
# General Regionalization Heuristic to Map Spatial Heterogeneity of Macroeconomic Impacts:

## The Case of the Green Energy Transition and the Manufacturing Sector in NRW

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FCN | Future Energy Consumer Needs and Behavior
E.ON Energy Research Center
RWTH AACHEN UNIVERSITY

# Presentation Outline

1. Introduction
2. Method: regionalization heuristic
3. Application: sustainable energy transition and the manufacturing sector in NRW
4. Selected Results
5. Conclusion and Outlook

# Introduction

## Industrial Transformation in NRW in Light of the *Energiewende*

2-year research project (2015-2017)

6 partners (Virtual Institute „Transformation – Energiewende NRW“)


Economic Effects of the Energiewende in NRW

- I-O Analysis of expanding renewables
- Regional distribution
- Real options analysis on flexibilization of fossil-fueled power plants

Success Factors for Transformation Processes

Design of Transformation Processes

www.vi-transformation.de

# Introduction
## Research Motivation

- Empirical insights on the spatially disaggregated level can often either:
  - not be provided due to a lack of available data or
  - only be provided with significant time delay.

- **Modeling spatial variations of macroeconomic effects** is valuable for:
  a. providing a better understanding of the regional development by the (regional) decomposition of macroeconomic effects
  b. designing region-specific policies
  c. anticipating and assessing local and regional acceptance of policy measures

- North Rhine-Westphalia (NRW) as the largest and very energy-intensive federal state, heavily affected by the transformation / transition towards renewables

# Introduction
## Aim

- Development of a relatively simple **regionalization heuristic** with a consistent mathematical framework to:
  - Regionalization of macroeconomic impacts
  - Investigation of macroeconomic effects with high spatial heterogeneity and relatively small overall net impact on the macroeconomic development

- Efficient **mapping of spatial variation / heterogeneity** of macroeconomic effects / impacts and developments

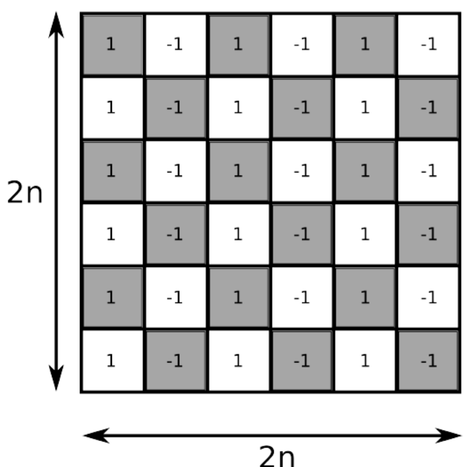


Fig. 1. Exemplary spatial distribution of some quantity $\boldsymbol{\kappa}$

- **Input-output analysis** on the **aggregated economic effects** of the *Energiewende* in NRW (Többen & Kuckshinrichs, 2016)
  - Impacts of the **expansion and promotion of renewable energies** on industrial value creation **in 2011**

- 5 impact channels / mechanisms:

**A. Operation of assets**

1) Demand for maintenance, spare parts; labor income – Expansionary.
2) Direct and indirect impact of EEG levy – Contractionary.
3) Preferential dispatch / Merit order effect (displacement of conventional power generation assets and related fuel, maintenance etc. needs – Contractionary.

**B. Production of assets**

4) Demand for intermediate products, increased consumption/PP – Expansionary.
5) Replacement of conventional gen assets – Contractionary.


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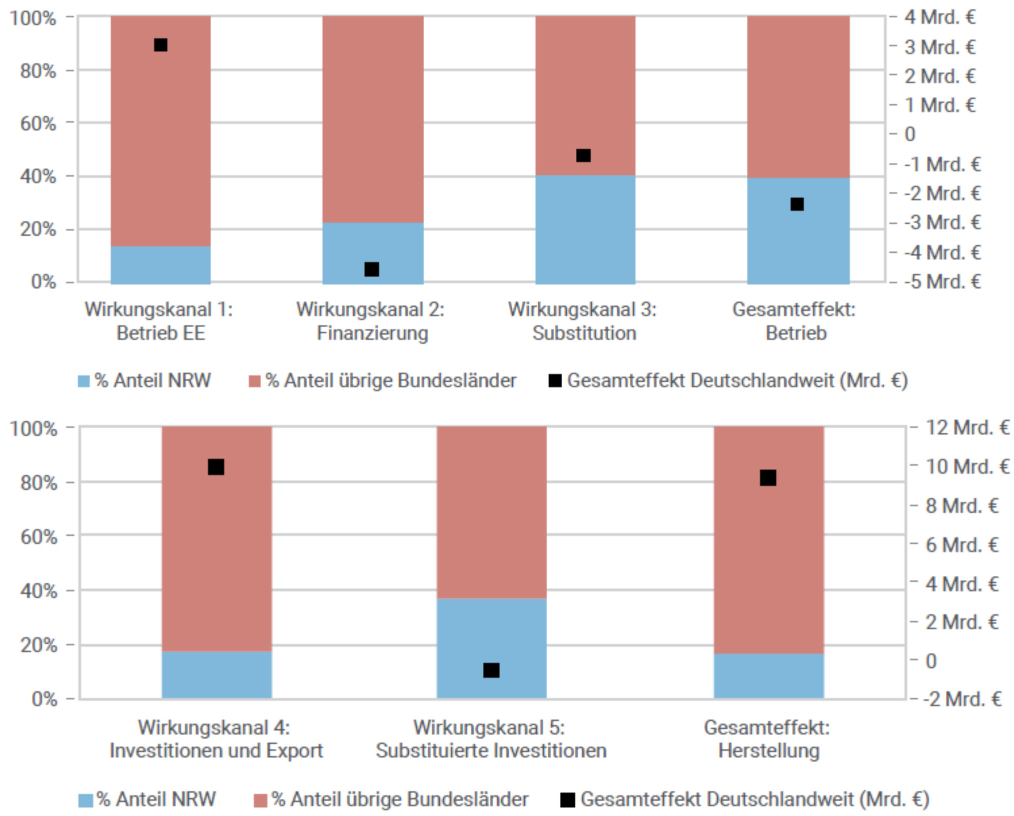
- Main results:
  - The operation and  construction of renewable energies in 2011 resulted in a **positive overall industrial value creation**
  - Measured by the size of NRW (21% of German population and GDP) the **value created is low** compared to the rest of the country



# **Introduction** Distribution of Total Effects from Producing and Operating Renewable Energy Assets Among 35 Sectors in NRW

# Introduction
## Input 2: Meta Analysis – Kobiela & Vallentin (2016)

- **3 industry branches** identified (Kobiela & Vallentin, 2016):
  - Machinery
  - Chemicals
  - Fabricated metals

- These branches are **particularly important for the *Energiewende* in NRW**:
  - Include a broad range of companies and employees
  - Very energy- and $CO_2$-intensive
  - Produce relevant equipment for the *Energiewende*
  - Particularly affected by structural change in the energy sector

# Method

- The **regionalization heuristic** is applied to results from the I-O analysis undertaken by Kobiela & Vallentin (2016)

- Detailed regional economic investigation in North Rhine-Westphalia (NRW) of:

  - Industrial value creation
  - Private consumption
  - Changes in economic structure

→ Regionalization procedure
- by 53 labor market districts
- by commuter classes (Oberst 2011)
- by labor market regions (Kropp & Schwengler 2011)

# Method

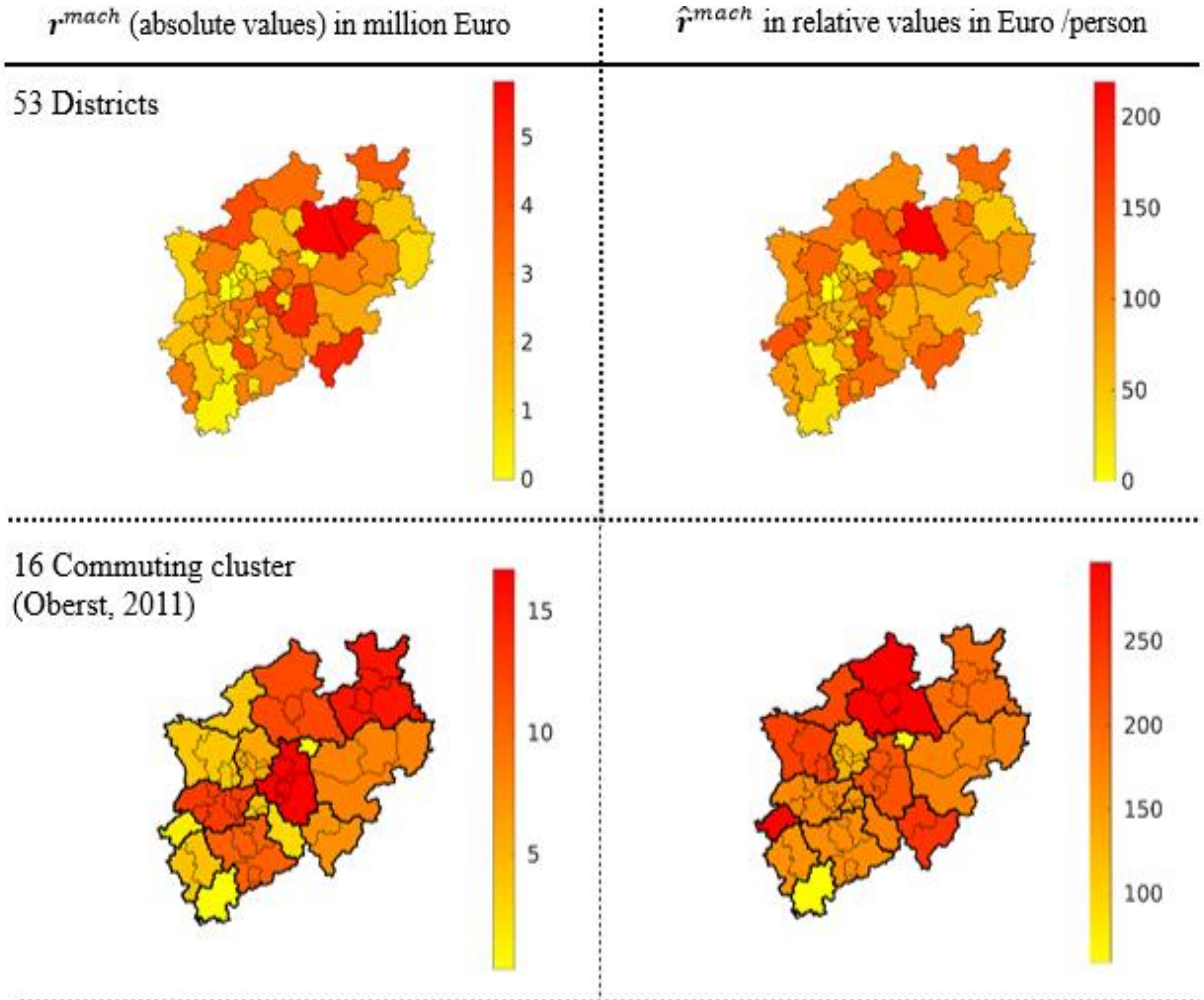
1. Delineation of **Functional Regions**
   - Contemplation of two well comparable delineation approaches
   - Labor markets by Eckey et al. (2006)
   - Commuting areas by Oberst (2011)

2. **Regional Assignment**
   - Modeling of macroeconomic effects with a simplified heuristic
   - fitting macroeconomic effects with high regional differences
   - but no central influence on the assessed Developments

3. Computation of **Regionalization Vector r** (→see *FCN Working Paper* for details)
   - Assuming that value added is distributed uniformly among all employees in a given branch

# Selected Results 1/3

## Regionalized macroeconomic net effects for the **Machinery branch**




- **Largest industry branch** in NRW
- Benefit the most from the expansion of renewable energies
- Highest estimated individual effect occurs on the **rural district in the north** of the state (Warendorf), where over 1/3 of the employees (9,843) work
- **Broad regional spread** of the effects in the branch
- Big chance for widespread positive economic effects by **expansion of know-how** in renewable energy plant production



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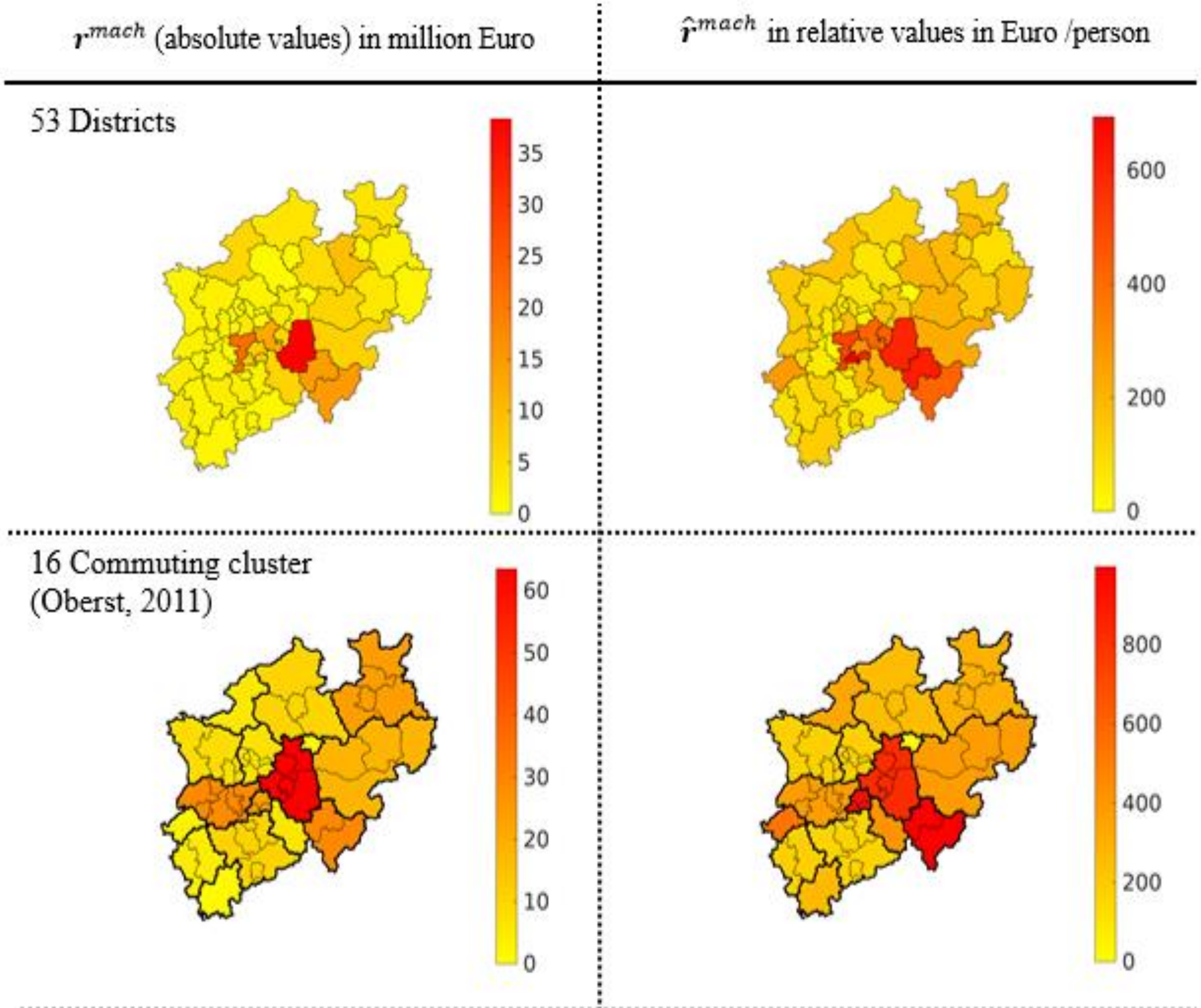
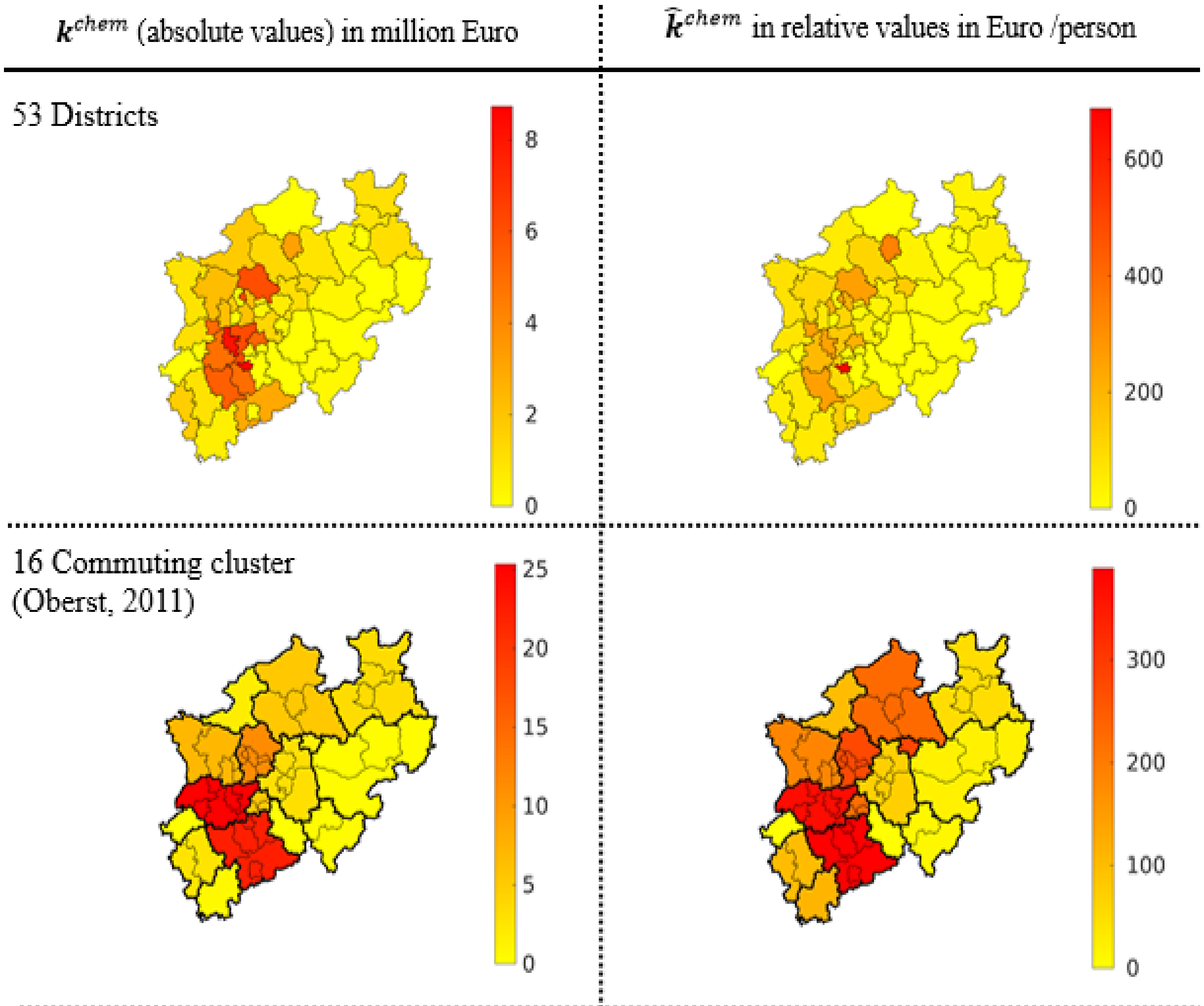
# Selected Results 2/3

## Regionalized macroeconomic net effects **Fabricated metals branch**




- Highest absolute and relative value added effects of the branches analyzed
- **High regional concen-tration** of the value added effects (eastern and southeastern Ruhr-Region, Bergisches Land)
- Chance of further increased value added effects by use of tailored political instruments
- **Risk** of strong **negative economic effects** by changing market conditions

## Regionalized macroeconomic net effects for the **Chemicals branch**




- Lower absolute value added effects than for the Machinery branch, but comparable relative effects
- Highest effects in **Cologne/ Bonn and Dusseldorf** (incl. Leverkusen)
- Low benefits in the western regions of NRW
- High concentration of the value added effects on a few regions suggests strongly **site-specific policy measures** to stimulate value added effects

# Conclusion and Outlook

We introduce a general **regionalization heuristic for mapping the spatial heterogeneity** of macroeconomic impacts – applied to the case of the sustainable energy transition in North Rhine-Westphalia, Germany

- We develop and apply **several new metrics** which:
  - can be used to assess regional heterogeneities in a variety of contexts
  - illustrate the potential variance across regions
  - enable the discussion of economic effects separately from the net macroeconomic impact in a standardized, mathematically well-defined framework
- Each regionalization vector can be used to regionalize a certain class of effects
  - Once a vector is established, it can easily be transferred to another problem containing effects of the same class
  - The framework is particularly useful if effects with high regional heterogeneity and small overall impact are to be discussed
- Future research ideas: To what degree do the assumptions hold for the considered sectors? What are the dynamics of the effects (trends)?

# Thank you for your kind attention! Questions?

## Contact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# Appendix

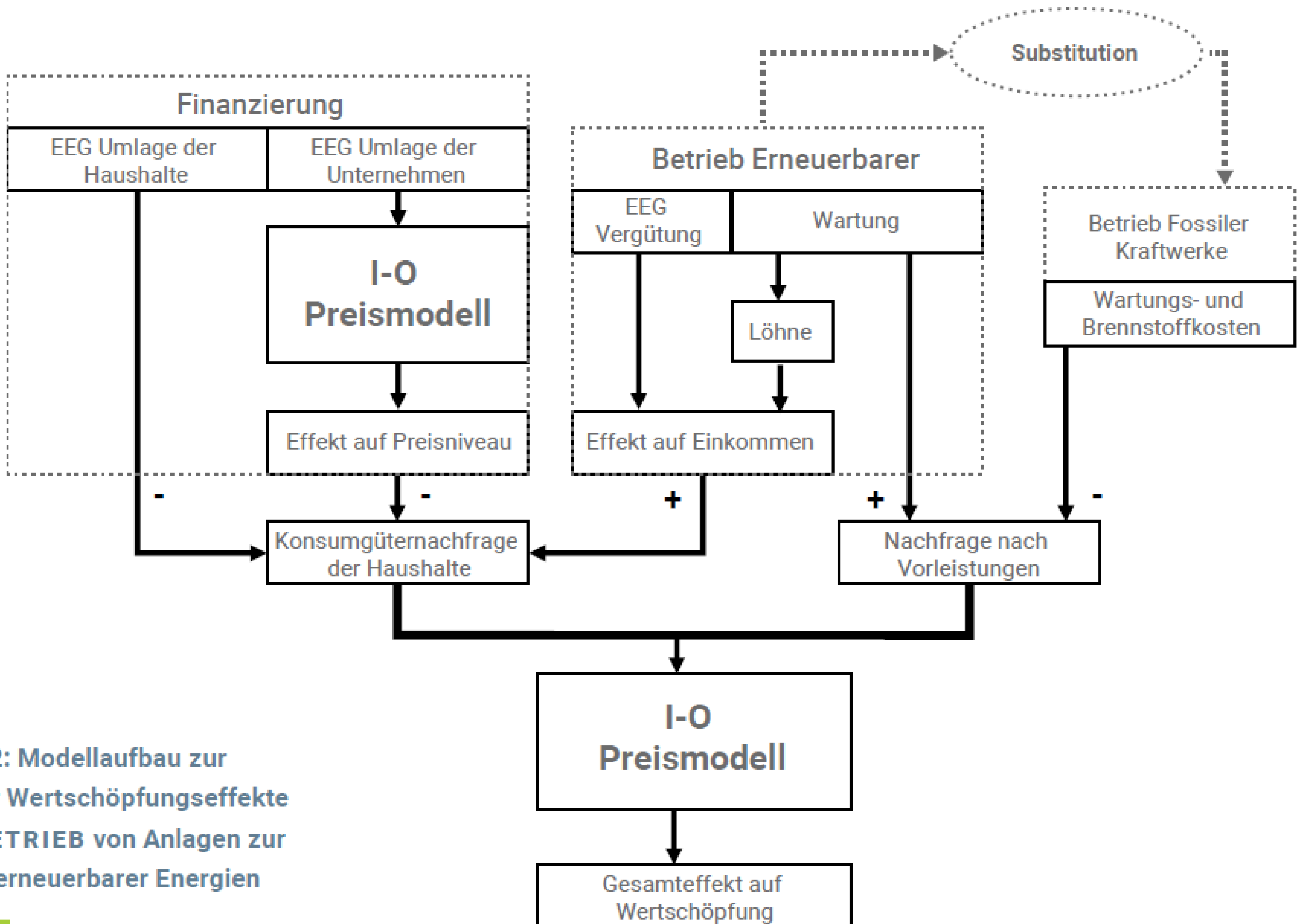


**Abbildung 2: Modellaufbau zur Analyse der Wertschöpfungseffekte aus dem BETRIEB von Anlagen zur Erzeugung erneuerbarer Energien**

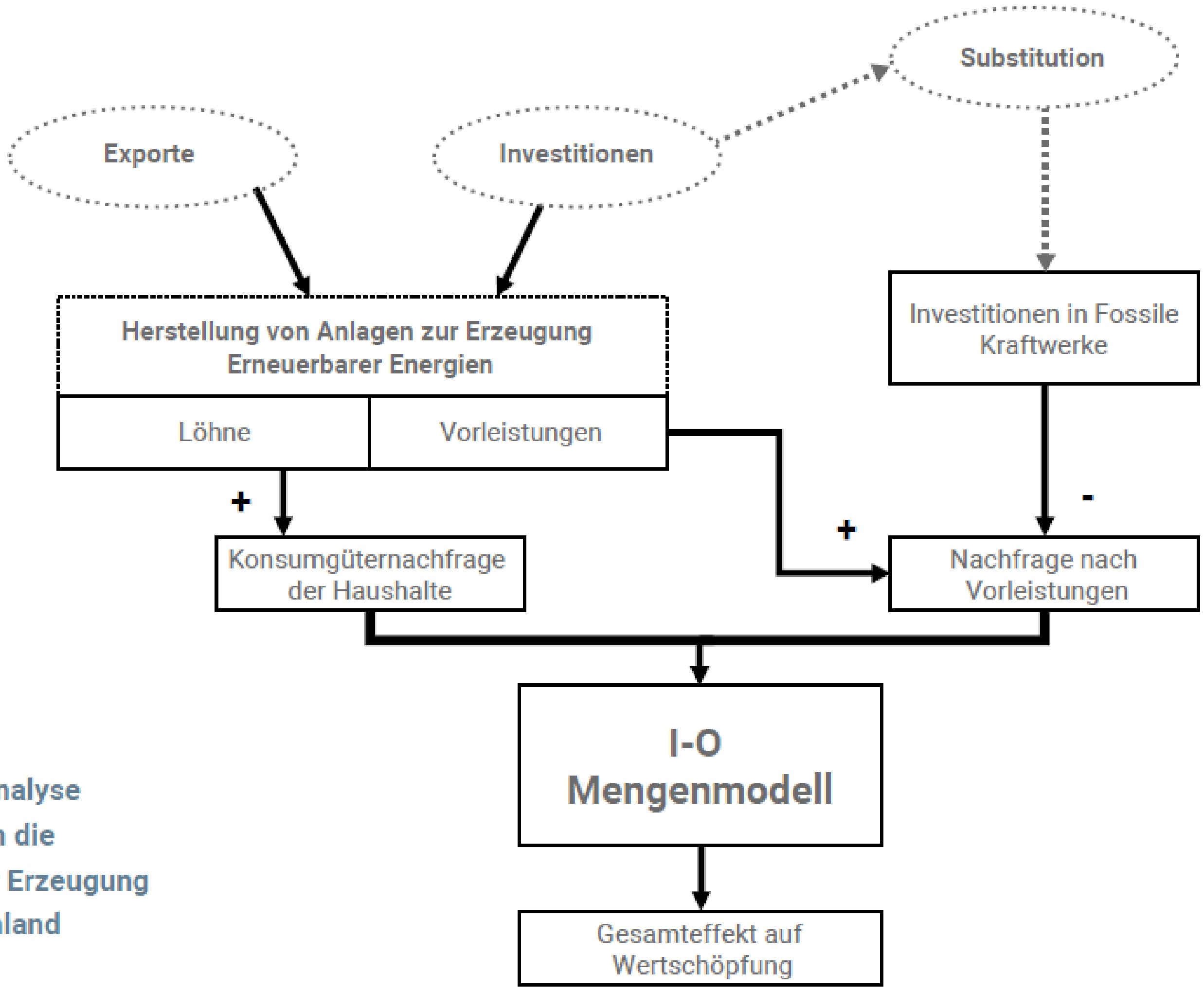


**Abbildung 3: Modellaufbau zur Analyse der Wertschöpfungseffekte durch die HERSTELLUNG von Anlagen zur Erzeugung erneuerbarer Energien in Deutschland**

# Regionalization metrics: Machinery Branch

**Table 3: Summary of regionalization metrics machinery branch**

| Metric | 53 Districts | 6 Labor Market Regions | 16 Functional Economic Regions |
|---|---|---|---|
| $\kappa^{mach}$ $[m.Euro]$ | 117 | | |
| $\max(\boldsymbol{r}^{mach})$ $[m.Euro]$ | 6 ∗ | 53 | 18 |
| $\min(\boldsymbol{r}^{mach})$ $[m.Euro]$ | 0 | 4.5 | 0.3 |
| **spread [m. Euro]** | 6.2 | 48.8 | 17.5 |
| $var(\boldsymbol{r}^{mach})$ $[m.Euro]$ | $12.5 * 10^6$ | $2.6 * 10^8$ | $2.9 * 10^7$ |
| $\sigma(\boldsymbol{r}^{mach})$ $[m.Euro]$ | 1.6 | 1.6 | 5.4 |
| $var(\boldsymbol{l}^{mach})$ $[-]$ | $1.7824 * 10^{-4}$ | $1.8596 * 10^{-2}$ | $2.1307 * 10^{-3}$ |
| $\sigma(\boldsymbol{l}^{mach})$ $[-]$ | $1.3351 * 10^{-2}$ | $1.3637 * 10^{-1}$ | $4.6159 * 10^{-2}$ |
| **spread ratio [−]** | - | 9.5848 | 0.35354 |
| **σ-ratio [−]** | - | 0.0979 | 0.289239 |
| $\kappa^{mach}$ $[\frac{Euro}{pers}]$ | 102.63 | | |
| $\max(\hat{\boldsymbol{r}}^{mach})$ $[\frac{Euro}{pers}]$ | 219 | 277 | 297 |
| $\min(\hat{\boldsymbol{r}}^{mach})$ $[\frac{Euro}{pers}]$ | 0 | 161 | 59 |
| **spread** $[\frac{Euro}{pers}]$ | 219.37 | 115.57 | 237.49 |
| $var(\hat{\boldsymbol{r}}^{mach})$ $[Euro]$ | 2152.3 | 1896.3 | 4338 |
| $\sigma(\hat{\boldsymbol{r}}^{mach})$ $[Euro]$ | 46.393 | 43.546 | 65.864 |
| $var(\boldsymbol{l}^{mach})$ $[-]$ | 0.156243 | 0.13765 | 0.3149 |
| $\sigma(\boldsymbol{l}^{mach})$ $[-]$ | 0.39527 | 0.37102 | 0.56116 |
| **spread ratio [−]** | - | 1.8981 | 0.9237 |
| **σ-ratio [−]** | - | 1.27401 | 0.70425 |



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# Regionalization metrics: Chemicals Branch

**Table 3: Summary of regionalization metrics chemicals branch**

| Metric | 53 Districts | 6 Labor Market Regions | 16 Functional Economic Regions |
|---|---|---|---|
| $\kappa^{chem}$ | $94.85 * 10^{6}$ | $94.85 * 10^{6}$ | $94.85 * 10^{6}$ |
| $\max(\boldsymbol{r}^{chem})\ [Euro]$ | $8.732 * 10^{6}$ | $54.391 * 10^{6}$ | $25.34 * 10^{6}$ |
| $\min(\boldsymbol{r}^{chem})\ [Euro]$ | $0.0$ | $0.36126 * 10^{6}$ | $0.0$ |
| **spread [Euro]** | $8.732 * 10^{6}$ | $54.029 * 10^{6}$ | $25.34 * 10^{6}$ |
| $\mathrm{Var}(\boldsymbol{r}^{chem})\ [Euro]$ | $4.827 * 10^{12}$ | $3.619 * 10^{14}$ | $5.622 * 10^{13}$ |
| $\cdot\ \sigma(\boldsymbol{r}^{chem})\ [Euro]$ | $2.197 * 10^{6}$ | $1.902 * 10^{6}$ | $7.499 * 10^{6}$ |
| $\mathrm{Var}(\boldsymbol{l}^{chem})\ [-]$ | $5.366 * 10^{-4}$ | $4.023 * 10^{-2}$ | $6.250 * 10^{-3}$ |
| $\sigma(\boldsymbol{l}^{chem})\ [-]$ | $2.315 * 10^{-2}$ | $2.005 * 10^{-1}$ | $7.906 * 10^{-2}$ |
| **spread ratio [–]** | - | 0.16161 | 0.34459 |
| **σ-ratio [–]** | - | 0.116 | 0.293 |
| $\kappa^{chem}\ [\frac{Euro}{pers}]$ | 102.19 | 102.19 | 102.19 |
| $\max(\hat{\boldsymbol{r}}^{chem})\ [\frac{Euro}{pers}]$ | 687.92 | 366.8 | 389.04 |
| $\min(\hat{\boldsymbol{r}}^{chem})\ [\frac{Euro}{pers}]$ | 0.0 | 12.208 | 0.0 |
| **spread** $[\frac{Euro}{pers}]$ | 687.92 | 354.59 | 389.04 |
| $\mathrm{Var}(\hat{\boldsymbol{r}}^{chem})\ [Euro]$ | 14370 | 14135 | 15915 |
| $\cdot\ \sigma(\hat{\boldsymbol{r}}^{chem})\ [Euro]$ | 119.88 | 118.89 | 126.16 |
| $\mathrm{Var}(\boldsymbol{l}^{chem})\ [-]$ | 1.5973 | 1.5712 | 1.769 |
| $\sigma(\boldsymbol{l}^{chem})\ [-]$ | 1.2638 | 1.2535 | 1.33 |
| **spread ratio [–]** | - | 1.9400 | 1.7682 |
| **σ-ratio [–]** | - | 1.0083 | 0.95023 |

# Regionalization metrics: Fabricated Metals Branch

**Table 3: Summary of regionalization metrics fabricated metals branch**

| Metric | 53 Districts | 6 Labor Market Regions | 16 Functional Economic Regions |
|---|---|---|---|
| $\kappa^{met}$ $[Euro]$ | $247.92 * 10^6$ | $247.92 * 10^6$ | $247.92 * 10^6$ |
| $\max(\boldsymbol{r}^{met})$ $[Euro]$ | $38.367 * 10^6$ | $148.46 * 10^6$ | $63.507 * 10^6$ |
| $\min(\boldsymbol{r}^{met})$ $[Euro]$ | $0.0$ | $4.797 * 10^6$ | $0.0$ |
| **spread [Euro]** | $38.367 * 10^6$ | $143.66 * 10^6$ | $63.507 * 10^6$ |
| $\mathrm{Var}(\boldsymbol{r}^{met})$ $[Euro]$ | $3.9786 * 10^{13}$ | $2.3664 * 10^{15}$ | $2.4359 * 10^{14}$ |
| $\cdot\ \sigma(\boldsymbol{r}^{met})$ $[Euro]$ | $6.3076 * 10^6$ | $4.8645 * 10^7$ | $1.5607 * 10^7$ |
| $\mathrm{Var}(\boldsymbol{l}^{met})$ $[-]$ | $6.473 * 10^{-4}$ | $3.85 * 10^{-2}$ | $3.9631 * 10^{-3}$ |
| $\sigma(\boldsymbol{l}^{met})$ $[-]$ | $2.5442 * 10^{-2}$ | $1.9621 * 10^{-1}$ | $6.2953 * 10^{-2}$ |
| **spread ratio [−]** | - | 0.28491 | 0.60413 |
| **σ-ratio [−]** | - | 0.12896 | 0.40195 |
| $\kappa^{met}$ $[\frac{Euro}{pers}]$ | 210.18 | 210.18 | 210.18 |
| $\max(\hat{\boldsymbol{r}}^{met})$ $[\frac{Euro}{pers}]$ | 694.44 | 996.99 | 996.99 |
| $\min(\hat{\boldsymbol{r}}^{met})$ $[\frac{Euro}{pers}]$ | 0.0 | 182.434 | 0.0 |
| **spread** $[\frac{Euro}{pers}]$ | 694.44 | 814.66 | 996.99 |
| $\mathrm{Var}(\hat{\boldsymbol{r}}^{met})$ $[Euro]$ | 26760 | 77496 | 78089 |
| $\cdot\ \sigma(\hat{\boldsymbol{r}}^{met})$ $[Euro]$ | 163.58 | 278.38 | 279.44 |
| $\mathrm{Var}(\boldsymbol{l}^{met})$ $[-]$ | 0.43537 | 1.2608 | 1.2705 |
| $\sigma(\boldsymbol{l}^{met})$ $[-]$ | 0.65983 | 1.1229 | 1.1272 |
| **spread ratio [−]** | - | 0.85242 | 0.6953 |
| **σ-ratio [−]** | - | 0.58763 | 0.58539 |