. levels also composite indicators of weak (WES) and strong (SES) environmental sustainability are developed with the same aggregation rules as above

Composite indicator correspondence with env-adjusted TFP

Simplified TFPE:

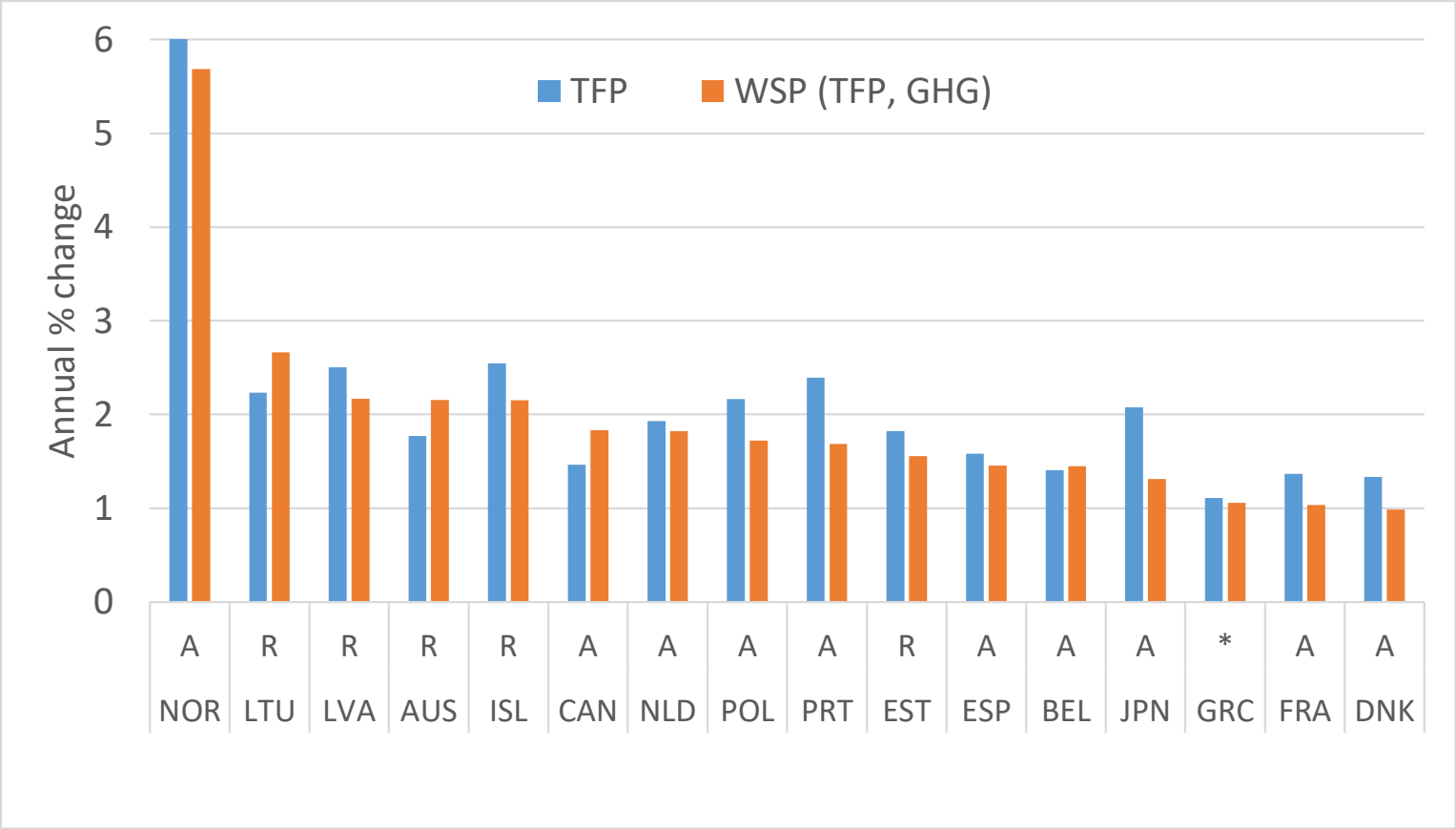
$$g(TFPE) = g(Y) - \sum_{j=1}^{j} S_j g(X_j) - \sum_{k=1}^{k} \varphi_k g(E_k)$$

where S_j is the weight of the jth input, and φ_k is the weight of kth environmental variable

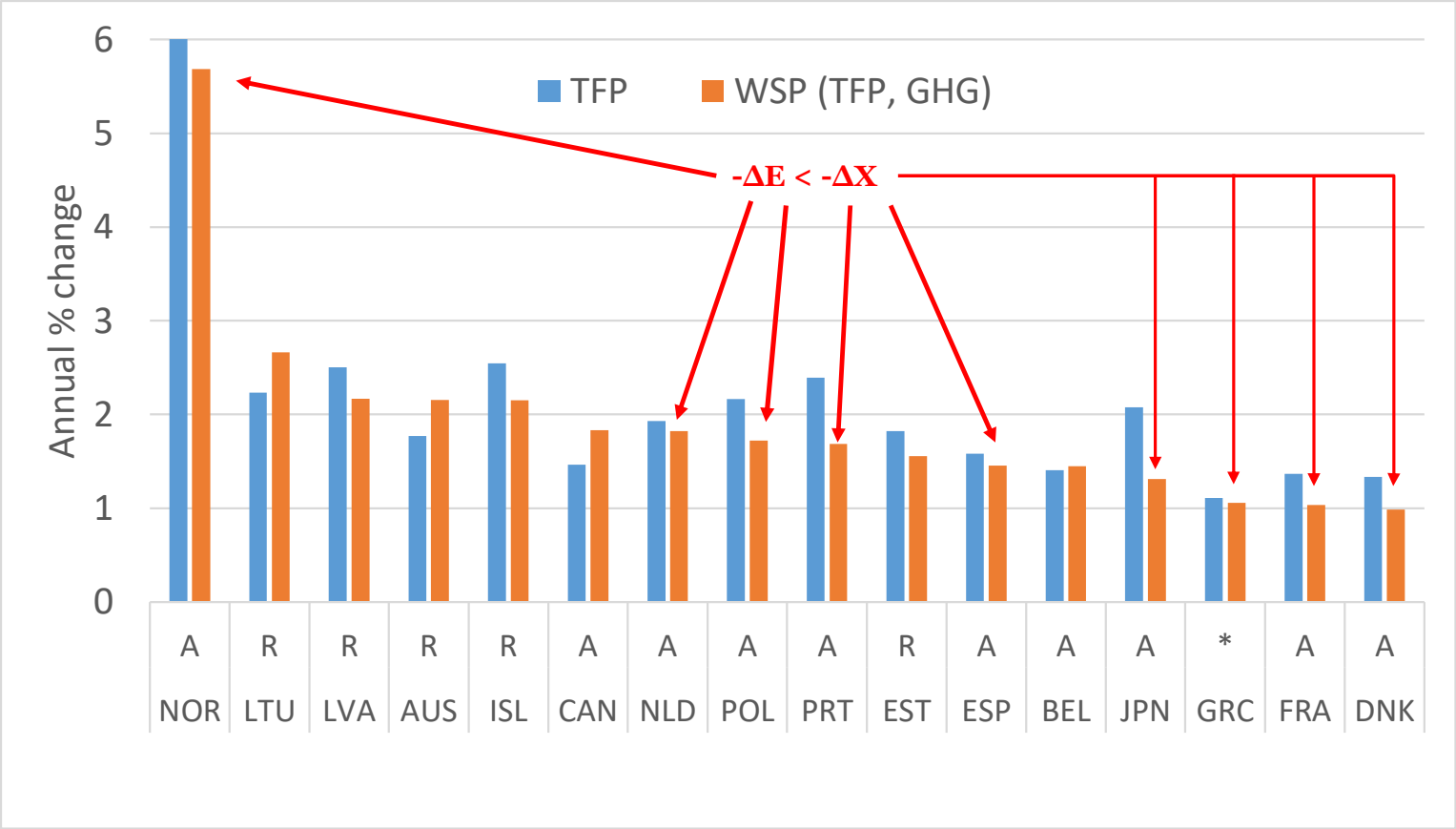
Simple composite indicator (WSP) – based on average of change in TFP and an environmental intensity variable (E/Y)

$$g(WSP) = average\left(g(TFP) - g\left(\frac{E}{Y}\right)\right)$$

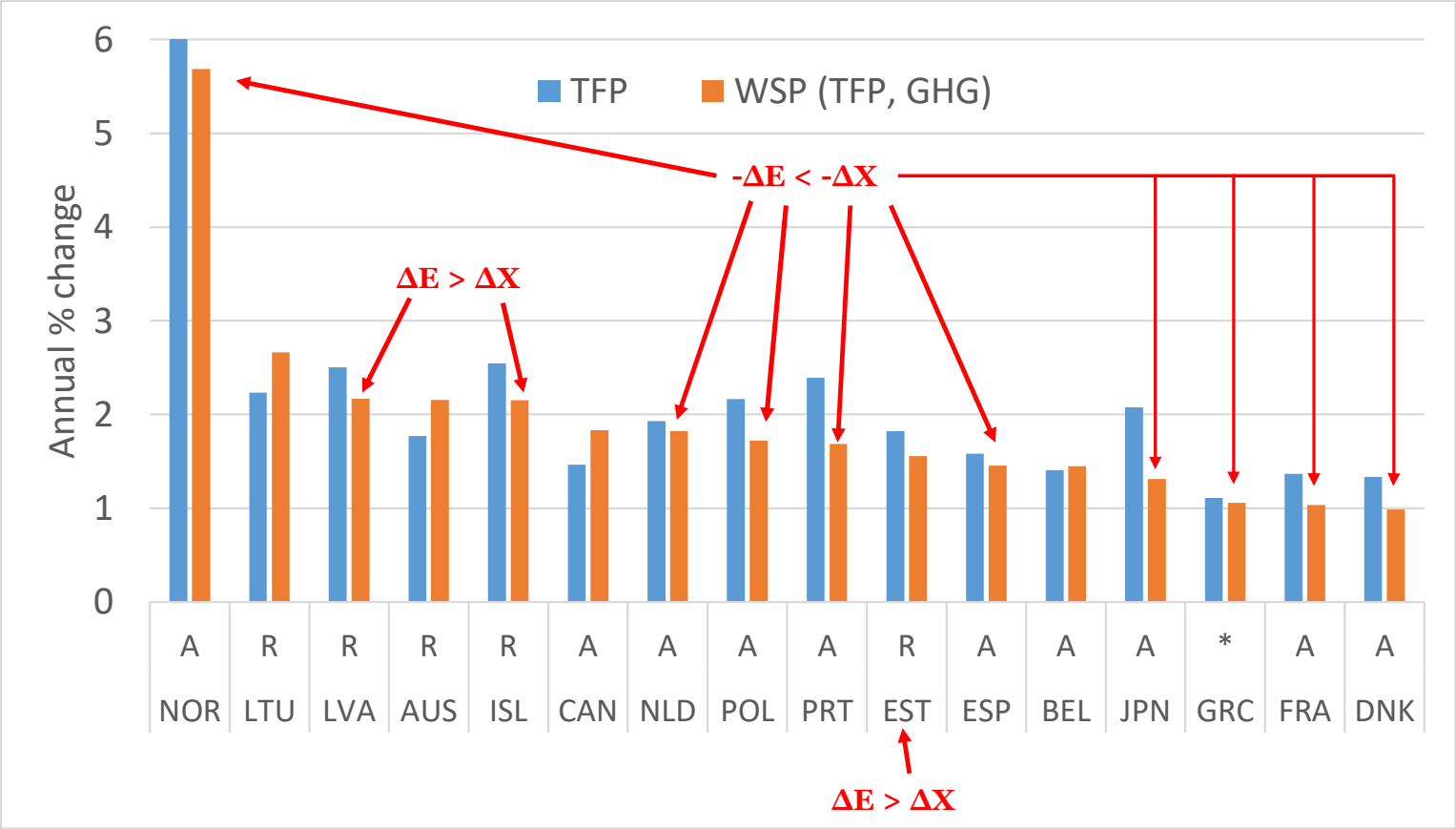
$$= \mathrm{g(Y)} - 0.5\mathrm{g(X)} - 0.5\mathrm{g(E)}$$


TFP
WSP (TFP, GHG)
Annual % change
0
1
2
3
4
5
6
A NOR
R LTU
R LVA
R AUS
R ISL
A CAN
A NLD
A POL
A PRT
R EST
A ESP
A BEL
A JPN
* GRC
A FRA
A DNK

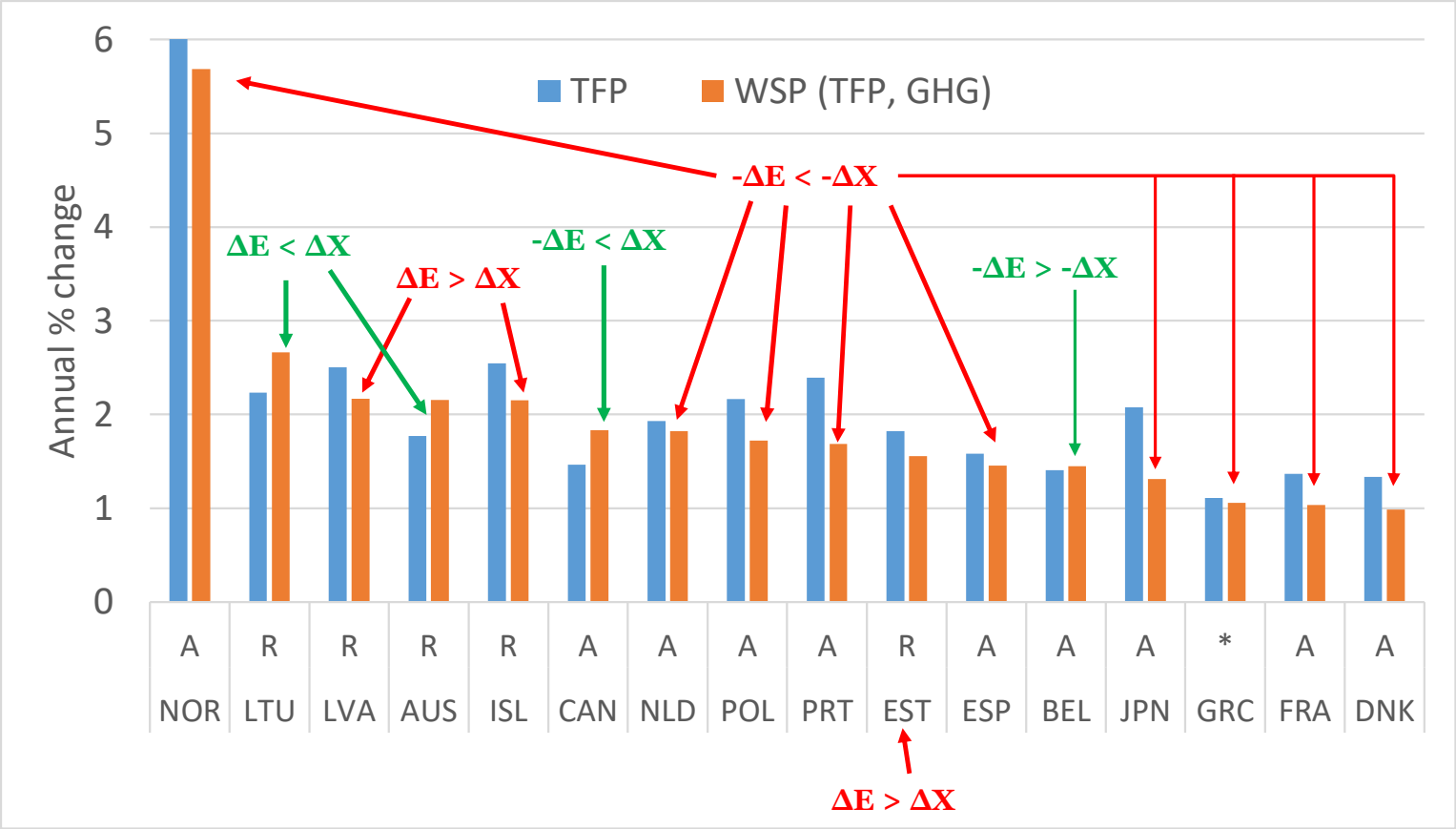
TFP versus WSP index (= 0.5TFP x 0.5E/Y)
Top 50% of performers based on WSP index



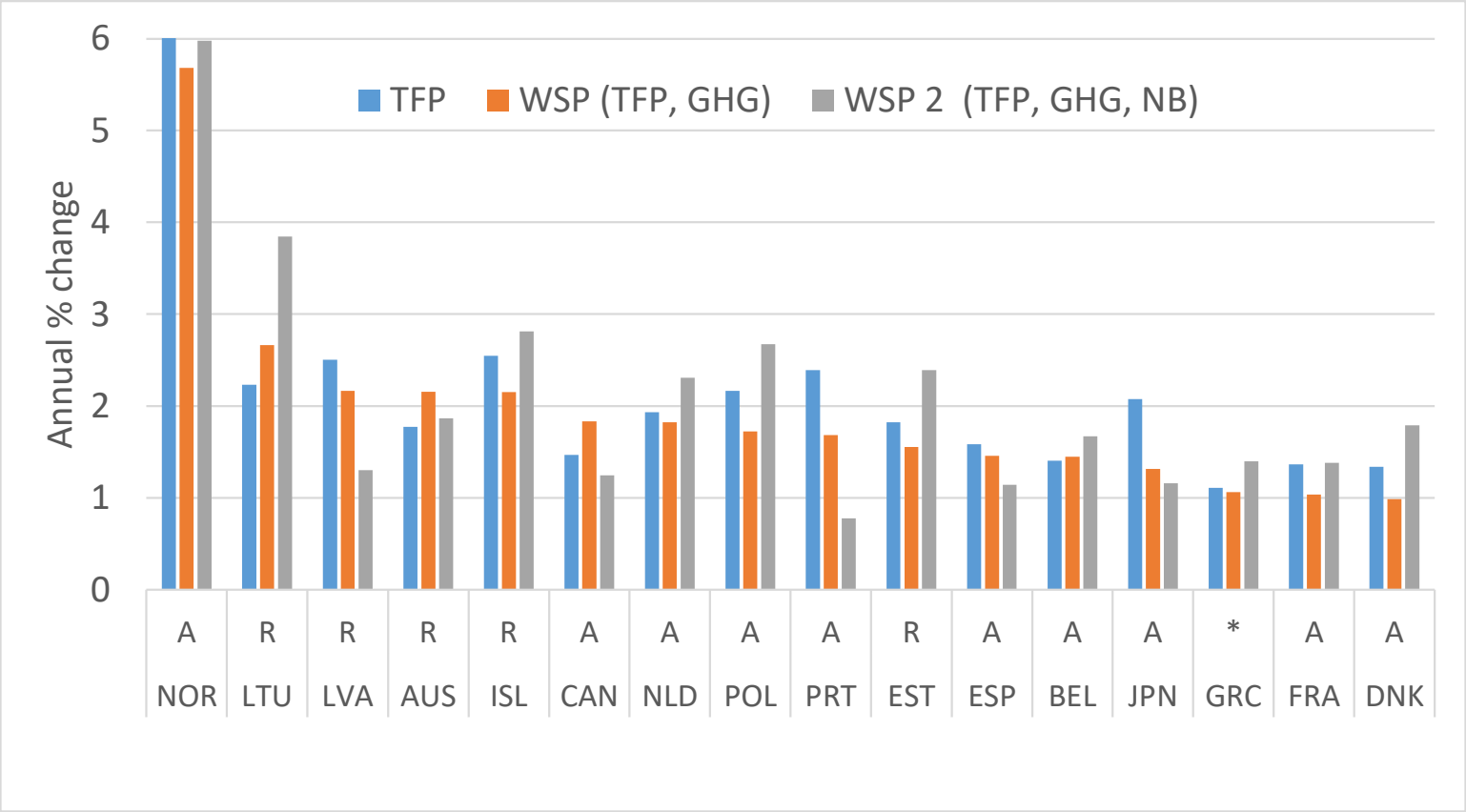
TFP versus WSP index (= 0.5TFP x 0.5E/Y)
Top 50% of performers based on WSP index



TFP versus WSP index (= 0.5TFP + 0.5E/Y)
Top 50% of performers based on WSP index



TFP versus WSP index (= 0.5TFP + 0.25GHG/Y + 0.25NB/Y)



Next steps and questions

Questions

- Is there value in increasing the number of environmental variables in a larger composite indicator?
- Is equal weighting schema telling us anything useful and how far beyond this should we go?

Proposed next steps

- Expand the set of AEIs considered in both parts of the analysis
- Further examine data, identify biases and propose refinements

Thank you for your attention

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APPENDIX

Decomposing changes in EF into underlying components

$$g(E) = g(Y) - g(TFP) + g(EF)$$

Changes in EF can be decomposed into changes in emitting inputs and their specific emission factors and the change in the total input bundle

$$g(EF) = \sum_{k=1}^{k} \gamma_k \left(g(EF_k) + g(X_k) - g(X) \right)$$

Decomposing changes in the emission factor (EF)

Defining aggregate variables for total input bundle, total emitting input bundle, and total GHG emissions

$g(X_{TOT}) = \sum_{j=1}^{j} S_j \, g(X_j)$

Separating the vector of inputs into two mutually exclusive subsets, X_E and X_{-E}, i.e., $X_{TOT} = (X_E, X_{-E})$. . Let $k = 1, \ldots, K$, where $k \leq j$ index the vector of emitting inputs X_E.

$g(X_E) = \sum_{k=1}^{k} \varphi_k \, g(X_k)$

$g(E_{TOT}) = \sum_{k=1}^{k} \gamma_k \, g(E_k)$

- $g(X_{TOT})$ is the change in the entire input bundle, in which the change in each of j-th input is weighted by its share of the total costs of all inputs, S_j
- $g(X_E)$ is the change in the bundle of emitting inputs, in which the change in each of k-th emitting input is weighted by its its share of the total cost of all emitting inputs, φ_j
- $g(E_{TOT})$, is the change in the bundle of emitting inputs, in which the change in each of the k-th emission weighted by its share of the total emissions bundle, γ_k

EF can be decomposed into changes in the emitting inputs relative to the entire input bundle and the change in the emissions per unit of the emitting input bundle:

$$g(EF) = g\left(\frac{X_E}{X_{TOT}}\right) + g\left(\frac{E}{X_E}\right)$$

which can be decomposed further into changes in each emitting input and emission source:

$$g(EF) = \sum_{k=1}^{k} \varphi_k g\left(\frac{X_k}{X_{TOT}}\right) + \sum_{k=1}^{k} \gamma_k g(E_K) - \sum_{k=1}^{k} \varphi_k g(X_k)$$