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Power Generation and Structural Change: Quantifying Economic Effects of the Coal Phase-out in Germany*

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Abstract

In the fight against global warming, the reduction of greenhouse gas emissions is a major objective. In particular, a decrease in electricity generation by coal could contribute to reducing CO_2 emissions. We study potential economic consequences of a coal phase-out in Germany, using a multi-region dynamic general equilibrium model. Four regional phase-out scenarios before the end of 2040 are simulated. We find that the worst case phase-out scenario would lead to an increase in the aggregate unemployment rate by about 0.13 [0.09 minimum; 0.18 maximum] percentage points from 2020 to 2040. The effect on regional unemployment rates varies between 0.18 [0.13; 0.22] and 1.07 [1.00; 1.13] percentage points in the lignite regions. A faster coal phase-out can lead to a faster recovery. The coal phase-out leads to migration from German lignite regions to German non-lignite regions and reduces the labour force in the lignite regions by 10,100 [6,300; 12,300] people by 2040. A coal phase-out until 2035 is not worse in terms of welfare, consumption and employment compared to a coal-exit until 2040.

Keywords: dynamic general equilibrium model, labour market friction, energy, structural change

JEL classification: E17, O11, O21, O44, Q28

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1 Introduction

Economic growth and development are accompanied by structural change. Technological progress, international competition and shifting preferences, for example, affect the industry structure and the regional distribution of economic activities. An important source of structural change is the decarbonization of the economy that many countries are trying to achieve. According to the Paris Agreement 2015, greenhouse gas emissions, which are a major driver of global warming, need to be reduced strongly in order to prevent the global average temperature to increase further. Germany aims to reduce its greenhouse gas emissions by 40% by 2020 and by 55% by 2030 compared to 1990 (Figure 5 in the Appendix). A possible way to achieve these targets is to stop producing electricity from lignite. Among the electricity-producing technologies, burning lignite is the one that generates the most CO_2 emissions per unit of electricity. In 2014, the lignite industry accounted for 25% of the total electricity generation but for 50% of CO_2 emissions in the electricity sector in Germany (Icha 2013) and employed about 21,000 persons (0.05% of all employees).

The German government plans to shut down lignite coal power plants by 2038. The coal phase-out will trigger two types of structural change: First, other energy sources will replace lignite to produce electricity. New technologies and industries will develop while the lignite coal power plants will disappear. Second, since lignite coal industries are regionally concentrated, regional effects of the coal phase-out vary across the country. In the lignite regions, employment may decline, unemployment may be elevated during the process of structural change and average labour income may decrease because salaries in the lignite industry are above average. Other regions will be affected through production linkages as well as income and price effects. Overall, the lignite coal phase-out will trigger or amplify structural change in terms of both sectoral composition and regional distribution. In order to achieve a broad consensus about the coal-phase out throughout Germany, the federal government inaugurated a commission on growth, structural change and employment to develop a plan for the stepwise reduction of electricity generation by lignite.[1] The political decision process needs to be informed about the sectoral and regional consequences of various phase-out pathways. Existing studies investigating the potential economic consequences of a coal phase-out in Germany have assessed the current economic situation of the lignite regions using descriptive statistics (e.g. Markwardt & Zundel 2017). Others have focused on the consequences for energy markets (see, e.g. Heinrichs & Markewitz 2015). Studies quantifying the potential employment effects have used static input-output

[1]See Federal Ministry for Economic Affairs and Energy:
https://www.bmwi.de/Redaktion/DE/Downloads/E/einsetzung-der-kommission-wachstum-strukturwandel-beschaeftigung.pdf?__blob=publicationFile

models (see Frondel et al. 2018). Welsch (1998) investigates the potential economic effects of a hard-coal and nuclear phase-out for Germany on the national level with a dynamic general equilibrium model. However, many important aspects as labour market frictions, migration and regional distribution have been neglected in these studies. We contribute to the literature by incorporating these aspects into a dynamic general equilibrium model with multiple sectors and multiple regions. Important features of the model are an imperfect labour market (hiring costs like in Blanchard & Galí (2010)), market power, trade and migration between lignite and non-lignite regions and fiscal transfers among regions. We use the model to assess the economic effects of various coal phase-out pathways that differ with respect to regional timing and speed of power plant shutdowns. First, we specify a Null-Scenario in which the share of lignite in electricity production is constant but the population is decreasing due to demographic change. Second, we define a baseline scenario, in which the political measures implemented before 2015 reduce the share of lignite in electricity production to about 48%. This already contributes to structural change but is by far not sufficient to achieve the emission targets. We draw model parameters from specific probability distributions in order to account for the uncertainty about the exact structure of the economy. Due to the already implemented political measures to reduce electricity generation by lignite in Germany, employment will drop by 4,500 to 18,000 persons until 2035 and the unemployment rate will increase by 0.01 to 0.04 percentage points. Then, we model coal phase-out scenarios in which the emission targets are actually met. The decline in employment may amount to 74,800 persons and the unemployment rate might increase by up to 0.18 percentage points, depending on the specific decommissioning plan. Regional employment effects differ depending on the regional importance of the lignite industry. Absolute effects will be largest in Rhineland and relative effects will be largest in Lusatia. We show in detail how the effects depend on the persistence in unemployment benefits and wages, preferences for local production, and the magnitude and persistence of market power. We also assess the welfare effects of the decommissioning plans currently under consideration. It turns out that none of these plans clearly dominates the others. The paper is structured as follows: Section 2 reports the current economic profiles of the lignite regions and describes the phase-out scenarios. Section 3 explains the multi-sector multi-region dynamic general equilibrium model. The calibration of the model is described in Section 4. The results and a sensitivity analysis are presented in Section 5. Section 6 summarizes the main results of the paper.

2 The Lignite Industry in Germany

2.1 Status quo

Lignite industries are located in four German regions: Central Germany, Lusatia, the Rhineland, and Helmstedt. In the smallest of these territories, Helmstedt, lignite has no longer been extracted since 2016. However, renaturation activities in Helmstedt have been employing some people since 2016. The lignite regions can be defined in various ways. For the economic analysis of regional structural change, labour market regions are a reasonable regional unit. labour market regions consist of several counties with intensive commuting flows (Kosfeld & Werner 2012) implying that the majority of workers in a region are living in the same region. First, we cluster counties into lignite and non-lignite territories by sorting all counties with an active lignite mine or power plant with an installed capacity of at least 50 MW into one of the three active lignite territories Central Germany, Lusatia, or Rhineland. Table 5 in the Appendix tabulates the identified territories. We then define lignite regions as labour market regions which include at least one county belonging to a lignite territory. Overall, we consider four regions: three lignite labour market regions and the rest of Germany. Table 1 reports the employment shares in 2014 for each region and sector. In 2014, roughly 0.05% of the workforce worked in the lignite industry. The Lusatia region, located in East Germany, has the highest employment share in the lignite sector, and Central Germany the lowest. In the rest of Germany, only about 500 people are employed in the lignite sector. In all lignite regions, unemployment rates are above the average national level. Gross value-added shares are similar to employment shares,

Table 1: Employment shares

Region	Energy		Non-Energy	Unemployment Rate	Total
	Lignite Coal	Non-Lignite Coal			
Rest of Germany	0.001%	0.64%	94.03%	5.32%	100%
Central Germany	0.15%	0.67%	90.01%	9.17%	100%
Lusatia	1.54%	0.56%	86.92%	10.97%	100%
Rhineland	0.31%	0.74%	91.61%	7.34%	100%
Germany	0.05%	0.65%	93.64%	5.67%	100%

Note: Employment shares by region and sector in 2014.
Sources: German Federal Statistical Office, German Federal Agency for Employment and own calculations.

see Table 6 in the Appendix. More important is the role of the lignite industry as a high wage paying regional employer. Wages are retrieved from balance sheet data of the three major companies operating the lignite mines and power plants.[2] Wages are high compared to other sectors. The average annual compensation (including social security contributions) in Lusatia for a worker in 2014 was about 26,500 euro. In contrast, the average annual compensation in Lusatia for a worker in the lignite sector in 2014 was about 66,000 euro. Labour shares are reported in Table 7 in the Appendix.

2.2 Phase-out paths

We start with a Null-Scenario in which the share of lignite in total electricity production stays constant but the expected demographic change is taken into account. According to official projections, the labour force will shrink by 3.5 million people by 2040 (Figure 6). Employment will decrease because more old employees will be retired in the years to come than young employees enter the labour market. Given the large regional variation in demographic dynamics it is important to isolate the employment effects triggered by the coal phase-out to the ongoing regional demographics without coal phase-out. Some specific measures to reduce the share of lignite in electricity production have already been decided. These measures constitute our baseline scenario, see Table 3. They are described in Bundesregierung (2017).[3] In this scenario, electricity generation by lignite coal is reduced by 28% until 2030 and by 52% until 2040 in relation to the level of 2014, see Table 2. This is not sufficient to meet the greenhouse gas emission targets.

Additional actions to achieve the greenhouse gas emission reduction goals are implemented in scenarios named Phase-Out-2035-Weak, Phase-Out-2040-Age, Phase-Out-2040-Balanced, and Phase-Out-2035-Strong. The scenarios differ with respect to speed and regional distribution of emission reduction. Phase-Out-2035-Weak and Phase-Out-2035-Strong only consider reductions in lignite and exclude additional reductions in hard coal. Without further capacity management for hard coal power plants the installed capacity in 2030 is 18 GW and this requires a capacity reduction to 10 GW for lignite power plants. Therefore, a total phase-out by 2035 is necessary to be consistent

[2]Balance sheets for RWE Power AG, Vattenfall Mining and Generation, and MIBRAG are provided at `https://www.unternehmensregister.de/ureg/`

[3]EU regulation No. 525/2013 of the EU Parliament makes it mandatory for every member state to report historic and projected future developments of anthropogenic GHG emissions on the national level. The German government assumes an annual reduction rate of EU emission allowances of 1.74% until 2020 and after 2021 by 2.2% as well as the introduction of a Market Stability Reserve (MSR). Second, the federal government estimates that by 2035 the share of renewable energy sources in electricity consumption will be roughly 60%. Third, subsidies to increase the capacity of combined heat and power plants using natural gas will disincentive investments to increase the lifetime of current coal fired power plants. We consider the net electricity generation of lignite reported for the scenario "Mit-Weiteren-Maßnahmen" as our baseline scenario and assume uniform percentage reductions in the regions.

Table 2: Net electricity generation by lignite coal

Year	Germany	Central Germany	Lusatia	Rhineland
Null-Scenario				
2014	100%	100%	100%	100%
2020	107%	107%	107%	107%
2025	108%	108%	108%	108%
2030	108%	108%	108%	108%
2035	109%	109%	109%	109%
2040	111%	111%	111%	111%
Baseline				
2014	100%	100%	100%	100%
2020	81%	81%	81%	81%
2025	82%	82%	82%	82%
2030	72%	72%	72%	72%
2035	48%	48%	48%	48%
2040	48%	48%	48%	48%
Phase-Out-2035-Weak				
2014	100%	100%	100%	100%
2020	81%	81%	81%	79%
2025	44%	56%	56%	31%
2030	24%	15%	15%	31%
2035	0%	0%	0%	0%
2040	0%	0%	0%	0%
Phase-Out-2040-Age				
2014	100%	100%	100%	100%
2020	81%	81%	81%	79%
2025	63%	70%	70%	54%
2030	42%	54%	54%	28%
2035	21%	13%	13%	28%
2040	0%	0%	0%	0%
Phase-Out-2040-Balanced				
2014	100%	100%	100%	100%
2020	80%	83%	80%	79%
2025	61%	80%	44%	67%
2030	43%	54%	42%	41%
2035	22%	1%	22%	29%
2040	0%	0%	0%	0%
Phase-Out-2035-Strong				
2014	100%	100%	100%	100%
2020	60%	60%	60%	60%
2025	44%	56%	56%	31%
2030	24%	15%	15%	31%
2035	0%	0%	0%	0%
2040	0%	0%	0%	0%

Note: Net electricity generation reduction compared to the base year 2014 in percent.
Sources: The Baseline path is based on Bundesregierung (2017). Phase-Out-2035-Weak, Phase-Out-2040-Age and Phase-Out-2040-Balanced are based on Öko-Institut, Büro für Energiewirtschaft und technische Planung (BET) & Klinski (2017). Phase-Out-2035-Strong investigates the potential impact for the case that Germany will meet its 2020 target.

with the German greenhouse gas emission targets. Phase-Out-2035-Strong only deviates from Phase-Out-2035-Weak by assuming a strong initial decline in 2020. Phase-Out-2040-Age and Phase-Out-2040-Balanced consider an additional reduction in hard coal electricity generation in Germany. Lignite power plant capacity needs to be reduced until 2030 to about 9 GW for a path where hard coal power plant capacity is 10 GW in 2030. These paths lead to a total coal phase-out in Germany by 2040. In order to meet the GHG emission targets in the scenarios Phase-Out-2040-Age and Phase-Out-2040-Balanced it requires an additional hard coal power plant capacity reduction of roughly 30% compared to the installed capacity in 2014.

Table 3: Definition of scenarios

Path	Description
Null-Scenario	No change in the share of electricity generation by lignite in total electricity generation.
Baseline	Reduction of lignite electricity generation due to already implemented political actions.
Phase-Out-2035-Weak	Complete shutdown of lignite power plants by 2035 without further actions to reduce hard coal electricity generation.
Phase-Out-2040-Age	Complete shutdown by 2040 according to age criteria and further reduction in hard coal electricity generation.
Phase-Out-2040-Balanced	Complete shutdown by 2040 with balanced regional capacity contributions and further reduction in hard coal electricity generation.
Phase-Out-2035-Strong	Complete shutdown by 2035 as in Phase-Out-2035-Weak and a reduction of lignite electricity generation by 40% in 2020.

Sources: The Baseline path is based on Bundesregierung (2017). In Phase-Out-2035-Weak and Phase-Out-2035-Strong, net electricity generation falls according to the path “Kapa. nur BK” in Öko-Institut, Büro für Energiewirtschaft und technische Planung (BET) & Klinski (2017), except for the year 2020 in Phase-Out-2035-Strong. In Phase-Out-2040-Age and Phase-Out-2040-Balanced, net electricity generation falls according to the path “Kapa. BK&SK” in Öko-Institut, Büro für Energiewirtschaft und technische Planung (BET) & Klinski (2017).

3 Model

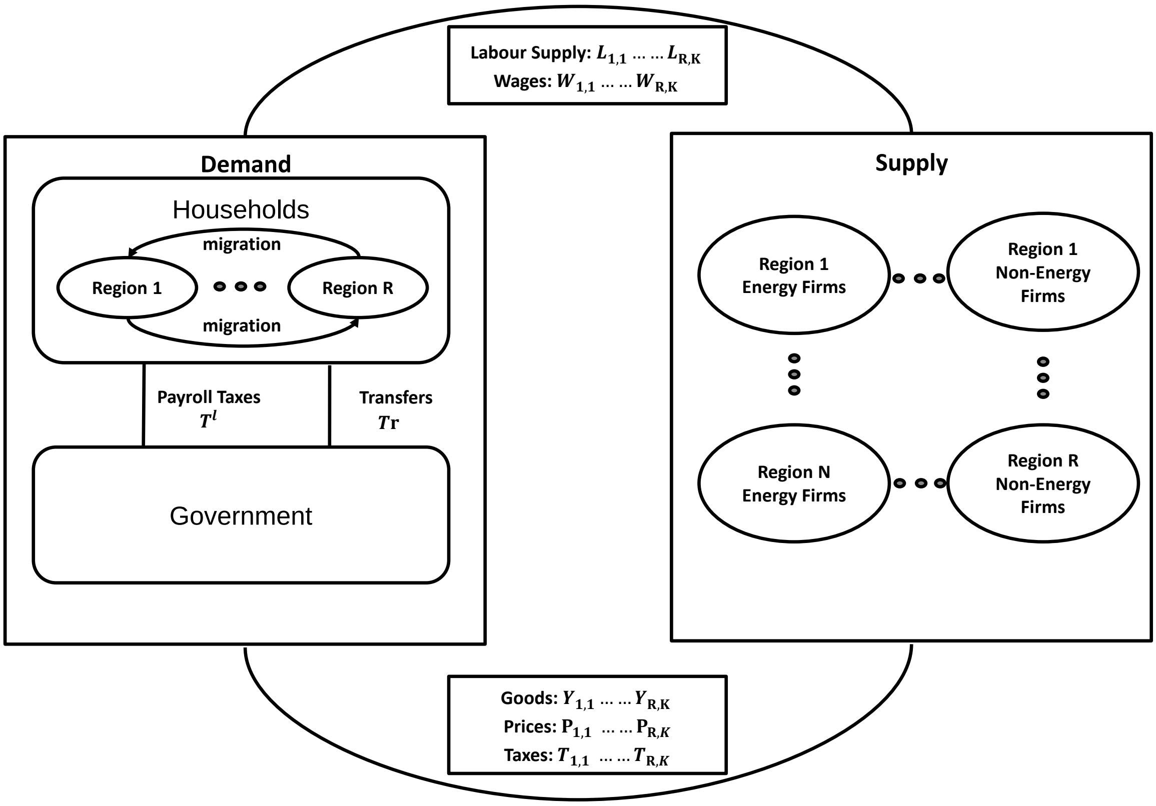
We use a dynamic general equilibrium model for Germany with four regions and three sectors. An overview of the model structure is depicted in Figure 1.[4] In order to include trade flows between regions, we need to differentiate between destination regions $r \in \{1, \ldots, R\}$ and regions of origin $o \in \{1, \ldots, R\}$ for traded goods. Regions are populated by a continuum of representative households h. Household members i^r live and work in the same region. Each household supplies labour to a representative firm f in its own region. Firms operate in the energy and non-energy sector $k \in \{E, NE\}$. The energy sector can allocate labour to the lignite sector or to other energy sources $s \in \{LC, NLC\}$ to produce energy. Further, households differentiate between three different employment opportunities indexed by $l \in \{E^{LC}, E^{NLC}, NE\}$. The central government collects taxes from labour income τ^l and charges a value-added tax on production τ.

The government consumes G_t, pays lump-sum transfers Tr_t, and unemployment benefits U_tB_t financed by tax revenues Tax_t. We assume a balanced government budget. Unemployment benefits are adjusted according to the development of national wages and with a backward-looking component to reflect rigidity in the adjustment of long-term unemployment benefits and wages. This specification allows for a sluggish adjustment of benefits, reflecting empirical evidence. All products produced in a given period are consumed and firms have no access to an inventory technology, i.e. we assume market clearing.[5]

[4]The notation is summarized in Tables 8–9.

[5]For further details see the Section D.2 in the Online Appendix.

Figure 1: Model overview



3.1 Households

3.1.1 Consumption and labour

Representative households maximize utility $u(C_{r,1,1,t}(h), \ldots, C_{r,R,K,t}(h), N_{r,1,t}, \ldots, N_{r,L,t}(h))$ with respect to (henceforth w.r.t.) consumption $C_{r,o,k,t}(h)$ and sectoral labour $N_{r,l,t}(h)$, given the utility function

$$u(C_{r,1,1,t}(h), \ldots, C_{r,R,K,t}(h), N_{r,1,t}, \ldots, N_{r,L,t}(h)) = \tag{1}$$
$$\Big[\sum_{k=1}^{K} \omega_k^{c\,\frac{1}{\eta^c}} C_{r,k,t}(h)^{\frac{\eta^c-1}{\eta^c}}\Big]^{\frac{\eta^c}{\eta^c-1}} - \sum_{l}^{L} \frac{z_t\, A_{r,l}^L N_{r,l,t}(h)^{1+\sigma_{r,l}^L}}{1+\sigma_{r,l}^L},$$
$$C_{r,k,t}(h) = \Big[\sum_{o=1}^{R} w_{r,o,k}^{d\;\frac{1}{\eta_k^M}} C_{r,o,k,t}(h)^{\frac{\eta_k^M-1}{\eta_k^M}}\Big]^{\frac{\eta_k^M}{\eta_k^M-1}}.$$

The utility from consumption depends on sectoral consumption k from different regions o and is transformed into utility by a standard CES function. The elasticity of substitution between sectors η^c defines whether sectoral consumption goods are complements or substitutes. Preference shares ω_k^c define for equal prices of both consumption goods the share of consumption expenditure. The disutility of labour is sector-specific l and region-specific r through a disutility parameter $A_{r,l}^L$. The inverse Frisch elasticity is given by $\sigma_{r,l}^L$ and defines the elasticity between wages and employment. The budget constraint of the representative household is

$$\begin{aligned} P_{r,t}^c\, C_{r,t}(h) &= P_{r,t}^c\, Tr_t(h) + P_{r,t}^c\, B_t\left(pop_{r,t}(h) - N_{r,t}(h)\right)\ldots \\ &\quad + \sum_k^K \Pi_{r,k,t}(h)\, P_{r,k,t} + (1-\tau^L)\, P_{r,t}^c W_{r,t} N_{r,t}(h). \qquad (2) \\ P_{r,t}^c C_{r,t}(h) &= \sum_k^K \sum_o^R P_{o,k,t} C_{r,o,k,t}(h). \\ P_{r,t}^c W_{r,t} N_{r,t}(h) &= \sum_l^L P_{r,l,t} W_{r,l,t} N_{r,l,t}(h). \end{aligned}$$

Households have no access to bonds or other assets to save money. Their income sources are the net profits of firms $\sum_k^K \Pi_{r,k,t}(h)\, P_{r,k,t}$, net labour income $\sum_l^L (1-\tau^l)\, P_{r,l,t}\, W_{r,l,t}\, N_{r,l,t}(h)$, lump-sum transfers from the state $Tr_t(h)$, and unemployment benefits $P_{r,t}^c B_t U_{r,t}(h)$. Households maximize utility (1) subject to the budget constraint (2) with respect to sectoral consumption and employment in each sector. The first order condition (henceforth first-order condition) for sectoral and regional consumption is

$$C_{r,k,t}(h) = w_k^c \left(\frac{P_{r,k,t}^c}{P_{r,t}^c}\right)^{-\eta^c} C_{r,t}(h). \qquad (3)$$

$$C_{r,o,k,t}(h) = w_{r,o,k}^d \left(\frac{P_{o,k,t}}{P_{r,k,t}^c}\right)^{-\eta_k^M} C_{r,k,t}(h). \qquad (4)$$

We derive this expression by assuming that the Lagrange multiplier of the optimization problem reflecting the marginal utility of relaxing the budget constraint is the inverse regional price level $P_{r,t}^c$. We can express the regional aggregate price index for consumption as

$$P_{r,t}^c = \left(\sum_k w_k^c {P_{r,k,t}^c}^{1-\eta^c}\right)^{\frac{1}{1-\eta^c}}. \qquad (5)$$

Further, regional sector specific aggregate price indexes for consumption are given by

$$P_{r,k,t}^c = \left(\sum_o w_{r,o,k}^d {P_{o,k,t}}^{1-\eta_k^M}\right)^{\frac{1}{1-\eta_k^M}}. \qquad (6)$$

Households derive income from labour and are compensated by the government for unemployed household members. Firms that produce intermediate goods hire household members. Households only send their members to work if the nominal wage compensates for the disutility of working and the unemployment benefits. The first-order condition for labour is

$$P_{r,l,t}\,W_{r,l,t} = z_t A^L_{r,l} N_{r,l,t}(h)^{\sigma^L_{r,l}} P^c_{r,t} + B_t. \tag{7}$$

The left-hand side of (7) defines the nominal regional sectoral wage. The associated marginal disutility by increasing labour supply in this sector and region is represented by the first term on the right-hand side. Furthermore, the outside option of being unemployed is also considered.

All households in a region are identical by assumption. Therefore, per capita variables $x_{r,t} = \frac{X_{r,t}}{pop_{r,t}} = \frac{\int_0^1 X_{r,t}(h)\mathrm{d}h}{\int_0^1 pop_{r,t}(h)\mathrm{d}h}$ are identical to individual variables $x_{r,t} = X_{r,t}(h)$ and we can drop the index h.

3.1.2 Migration

Migration is an important mechanism for regional economic adjustments after a regional sector-specific shock. Smets & Beyer (2015) show that migration flows in the U.S. can explain up to 50% of the long-run adjustment to region-specific economic shocks. After the reunification of Germany, East Germany lost up to 15% of its inhabitants since 1990, also in response to higher unemployment rates in East Germany. Accordingly, household members in our model can migrate to different regions in Germany. Most of the migrants have been between 20 and 30 years old belonging to cohorts entering the labour force (see Kühntopf & Stedtfeld 2012). Our approach to model intra-national migration as response to the coal phase-out reflects this finding. Migration is therefore more rigid than implied by standard classical economic models, because of hidden migration costs due to the potential loss of social networks, cultural preferences or real estate investments. Every German citizen can freely choose where to live and work.

In each period t the labour force population pop_t consists of individuals $i_t = \{1, \dots, pop_t\}$. A fraction $1 - \rho^{pop}$ of individuals enters the labour force in period t and the other fraction ρ^{pop} has been part of the labour force in the previous period. Individuals entering the labour force in the current period actively decide in what region n they want to live and work. The decision problem of an individual for one specific region is modelled by a random utility maximization problem, standard in the empirical migration literature (see Beine et al. 2016).

Individuals participate in the labour market for T periods. At the beginning of their working life, they decide where to work and live, taking into account the utility at the end of their working life

$$U^L_{i,r,T|t} = \log\Big\{ (C_{r,T|t}(h) - \sum_l^L (1+\sigma^L_{r,l})^{-1} A^L_{r,l} N_{r,l,T|t}(h)^{1+\sigma^L_{r,l}}) \Big\} + \eta^{pop}_{n,T|t} + \eta_{i,r} \qquad (8)$$

given the information in period t. The first part of (8) is the utility function of the representative household at the end of the working life and $\eta^{pop}_{n,T|t}$ denotes that part of utility which depends on the economic fundamentals and common unobservable characteristics of the region among individuals given the information available at time t. The law of motion of exponential average regional attractiveness is given by

$$\epsilon^{pop}_{r,t} = \rho^{pop}\,\epsilon^{pop}_{r,t-1} + (1-\rho^{pop})\,\exp(U^L_{i,r,T|t}).$$

It is the weighted average of the utility derived from living in region r. The individual-specific stochastic component $\eta_{i,r}$ follows the Gumbell distribution (see McFadden et al. 1973). The probability of an individual choosing region r in period t is

$$\Pr(i=r|t) = \frac{\exp(U^L_{i,r,T|t})}{\sum_o \exp(U^L_{i,o,T|t})}. \qquad (9)$$

The fraction $(1-\rho^{pop})$ choose to live in region r at time t with probability $\Pr(i=r|t)$ the remaining individuals ρ^{pop} stay at their current living and working place. Therefore, the regional shares in the labour force are also given by $w^{pop}_{r,t} = \rho^{pop} w^{pop}_{r,t-1} + (1-\rho^{pop})\Pr(i = r|t)$.

3.2 Firms

3.2.1 Producers of final goods

In each region, there is a continuum of firms f in the energy and non-energy sectors, producing differentiated goods. These goods are combined into a final good $Y_{r,k,t} = \left(\int_0^1 Y_{r,k,t}(f)^{\frac{1}{\lambda_{r,k,t}}} \mathrm{d}f\right)^{\lambda_{r,k,t}}$ in each sector, which is sold to the households. Firms operating in the final goods sector are perfectly competitive and have no market power. This set-up allows including price-setting power by firms (see Petrella & Santoro 2011). The profit maximization problem of the final goods firm in each sector looks as follows

$$\underset{Y_{r,k,t}(f)}{max} P_{r,k,t}\, Y_{r,k,t} - \int_0^1 P_{r,k,t}(f)\, Y_{r,k,t}(f) \mathrm{d}f, \tag{10}$$
$$\text{s.t.} Y_{r,k,t} = \Big(\int_0^1 Y_{r,k,t}(f)^{\frac{1}{\lambda_{r,k,t}}} \mathrm{d}f \Big)^{\lambda_{r,k,t}}.$$

The first-order condition of the final goods producer w.r.t. an intermediate good is also the demand curve for each intermediate good given by

$$Y_{r,k,t}(f) = \Big(\frac{P_{r,k,t}(f)}{P_{r,k,t}} \Big)^{\frac{\lambda_{r,k,t}}{\lambda_{r,k,t}-1}} Y_{r,k,t}. \tag{11}$$

Living costs depend on migration and regional attractiveness. We assume that the market power of a firm depends on the attractiveness of the region it operates in. A higher attractiveness leads to a higher share of the population and therefore to more demand for housing services. Further, a greater number of people in one region will increase the demand for local services and increase the bargaining position of domestic firms. The market power of a firm $\lambda_{r,k,t}$ follows an auto-regressive process of order one. Firms have a higher market power in regions with a higher attractiveness $\epsilon_{r,t}^{pop}$ and therefore with a higher share of the population. Other unobserved determinants of the market power in a region and sector are summarized by the parameter $\sigma_{r,k}^{\lambda}$.

$$\lambda_{r,k,t} = \rho^{\lambda} \lambda_{r,k,t-1} + (1 - \rho^{\lambda})\, \epsilon_{r,t}^{pop}\, \sigma_{r,k}^{\lambda}. \tag{12}$$

3.2.2 Non-energy sector intermediate goods producers

Producers of intermediate goods in the non-energy sector use labour $N_{r,k,t}$. They face adjustment costs $MC_{r,k,t+h}^{h}$, so that a fraction of their production is used by adjusting their employment stock. We introduce hiring costs as in Blanchard & Galí (2010) with a non-cyclical and a cyclical component. Non-cyclical components include, e.g. training costs. Cyclical hiring costs depend on the tightness in the current labour market $\frac{H_{r,t+h}}{U_{r,t+h}^{s}}$. A structural change in the lignite regions is likely to increase unemployment rates for a longer time period. A region's losing a key industry leads to higher unemployment rates in that regions for decades, compared to the national average – e.g. the Ruhrgebiet in Germany or the Rust Belt in the US. A higher labour supply and a smaller labour demand will shift wage bargaining power from employees to employers. Including a cyclical component in hiring costs captures this bargaining shift. The optimization problem of the firm is

$$\max_{N_{r,k,t}(f)} \sum_{h=0}^{\infty} \beta^h \Big\{(1-\tau_{r,k,t+h})\, P_{r,k,t+h}(f)\, Y_{r,k,t+h}(f) - W_{r,k,t+h}\, N_{r,k,t+h}(f)\Big\} \tag{13}$$

$$\text{s.t. } Y_{r,k,t+h}(f) = \epsilon_{r,k,t+h}\Big(A_{r,k,t+h}(f) N_{r,k,t+h}(f)^{\alpha_{r,k}} - \frac{1}{\Psi} MC^h_{r,k,t+h}(f) H_{r,k,t+h}(f)^{\Psi}\Big), \tag{14}$$

$$MC^h_{r,k,t+h} = B^h_{r,k}\left\{\psi + (1-\psi)\left(\frac{H_{r,t+h}}{U^s_{r,t+h}}\right)^{v}\right\} pop^{1-\psi}_{r,t+h}, \tag{15}$$

$$H_{r,k,t+h}(f) = N_{r,k,t+h}(f) - \Big(\mu^{pop}_{r,t} - \delta\Big) N_{r,k,t+h-1}(f), \tag{16}$$

$$P_{r,k,t+h}(f) = \left(\frac{Y_{r,k,t+h}(f)}{Y_{r,k,t+h}}\right)^{\frac{1-\lambda_{r,k,t+h}}{\lambda_{r,k,t+h}}} P_{r,k,t+h}. \tag{17}$$

The index f can be omitted when prices are flexible. All firms behave identically, and therefore aggregated variables are the same as individual variables, see Christiano et al. (2010). We can derive the first-order condition with respect to labour by plugging the constraints into the objective function and taking the first derivative with respect to labour. Labour market friction is the only source of intertemporal optimization. The first-order condition for firms is

$$\frac{P_{r,k,t}}{\lambda_{r,k,t}} \alpha_{r,k}\, \epsilon_{r,k,t}\, A_{r,k,t}\, (1-\tau_{r,k,t})\, N^{\alpha_{r,k}-1}_{r,k,t} - \frac{P_{r,k,t}}{\lambda_{r,k,t}}\, MC^h_{r,k,t}\, \epsilon_{r,k,t}\, (1-\tau_{r,k,t}) H^{\Psi-1}_{r,k,t} \dots$$
$$+ \Big(\mu^{pop}_{r,t+1} - \delta\Big)\, \beta\, \frac{P_{r,k,t+1}}{\lambda_{r,k,t+1}}\, MC^h_{r,k,t+1}\, \epsilon_{r,k,t+1}\, (1-\tau_{r,k,t+1}) H^{\Psi-1}_{r,k,t+1} = W_{r,k,t}. \tag{18}$$

3.2.3 Producers of intermediate goods in the energy sector

The intertemporal optimization problem of producers of intermediate goods in the energy sector is very similar to the problem of those in the non-energy sector. Energy firms can produce energy by allocating labour between the lignite and non-lignite sectors $s \in \{LC, NLC\}$. They face hiring costs in each input sector. The intertemporal optimization problem of the energy firm is the following:

$$\underset{N_{r,k,s,t}(f)}{max} \sum_{h=0}^{\infty} \beta^h \Big[P_{r,k,t+h}(f)\, Y_{r,k,t+h}(f) - \sum_s \Big\{ W_{r,k,s,t+h}\, N_{r,k,s,t+h}(f) + Tax_{r,k,s,t+h}(f) \Big\} \Big] \tag{19}$$

$$\text{s.t. } Y_{r,k,t+h}(f) = \Big(\sum_s \phi_{r,k,s}^{\frac{1}{\eta^b}} Y_{r,k,s,t}(f)^{\frac{\eta^b-1}{\eta^b}} \Big)^{\frac{\eta^b}{\eta^b-1}}, \tag{20}$$

$$Y_{r,k,s,t+h}(f) = \epsilon_{r,k,s,t+h} \Big(A_{r,k,s,t+h}(f) N_{r,k,s,t+h}(f)^{\alpha_{r,k,s}} - \frac{1}{\Psi} MC^h_{r,k,s,t+h}(f) H_{r,k,s,t+h}(f)^{\Psi} \Big), \tag{21}$$

$$MC^h_{r,k,s,t+h} = B^h_{r,k,s} \left\{ \psi + (1-\psi) \left(\frac{H_{r,t+h}}{U^s_{r,t+h}} \right)^v \right\} pop^{1-\Psi}_{r,t+h}, \tag{22}$$

$$H_{r,k,s,t+h}(f) = N_{r,k,t+h}(f) - \Big(\mu^{pop}_{r,t} - \delta \Big) N_{r,k,t+h-1}(f), \tag{23}$$

$$P_{r,k,t+h}(f) = \left(\frac{Y_{r,k,t+h}(f)}{Y_{r,k,t+h}} \right)^{\frac{1-\lambda_{r,k,t+h}}{\lambda_{r,k,t+h}}} P_{r,k,t+h}. \tag{24}$$

Energy firms allocate labour to the input sectors according to their relative marginal productivity of labour and the respective wage paid to the workers, and the respective taxes. The first-order condition for firms is

$$\underbrace{\frac{P_{r,k,s,t}(f)}{\lambda_{r,k,t}} \alpha_{r,k,s}\, A_{r,k,s,t}\, (1-\tau_{r,k,s,t})\, N^{\alpha_{r,k,s}-1}_{r,k,s,t} - \frac{P_{r,k,s,t}(f)}{\lambda_{r,k,t}} MC^h_{r,k,s,t}\, \epsilon_{r,k,s,t}\, (1-\tau_{r,k,s,t}) H^{\Psi-1}_{r,k,s,t} \ldots}_{\text{1) contemporaneous increase in production}}$$
$$+ \underbrace{(\mu^{pop}_{r,t+1} - \delta)\, \beta\, \frac{P_{r,k,s,t+1}(f)}{\lambda_{r,k,t+1}} MC^h_{r,k,s,t+1}\, \epsilon_{r,k,s,t+1}\, (1-\tau_{r,k,s,t+1}) H^{\Psi-1}_{r,k,s,t+1}}_{\text{2) avoided future hiring costs}} = W_{r,k,s,t}. \tag{25}$$

As for the non-energy firm, the marginal product of labour for the respective input sector equals the marginal cost. The marginal cost is the respective wage.

$$P_{r,k,s,t}(f) = \frac{\partial Y_{r,k,t}(f)}{\partial Y_{r,k,s,t}(f)} = \phi_{r,k,s}^{\frac{1}{\eta^b}} \Big(\frac{Y_{r,k,s,t}(f)}{Y_{r,k,t}(f)} \Big)^{\frac{1}{\eta^b}} P_{r,k,t}(f), \tag{26}$$

$$\frac{\partial Tax_{r,k,s,t}(f)}{\partial Y_{r,k,s,t}(f)} = \tau_{r,k,s,t}\, P_{r,k,s,t}(f). \tag{27}$$

The marginal product of labour in one energy input sector depends on the marginal product of energy (26) and the marginal tax burden (27). We could also assume that energy input firms are independent companies selling to a competitive energy wholesaler. The energy wholesaler would need to pay a price according to (26) for the inputs. The first term on the left-hand side of (25) states the contemporaneous increase in energy production by increasing labour in one input sector less hiring costs. Hiring one more person today will reduce hiring costs in the next period, as captured by the second term in (25).

4 Calibration and Simulation

We simulate a deterministic transition of the economy from an initial steady-state to a terminal steady-state.[6] A provides a detailed description of the calibration of the initial and terminal steady-states.

The initial steady-state reflects the state of the German economy in 2014. The regional gross value-added shares of the initial steady-state are identical to the shares reported in Table 6. To match the reported shares we set regional and sector specific productivity $a_{n,l}$ accordingly. Therefore, the model will consider the contribution of each sector to overall gross value-added in the region. Our initial calibration also matches initial labour cost shares as reported in Table 7 by setting the labour productivity exponent $\alpha_{n,l}$ in the production function accordingly. Due to hiring costs and value-added taxes the parameter is not identical to the labour cost shares. We need to calibrate the slope of the labour supply curve $A_{n,l}$ to match the employment shares reported in Table 1.

The terminal steady-state is computed by alternating regional sector-specific productivity shocks to the lignite sector $\epsilon_{n,E,LC,t}$ to match the relative net electricity generation reported in Table 2. All structural parameters of the model are not changed as response to the coal phase-out. We are not explicitly modeling the political actions described in Section 2.2. We assume that the government has access to instruments to reduce the regional net electricity generation by lignite as reported by the electricity market model. One instrument is the decommissioning of power plants. Our model has no capital as input to the production of the intermediate goods producers. Nevertheless, decommissioning power plants affects capital utilization and capital stocks in the industry. The computation of productivity shocks is a simplified way to implement the decommissioning plan. Another instrument are regional lignite coal specific value-added tax rates (see **?**, p.57). Because of legal constraints they are hard to implement and are not considered here.

We explicitly model the evolution of regional and sectoral gross value-added of the lignite coal industry $P_{n,E,LC,t}\,Y_{n,E,LC,t}$. We set $\epsilon_{n,E,LC,t}$ such that net electricity gener-

[6] The model is implemented in Dynare (see Adjemian et al. 2006).

ation $Y_{n,E,LC,t}$ compared to 2014 corresponds to the reported net electricity generation by the electricity market model with a tolerance level of $\pm 2\%$. This approach requires that all potential fluctuations of the ratio between intermediate inputs and net electricity are included in the region and sector specific price $P_{n,E,LC,t}$.

Unemployment rates of the labour market regions are converging since the beginning of the 2000's. One of the main reasons of a convergence of unemployment rates is migration from lignite coal regions to other regions in Germany. In the long-run the lignite coal phase-out will decrease the number of people staying in or moving to the region. We assume that migration as a response to the coal phase-out will reduce the unemployment rate to the values for the year 2014 in the long-run.

In order to evaluate the sensitivity of the results to our calibrated parameter values we define a parameter space. The parameter space is summarized in Table 4. We define marginal uniform distributions $\mathcal{U}(a, b)$ for the reported parameters. We will report the simulation results for all parameters set to the mean of their respective distributions. For our sensitivity analysis we will draw 1200 parameter combinations and simulate all paths. We conduct a univariate sensitivity analysis by changing only one parameter at the time and all other parameters are set to their respective mean. We report the sensitivity of our results for the minimum, the first quartile, the mean/median, the third quartile and the maximum of the respective univariate distributions.

Table 4: Parameter space

Parameter	Interval	Description	Source for the mean
η_E^m	$\mathcal{U}(760, 840)$	elasticity of substitution between regions for energy	estimated from regional national accounts data
I_E^{Home}	$\mathcal{U}(0.475, 0.525)$	home bias energy	calibrated
I_{NE}^{Home}	$\mathcal{U}(0.8075, 0.8925)$	home bias non-energy	Hristov (2016)
σ^L	$\mathcal{U}(0.2375, 0.2625)$	inverse Frisch elasticity / excluding lignite Rest of Germany	King & Rebelo (1999)
$\bar{\lambda}_n$	$\mathcal{U}(1.1875, 1.3125)$	market power in region n at start	calibrated
η_n^b	$\mathcal{U}(19.57, 21.63)$	elasticity of substitution between lignite coal and non lignite coal in region n	calibrated
x	$\mathcal{U}(0.2131, 0.2355)$	steady-state job finding rate	according to long-term unemployed share
β	$\mathcal{U}(0.9975, 0.9984)$	discount factor	Hristov (2016)
v	$\mathcal{U}(0.95, 1.05)$	hiring cost elasticity to labour market tightness	Blanchard & Galí (2010)
ρ_ϵ^{pop}	$\mathcal{U}(0.9921, 0.9929)$	persistence in living preferences	calibrated
ρ^λ	$\mathcal{U}(0.855, 0.945)$	posterior mode of mark-up shocks	estimated by Smets & Wouters (2007)
ρ^b	$\mathcal{U}(0.8075, 0.8925)$	AR(1) coefficient for adjustment replacement rate	estimated from OECD data
η^c	$\mathcal{U}(0.7125, 0.7875)$	elasticity of substitution between energy and non-energy sector	estimated from national accounts data
$\frac{\kappa}{w\,n}$	$\mathcal{U}(0.0617, 0.0683)$	relation of hiring costs to wage bill	estimated by Christiano et al. (2016)

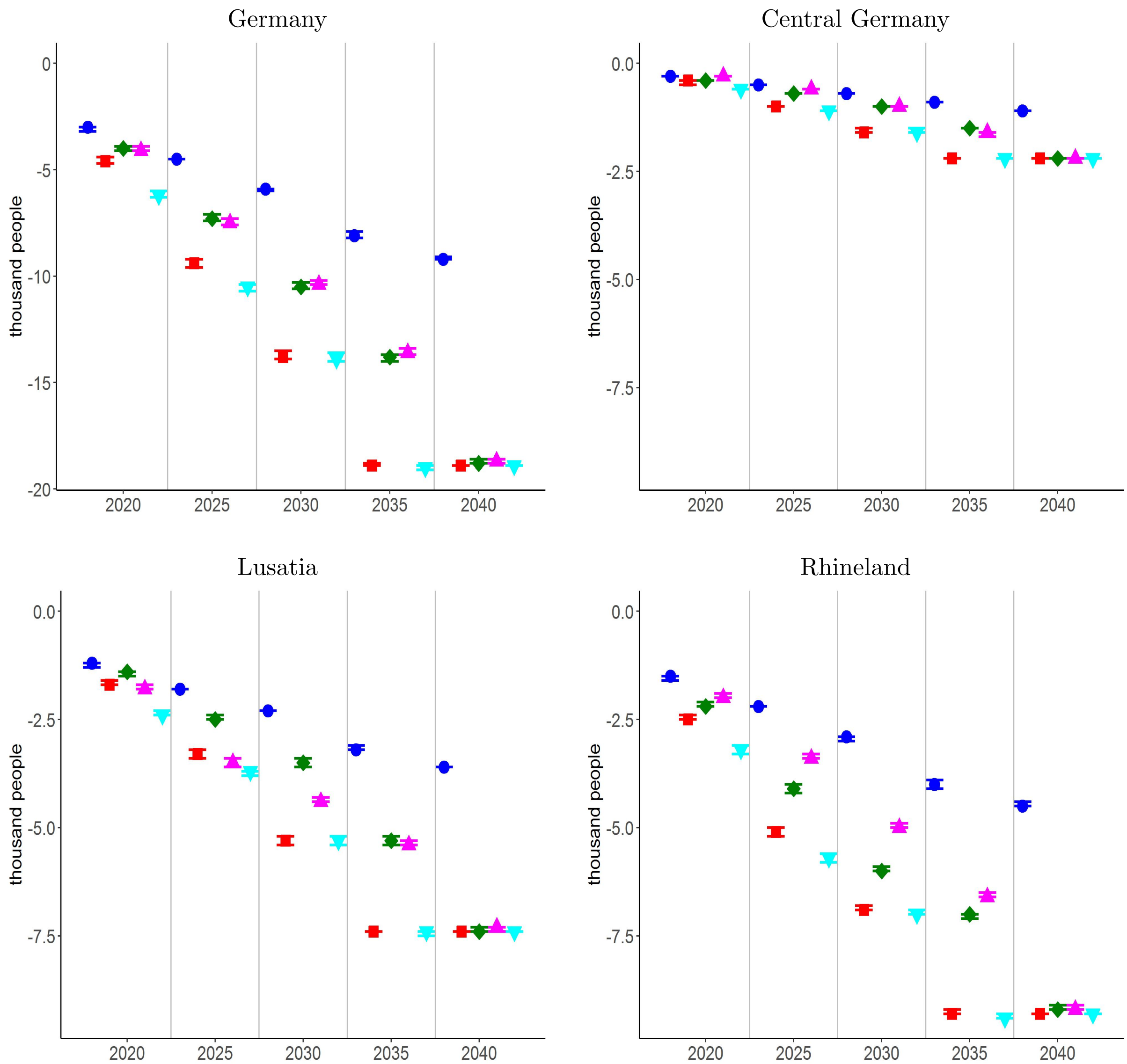
5 Results

A reduction of net electricity generation by lignite according to Table 2 described in Section 2 will directly affect the demand for workers in the lignite industry, temporarily increase unemployment rates, reduce labour income and lead to migration. To explain the main results of the simulations we need to refer to simulation results of other variables. Therefore, we report results for other variables in Table 11 to Table 17 and Figure 9 to Figure 15 in the Appendix.[7]

The reduction in lignite employees is depicted in Figure 2. The implemented climate policy measures captured by the Baseline scenario will reduce the number of employees in the lignite industry by 9,200 [9,200; 9,300] by 2040 compared to the Null-Scenario. The number of employees in the lignite industry compared to the Null-Scenario in the Rhineland, Lusatia and Central Germany will decrease by approximately 45% in each region compared to 2014. Additional political measures will reduce the number of lignite employees in the Rhineland, Lusatia, and Central Germany by 4,800 [4,700; 4,800], 3,800 [3,800; 3,800] and 1,100 [1,100; 1,100] people by 2040, respectively. Number in brackets indicate the smallest and largest difference to the Null-Scenario simulated for

[7]More results are reported in Table D.1 to Table D.24 and Figure D.1 to Figure D.15 in the Online Appendix.

Figure 2: Simulation results for employment in lignite sector



Note: Difference compared to the Null-Scenario in thousand people, Baseline (blue circle), Phase-Out-2035-Weak (red square), Phase-Out-2040-Age (green diamond), Phase-Out-2040-Balanced (magenta triangle point-up) and Phase-Out-2035-Strong (cyan triangle point-down). Horizontal lines indicate the maximum and minimum value observed for 1200 simulations.

the time period 2014 to 2040 and based on the results of the multivariate sensitivity analysis.

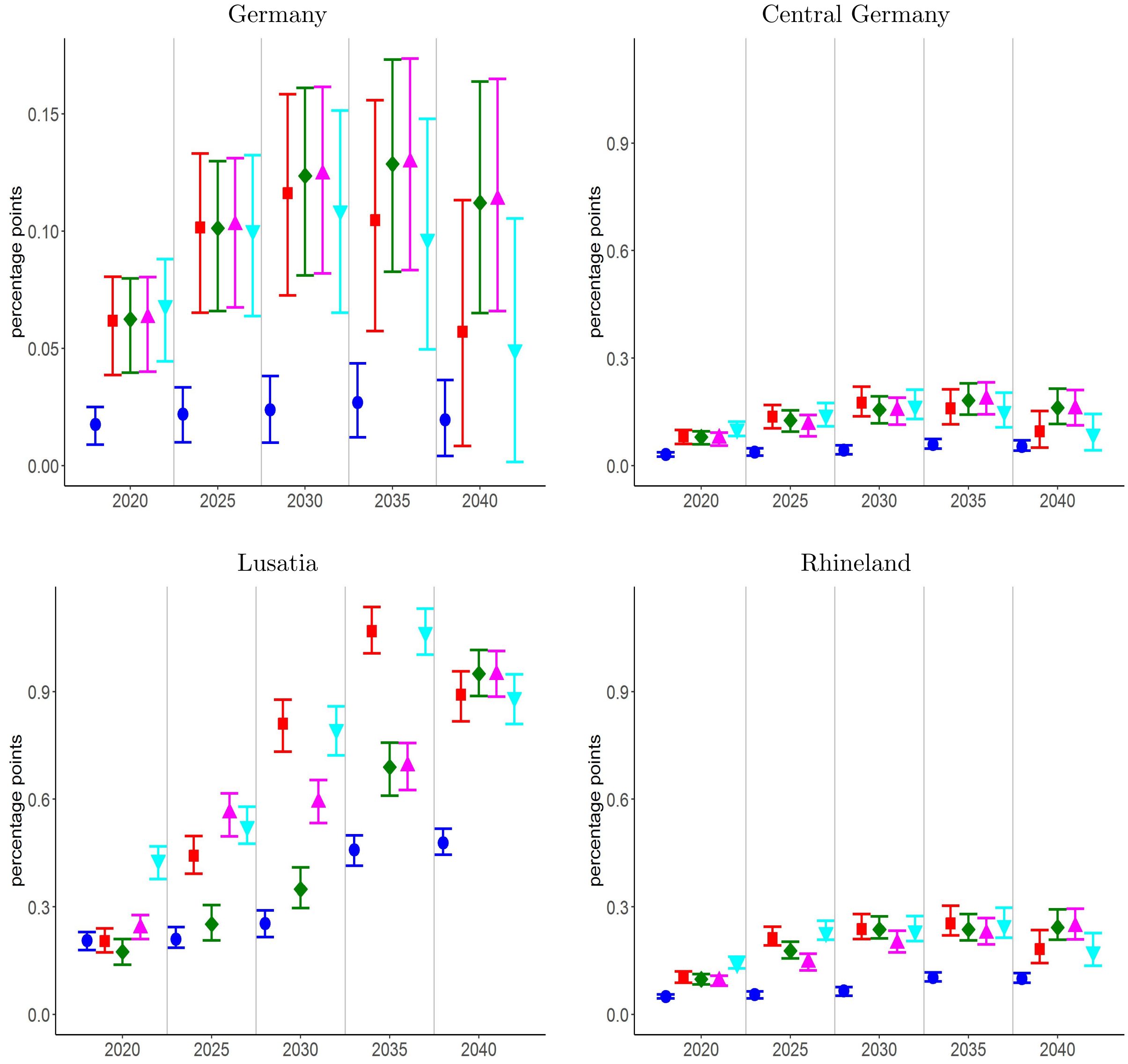
The direct employment effects will trigger negative indirect and induced employment effects, but also positive employment effects in other sectors by reducing labour costs and expanding other energy sources. Negative effects exceed the positive employment effects reflected by an increase in unemployment rates as depicted in Figure 3. Unemployment rates increase in the Baseline scenario by 0.02 [0.01; 0.03], 0.06 [0.04; 0.07], 0.48 [0.44; 0.51], and 0.10 [0.09; 0.11] percentage points between 2014 and 2040 compared to the Null-Scenario in the rest of Germany, Central Germany, Lusatia, and the Rhineland, respectively. There are up to 3,400 [-1,800; 9,700], 1,200 [1,000; 1,400], 5,000 [3,700; 5,700] and 5,500 [4,800; 6,100] fewer people employed between 2020 and 2040 compared to the Null-Scenario in the rest of Germany, Central Germany, Lusatia, and the Rhineland, respectively.

A total phase-out of coal increases the unemployment rates by 0.11 [0.06; 0.16] (Phase-Out-2040-Age, Phase-Out-2040-Balanced), 0.18 [0.13; 0.22] (Phase-Out-2035-Weak, Phase-Out-2040-Age, Phase-Out-2040-Balanced), 1.07 [1.00; 1.13] (Phase-Out-2035-Weak, Phase-Out-2035-Strong) and 0.25 [0.20; 0.28] [(Phase-Out-2035-Weak, Phase-Out-2035-Strong) percentage points in the rest of Germany, Central Germany, Lusatia, and the Rhineland. Therefore, up to 36,300 [20,400; 55,000] (Phase-Out-2040-Balanced), 2,800 [2,100; 3,300] (Phase-Out-2035-Weak), 9,500 [7,500; 10,600] (Phase-Out-2035-Weak) and 11,400 [9,900; 12,600] (Phase-Out-2040-Balanced) more people are unemployed compared to the Baseline in the rest of Germany, Central Germany, Lusatia, and the Rhineland. A total phase-out can lead to a maximum reduction in employment in Germany by up to 55,100 [36,300; 74,800] people in 2035 (Phase-Out-2040-Balanced). Only in the scenarios Phase-Out-2040-Age and Phase-Out-2040-Balanced the national unemployment rate will be above the value for the Null-Scenario in 2040. For the scenarios Phase-Out-2035-Weak and Phase-Out-2035-Strong the national unemployment rate is close to the value for the Null-Scenario in 2040. The recovery process is mainly driven by the rest of Germany and not the lignite coal regions itself.

The recovery process is mainly caused by lower real wages in the regions. This will also decrease labour income in the lignite regions permanently as depicted in Figure 11 in the Appendix. The fall in labour income is the greatest in Lusatia compared to all other regions. This even triggers in addition to the previous reasons a non-negative response in non-energy employment rates. Nevertheless, in absolute terms, migration leads to a smaller labour force and to a smaller number of employees in the non-energy sector in Lusatia. A reduction in wages will reduce unemployment benefits in the long-run and trigger an increase in employment rates in Germany. The outside option of not working becomes less attractive. The lignite industry pays relatively high wages and overall wages will fall after the industry is no longer a potential employer. Due to this fall, unemployment rates also fall, because lower overall wages will increase demand for employees and reduce unemployment benefit rates.

Welfare depends on consumption and labour disutility as formulated in (1). There is no phase-out path clearly dominating the other phase-out paths in terms of aggregate discounted future welfare (see Table 15 and Table 16). Only differences in discounted cumulative welfare for Lusatia differ notably and indicate that Phase-Out-2035-Weak is welfare efficient for Lusatia. Migration responds to new long-run differentials in

Figure 3: Simulation results for unemployment rates



Note: Difference compared to the Null-Scenario in percentage points, Baseline (blue circle), Phase-Out-2035-Weak (red square), Phase-Out-2040-Age (green diamond), Phase-Out-2040-Balanced (magenta triangle point-up) and Phase-Out-2035-Strong (cyan triangle point-down). Horizontal lines indicate the maximum and minimum value observed for 1200 simulations.

utility. A total phase-out will reduce the attractiveness of the lignite regions Lusatia and the Rhineland and increase the attractiveness of the rest of Germany and Central Germany, which will result in lower and higher labour force shares, respectively. Nevertheless, the attractiveness of Central Germany does not increase sufficiently to attract more people, and leads to a more or less unaffected labour force share (see Figure 10 in the Appendix). Migration decreases the labour force by 5,600 [3,000; 7,000] and 4,300 [3,000; 5,100] in Lusatia and the Rhineland in 2040 compared to the Null-Scenario, respectively. In Central Germany, the labour force only decreases by

200 [200; 300] people by 2040. Compared to the Baseline path, migration between Lusatia, the Rhineland and the rest of Germany increases by roughly 4,000 people or 80%.

The previous results depend on the calibrated parameter values. We specify subjective probability distributions for a systematic sensitivity analysis.[8] Further, we investigate what parameters drive the simulated maximum increase in the unemployment rate between 2014 and 2040. Figure 4 depicts how the simulated maximum increase depend on the four most important parameters.

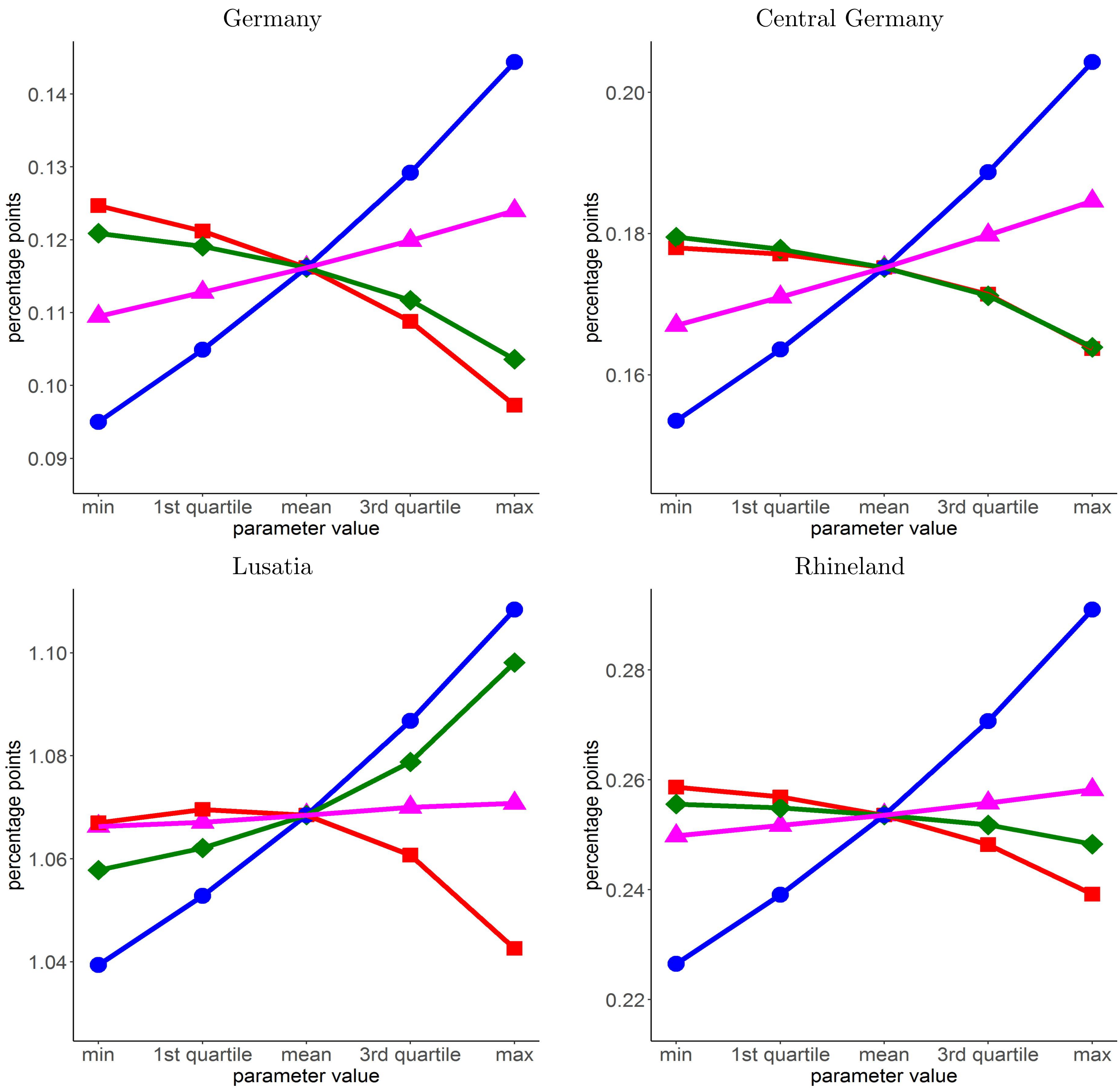
Figure 4 reports the sensitivity analysis for Phase-Out-2035-Weak. The reported parameters are the same for all phase-out paths. The maximum increase in the unemployment rate depends on the persistence in unemployment benefits. Higher persistence in unemployment benefits will reduce wage flexibility. At the mean the maximum increase in unemployment is about 0.12 percentage points. At the minimum value the maximum increase decreases by roughly 0.02 percentage points and at the maximum parameter value the maximum increase will be 0.02 percentage points higher. Future adjustments of unemployment benefits and wages have to be considered as potential policy tool to reduce the employment effects. Further, our introduction of rigid unemployment benefits also captures other rigidities in the adjustment of wages to changing economic fundamentals such as collective wage agreements. But reducing the rigidity in unemployment benefits will increase the maximum drop in wages. Nevertheless, the quantity effect dominates the price effect for labour compensation and more flexible unemployment benefits will reduce the maximum drop in labour compensation. The relationship between the maximum increase in the unemployment rate and the persistence in unemployment benefits is the same across all regions.

A home bias parameter for non-energy products set to the maximum value can increase the unemployment rate by less than 0.01 percentage points. Reducing the home bias parameter to its minimum value will decrease the maximum increase by roughly 0.02 percentage points. The simulated maximum increase in the lignite regions increases with a higher parameter value for the non-energy home bias. A higher home bias in the non-energy sector will reduce the demand in rest of Germany for non-energy products produced in the lignite regions. New jobs in the non-energy sector to replace the old jobs in the lignite industry require demand. A potential policy might be to stimulate demand for non-energy products from lignite regions.

The persistence in market power and the initial steady-state of market power have the weakest effect on the maximum increase in the unemployment rate. Unemployment rates depend positively on the persistence. Market power increases in regions experiencing a greater inflow of migration. More persistent market power will reduce the speed

[8] The detailed results for all parameters are discussed in the Online Appendix D.3.

Figure 4: Sensitivity analysis for maximum increase in the unemployment rate



Note: Change in maximum employment drop between 2014 to 2040 for Phase-Out-2035-Weak compared to the Null-Scenario in percentage points changing the value of only one parameter. The most important parameters for the maximum increase in the German unemployment rate in descending order are: persistence in unemployment benefits ρ^b (blue circle), home bias non-energy I^H_{NE} (red square), persistence of market power ρ^λ (green diamond), steady-state value of market power $\bar{\lambda}$ (magenta triangle point-up). We report the change in the maximum drop for the minimum, first quartile, median/mean, third quartile and maximum parameter value.

of adjustment. Therefore, the simulated maximum increase in the unemployment rate declines with a higher persistence in market power. A higher initial value for market power increases the maximum increase in the unemployment rate.

6 Conclusions

In January 2019, the Commission on Growth, Structural Change and Employment in Germany proposed a plan for the stepwise reduction of electricity generation by lignite. The proposal suggests a total phase-out until 2038 and includes an option to phase-out until 2035, if this does not threaten the security of electricity supply. Our analysis shows, that a phase-out until 2035 is not worse than a phase-out until 2040 in terms of discounted cumulative welfare and might even be preferable in terms of the national unemployment rate. A phase-out until 2035 leads to a faster increase of other energy sources by increasing energy prices. This causes more employment in the rest of Germany. Albeit our simulation results do not explicitly model other energy sources we very likely underestimate the required employees in the non-lignite energy sector to replace the lignite industry. An earlier exit date is therefore very unlikely to increase negative employment effects. Nevertheless, this finding depends not only on the technical feasibility of the phase-out paths, but also on the assumption that migration is only determined by long-run variables and does not vary with the timing of the decommissioning plan. Therefore, migration takes place in all total phase-out scenarios at the same speed. Our sensitivity analysis identifies that the persistence in unemployment benefits, the demand for domestic non-energy products and the persistence in market power are important for the maximum drop in employment, labour income and consumption. Policy measures to reduce the impact of a coal phase-out should focus on the flexibility of wages and unemployment benefits, but should also lower formal and informal costs of starting a business to reduce market power.

The potential employment effects in absolute terms seem to be large, but with regard to the labour force of Germany rather small. Moreover, the labour force in Germany will decrease by 3.5 million by 2040, i.e. 8% of the labour force in 2014, due to demographic change. Compared to the effects of demographic developments in Germany, the lignite phase-out has relatively small effects. Furthermore, our analysis excluded any potential technical progress in other energy sectors, such as the renewable energy sector. Potential technological improvements in these sectors might crowd out lignite as an energy source. Neither have increasing extraction costs been considered. These developments would reduce the potential economic effects of a politically induced lignite phase-out in Germany. Our results show that postponing the phase-out will only move negative effects more into the future.

Our analysis did not consider potential effects of higher energy prices on the current account of Germany. In recent years, Germany has been a net electricity exporter and, hence, a coal phase-out might turn Germany into a net electricity importer, i.e. importing electricity that might be generated by lignite in neighbouring countries, such as the Czech Republic and Poland. However, this seems to be unlikely due to capacity constraints in these countries (Matthes et al. 2018).

An unsettled issue is whether a coal-phase out is the abatement-cost minimizing policy to achieve the national greenhouse gas emissions targets. The decommissioning of coal fired power plants is an additional national measure parallel to the European Union Emissions Trading Scheme. Hybrid regulations to reduce greenhouse gas emissions are inefficient compared to purely market based mechanisms (Böhringer et al. 2006). Most studies investigating the abatement costs of different policies use static estimates (see Gillingham & Stock 2018) and ignore intertemporal dependencies. For instance, Lin & Chen (2019) show that higher electricity prices lead to more innovations in the renewable energy sector in the long run. Our analysis ignores the costs of stranded assets implied by the transition from lignite electricity generation to non-lignite electricity generation (see Rozenberg et al. 2018). The main source of stranded assets induced by a lignite phase-out in Germany is a shorter life time of lignite power plants and mining fields. The book value of old lignite power plants is already close to zero. If more efficient and younger power plants operate longer, then the effect of stranded assets is reduced. Further, coal fired power plants can be modified to run based on other energy sources, reducing also the opportunity costs to continue the operation of coal fired power plants based on lignite. Future research should evaluate the impact of different policies and stranded assets on dynamic abatement costs. Nevertheless, the major share of abatement costs associated with a lignite phase-out in Germany is very likely a lower labour market income in the lignite regions.

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A Calibration

A.1 Initial Steady State

Annual trend inflation is assumed to be 2% and the corresponding gross trend inflation π^c is set to 1.02. The annual real per capita technological trend growth rate is set to 0.75% corresponding to a real per capita gross growth rate μ^{z^*} of 1.0075. The discount factor β is set to 0.998.[9] Employment shares are set in such a way that the values in Table 1 are obtained. Furthermore, to reflect the relative importance of each sector for regional labour income, we set the labour productivity exponent in the production function $\alpha_{r,l}$ to be

$$\alpha_{r,l} = \frac{1 + (1-\tau_{r,l})\,\epsilon_{r,l}\,((1-(\mu^{pop}-\delta)\,\beta\,\mu^{z}\,\pi^{c})\,\psi\,\kappa^{w}_{r,l}\,\frac{n_{r,l}}{h_{r,l}}}{(1-\tau_{r,k})\,\epsilon_{r,l}\,(\frac{1}{\phi^{w}_{r,l}}+\kappa^{w}_{r,l})}. \tag{28}$$

We take into account the labour cost shares $\phi^{w}_{r,l} = \frac{w_{r,l}n_{r,l}}{y_{r,l}}$ reported in Table 6. The share of hiring costs relative to the wage bill $\kappa^{w}_{r,l} = \frac{\kappa_{r,l}}{w_{r,l}\,n_{r,l}}$ is 6.5%, in line with Christiano et al. (2016). The same formula holds for the energy input sectors. The exogenous separation rate δ is set such that the job finding rate x_t is 22%. A short-term unemployed person in Germany (less than one year) receives 60% of the last year's average net wage, depending on their family status, and a long-term unemployed person in Germany receives a compensation of 42% of the current net wage in Germany, including housing and other assistance.[10] The share of unemployed who are long-term unemployed in steady-state is $(1-x)^4$ and is around 37%. The effective labour tax rate τ^l is set to 35% (see Hristov 2016, p. 22). Unemployment benefits for a representative unemployed person in steady-state is a weighted average over unemployment benefits for short-term and long-term benefits. Therefore, unemployment benefits are set to 35% relative to the real gross wage $b = \psi^w\,w$ in steady-state. A regression of annual real unemployment benefits on past realizations shows that the persistence parameter ρ^b is estimated to be 0.85. The inverse Frisch elasticity of substitution $\sigma^{L}_{r,l}$ is set to 0.25 (see King & Rebelo 1999, p. 975).

[9] The calibration of the parameters is summarized in Table 10.

[10] Replacement rates for long-term and short-term unemployed are reported by the OECD: `http://www.oecd.org/els/soc/benefits-and-wages.htm`

In order to match the share of gross value-added to total production in Germany $\phi^y_{r,k}$ reported in Table 6, the productivity parameters $a_{r,k}$ are calculated by

$$\Omega^w_{r,k} = 1 - \frac{\kappa^w_{r,k}}{\frac{1}{\phi^w_{r,k}} + \epsilon_{r,k}\kappa^w_{r,k}}, \tag{29}$$

$$\Delta_{r,k,s} = \epsilon_{r,k,s}\, n_{r,k,s}^{\alpha_{r,k,s}}\, \Omega^w_{r,k,s} \left(\frac{\phi_{r,k,s}\, {\theta^y_{r,k,s}}^{-\eta^b}}{1-\tau_{r,k,s}}\right)^{\frac{1}{\eta^b-1}}, \tag{30}$$

$$\Delta_{r,k} = \begin{cases} \sum_{d=1}^{R} \frac{\phi_{d,k,s}^{\frac{1}{\eta^b}}\, \theta^y_{r,k}\, (1-\tau_{r,k,s})\, \epsilon_{r,k,s}\, (\frac{\sum_{r=1}^{S} \phi_{r,k,r}\, \Delta_{r,k,s}}{\Delta_{r,k,r}})}{(1-\tau_{r,k})\, w_r^{pop}} & \text{if } k = \text{E} \\ \frac{\theta^y_{r,k}}{(1-\tau_{r,k})\, w_r^{pop}\, \gamma_{r,k}\, \epsilon_{r,k}\, n_{r,k}^{\alpha_{r,k}}\, \Omega^w_{r,k}} & \text{if } k = \text{NE} \end{cases}, \tag{31}$$

$$a_{r,k} = \bar{a} \sum_{r=1}^{R} \sum_{h=1}^{K} \frac{1}{K\,R} \frac{\theta^y_{r,h}\, \Delta_{r,k}}{\theta^y_{r,k}\, \Delta_{d,h}}, \tag{32}$$

$$a_{r,k,s} = \Big(\Delta_{r,k,s} \sum_{q=1}^{S} \frac{\phi_{r,k,q}}{\Delta_{r,k,q}}\Big)^{-1} a_{r,k}. \tag{33}$$

The productivity parameters are rescaled such that on average $\bar{a} = 1$. In our special case, taxation is the same for each sector and region. The tax rate $\tau_{r,l}$ on sales is 19%, which corresponds to the value-added tax in Germany. Net value-added shares are identical to gross value-added shares, because tax rates are the same for each sector.

The CES demand weights $\omega^d_{r,o,k}$ are calibrated to reflect a home bias and transaction costs for trade between regions. Furthermore, the relative productivity profile and the size of the population are taken into consideration.

$$\omega^{pop,d}_{r,o,k} = \begin{cases} I^{HomeBias}_{r,k} & \text{if } r = d \\ (1 - I^{HomeBias}_{r,k})\, \frac{w_r^{pop}}{\sum_{o \notin r}^{R} w_o^{pop}} & \text{else} \end{cases}. \tag{34}$$

$$\omega^d_{r,o,k} = \frac{\omega^{pop,d}_{r,o,k}\, a_{r,k}}{\sum_{o=1}^{R} \omega^{pop,d}_{r,o,k}\, a_{o,k}}. \tag{35}$$

In the non-energy sector, non-tradable and tradable goods are combined. According to Hristov (2016), the non-tradable share in Germany is 0.56 and the tradable home bias is 0.6, therefore we have a home bias in the non-energy sector of $0.85 \approx 0.56 + 0.6 * (1 - 0.56)$. The home bias share for the energy sector is set to 0.5. The scaling coefficients for marginal hiring costs $B_{r,l}$ are

$$B^h_{r,l} = \frac{mc^h_{r,l}}{\Omega + (1-\Omega)\left(\frac{h_r}{u^s_r}\right)^v} \text{ with } mc^h_{r,l} = \psi\, \kappa^w_{r,l}\, w_{r,l}\, n_{r,l} h_{r,l}^{-\psi}. \tag{36}$$

Adjustment costs to the employment stock of a firm are quadratic $\psi = 2$. To fulfill the first-order conditions for wages, the disutility parameters $A^L_{r,l}$ are set such that

$$A^L_{r,l} = \left(1 - \tau^l\right) \frac{\gamma_{r,l}\, w^*_{r,l} - b_r}{\gamma^c_r\, n^{\sigma^L_{r,l}}_{r,l}}. \tag{37}$$

The elasticity of substitution between the energy and non-energy sectors η^c is estimated from gross-value-added data. The point estimate is 0.75, implying that the energy and non-energy sector are complements. Therefore, a price increase in one sector causes a reduction in demand for the other sector. To estimate the elasticity of substitution, we use (3).

The regional elasticity of substitution for non-energy products η^m_{NE} is estimated by pooled OLS with national accounts data for the German states. A point estimate of 1.15 is estimated in line with an estimate from Hristov (2016) for tradable regional products between European countries and Germany.

The regional elasticity of substitution for energy products η^m_E is estimated by pooled ordinary least squares with national accounts data for the German states. The point estimate is 800, in line with the fact that electricity and other products of the energy sector from different regions are perfect substitutes.

Unfortunately, there is no data source with which to estimate the elasticity of substitution between lignite and non-lignite $\eta^b \in (1, \ldots, \infty]$. Therefore, we calibrate this parameter to the smallest value such that a permanent sector productivity shock to lignite in one region triggers a non-negative employment reaction in the non-lignite energy sector of the region. This reaction depends on the relative elasticities of substitution between and within regions. The smallest value fulfilling this condition is $\eta^b = 20.6$. This value indicates also that other inputs to the energy sector are almost perfect substitutes.

A.2 Terminal Steady State

We simulate permanent shocks to sector productivity $\epsilon_{r,E,LC,t}$ of lignite in Germany. A decommissioning plan implies a stepwise reduction of sector specific productivity. We assume that the decommissioning plan is certain and irreversible.

The shutdown of lignite power plants implies new long-run differentials in sector productivity of German lignite regions and the rest of Germany. Our simulation is the transition from one deterministic steady-state to another. The terminal steady-state is calculated by solving the static equations of the model given the new sector productivity profile. More precisely, it is necessary to find new employment shares such that the first-order conditions of the households with respect to labour are satisfied. It is also necessary to find the relative prices given arbitrary employment shares such that the market clearing conditions hold.

Unobserved characteristics of regional attractiveness $\eta_{r,t}^{pop}$ adjust such that in the terminal steady-state regional total employment shares are the same as before. Migration leads to different population shares $w_{r,t}^{pop}$ and to different demands for products from each region.

A higher attractiveness of a region increases its population density, triggers higher housing prices and, therefore, alters the desired mark-ups in all sectors because the population density increases. This idea originates from Grossmann et al. (2017), who postulate that migration flows increase prices in regions with higher population densities through higher housing prices. We further assume that firms operating in regions with a higher attractiveness leading to higher population density can charge higher mark-ups than those in regions with lower attractiveness and population density.

The auto-correlation coefficient ρ^{pop} is set such that a population shock has a half-life of 22.5 years, corresponding to one-half of the time an individual participates in the labour force. Our implied annual share of individuals actively deciding to migrate is 3%. New individuals are assumed to have different preferences for where to live. In our set-up, the long-run attractiveness $\eta_r^{pop} = f_{r,T|t}(u(\{C_{r,k,T|t}(h)\}_{k=1}^{K}, \{N_{r,l,T|t}(h)\}_{l=1}^{L}))$ is a function of the terminal steady-state values of the endogenous variables of the model $\bar{Z}$ and exogenous variables X such that regional employment rates return to their original steady-state. Write $\tilde{Z}$ for the steady-state vector of endogenous variables without regional employment rates n_r and regional preferences η_r^{pop}. We can express regional employment shares as a function of living preferences

$$\bar{n}_r = f\{\eta_r^{pop}, \tilde{Z}(\bar{n}_r, \eta_r^{pop}, X), X\}. \tag{38}$$

Therefore, the steady-state is given such that $\bar{n}_r$ corresponds to the initial value given the new vector of exogenous and endogenous variables. The steady-state values of endogenous variables without regional employment rates depend on the regional employment rates, living preferences, and steady-state values of the exogenous variables. We are only able to find a numerical solution and not an analytical solution.

B Tables

Table 5: Lignite labour market regions

Central Germany	Lusatia	Rhineland
	Territory	
Landkreis Leipzig	Landkreis Elbe-Elster	Rhein-Kreis Neuss
Stadt Leipzig	Landkreis Oberspreewald-Lausitz	Kreis Düren
Burgenlandkreis	Landkreis Spree-Neiße	Rhein-Erft-Kreis
Nordsachsen	Stadt Cottbus	Städteregion Aachen
Saalekreis	Landkreis Bautzen	Kreis Heinsberg
Stadt Halle	Landkreis Görlitz	Kreis Euskirchen
Landkreis Mansfeld-Südharz		Stadt Mönchengladbach
	Labour Market Region	
Erzgebirgskreis		Düsseldorf
Mittelsachsen		Krefeld
Zwickau		Leverkusen
		Mettmann
		Kreis Heinsberg
		Mettmann
		Rheinisch-Bergischer Kreis
		Viersen

Note: The counties belonging to territories using lignite and counties building a labour market region with the former ones are tabulated.
Sources: German Federal Ministry for Economic Affairs and Kosfeld & Werner (2012).

Table 6: Gross value-added shares

Region	Energy		Non-Energy	Total
	Lignite Coal	Non-Lignite Coal		
Rest of Germany	0.002	1.81	98.18	88.66
Central Germany	0.42	2.94	96.64	2.70
Lusatia	3.86	4.92	91.22	0.86
Rhineland	0.60	2.08	97.32	7.78
Germany	0.09	1.89	98.02	100.00

Note: Gross value-added shares in 2014 in percent. Total states the share of gross value-added of the region in national gross value-added.
Sources: German Federal Statistical Office and own calculations.

Table 7: Labour shares

Region	Energy		Non-Energy	Total
	Lignite Coal	Non-Lignite Coal		
Rest of Germany	50.87	35.65	56.85	56.28
Central Germany	54.48	31.55	57.52	56.75
Lusatia	60.09	24.75	55.61	56.75
Rhineland	58.42	46.32	57.53	54.27
Germany	58.37	36.15	56.91	57.30

Note: Labour shares for 2014 in percent. The ratio is the wage sum of the respective sector divided by gross value added in the sector.
Sources: German Federal Statistical Office and own calculations.

Table 8: Symbols of variables

Symbol	Description
z	exogenous common trend
tax	tax
n	employment
y	output
b	unemployment benefit
u	unemployment
U	utility
h	hiring rate
w	real wage
c	consumption
g	government spending
tr	government transfers
γ	relative producer prices
γ^c	relative consumption prices
u^s	unemployment before hiring
u	unemployment rate
w^{pop}	population weight
τ	effective tax rate for the firm
h	hiring rate
x	job finding rate
mc^h	marginal hiring cost
κ	hiring cost
w^*	optimal real wage
λ	mark-up
$\pi^{profits}$	profits
ϵ	technology shocks
ϵ^l	labour preference shock
ϵ^h	hiring cost shock
ϵ^{pop}	preference shock for living

Table 9: Symbols of parameters

Symbol	Description
R	regions
K	sectors
S	input sectors
ω_k^c	CES weight for sector k
η^c	elasticity of substitution between energy and non-energy
η^m	regional elasticity of substitution
a	productivity constants
ϕ	CES shares for energy production with lignite coal
A^L	disutility to labour
B	marginal hiring cost constants
Ω	share of business cycle invariant hiring costs
I_{NE}^{Home}	home bias
ω^d	regional demand preferences
σ^L	inverse Frisch elasticity of labour
σ^λ	constant in law of motion of mark-up equation
$\sigma^{\epsilon^{pop}}$	constant in law of motion of regional attractiveness
α	labour share
δ	separation rate
β	discount factor
v	hiring cost elasticity
ψ	exponent for hiring costs
η^c	elasticity of substitution between sectors
η^b	elasticity of substitution between coal and non coal
τ^l	tax rate on labour
π^c	steady-state inflation
μ^z	growth rate of exogenous trend z_t
μ^{pop}	population growth rate
f	AR(1) coefficient for real wage rigidity
ρ^b	AR(1) coefficient for adjustment replacement rate
ρ_ϵ	persistence productivity shock
ρ_ϵ^{pop}	AR(1) coefficient for living preferences
ρ^λ	persistence in mark-up

Table 10: Parameter values

Parameter	Value	Description	Source
η_E^m	800	elasticity of substitution between regions for energy	estimated from regional national account data
$\bar{\tau}$	0.190	VAT tax rate	Hristov (2016)
I_E^{Home}	0.500	home bias	calibrated
I_{NE}^{Home}	0.8500	home bias	calibrated according to Hristov (2016)
σ^L	0.25 / 0.001	inverse Frisch elasticity / inverse Frisch elasticity lignite Rest of Germany	King & Rebelo (1999) and calibration
$\bar{\lambda}_n$	1.250	market power in region n at start	calibrated
η_n^b	20.600	elasticity of substitution between lignite coal and non lignite coal in region n	calibrated
δ	$\frac{x}{1-x}\frac{1-n}{n}\mu^{pop}$	separation rate	computed
x	0.22	steady-state job finding rate	according to long-term unemployed share
β	0.998	discount factor	Hristov (2016)
υ	1.000	hiring cost elasticity to labour market tightness	Blanchard & Galí (2010)
ρ_ϵ^{pop}	0.9925	persistence in living preferences	calibrated
ρ^λ	0.900	posterior mode of mark-up shocks	estimated by Smets & Wouters (2007)
ρ^b	0.85	AR(1) coefficient for adjustment replacement rate	estimated from OECD data
ψ	2.000	exponent for hiring costs	calibrated
η^c	0.750	elasticity of substitution between energy and non-energy sector	estimated from national accounts data
τ^l	0.350	tax rate on labour	Hristov (2016)
Ω	0.950	share of invariant business cycle varying hiring costs	Christiano et al. (2016)
ζ^w	0.350	unemployment benefits replacement ratio	estimated
π^c	1.005	steady-state inflation	long-run inflation target of the ECB
μ^z	1.002	steady-state growth rate	potential growth rate according to IWH
μ^{pop}	0.999	steady-state population growth rate	average of projected labour force growth (see Figure 6).

Table 11: Employees in lignite sector

Year	Germany	Rest of Germany	Central Germany	Lusatia	Rhineland
Null-Scenario					
2014	21.2 [0.0;0.0]	0.5 [0.0;0.0]	2.4 [0.0;0.0]	8.1 [0.0;0.0]	10.2 [0.0;0.0]
2020	-0.1 [0.0;0.0]	-0.4 [0.0;0.0]	0.0 [0.0;0.0]	0.1 [0.0;0.0]	0.2 [0.0;0.0]
2025	-0.7 [0.0;0.0]	-0.5 [0.0;0.0]	0.0 [0.0;0.0]	-0.1 [0.0;0.0]	-0.1 [0.0;0.0]
2030	-1.4 [0.0;0.0]	-0.5 [0.0;0.0]	-0.1 [0.0;0.0]	-0.4 [0.0;0.0]	-0.4 [0.0;0.0]
2035	-2.0 [0.0;0.0]	-0.5 [0.0;0.0]	-0.2 [0.0;0.0]	-0.6 [0.0;0.0]	-0.7 [0.0;0.0]
2040	-2.3 [0.0;0.0]	-0.5 [0.0;0.0]	-0.2 [0.0;0.0]	-0.7 [0.0;0.0]	-0.9 [0.0;0.0]
Baseline					
2020	-3.0 [0.0;0.2]	0.0 [0.0;0.0]	-0.3 [0.0;0.0]	-1.2 [0.0;0.1]	-1.5 [0.0;0.1]
2025	-4.5 [0.0;0.0]	0.0 [0.0;0.0]	-0.5 [0.0;0.0]	-1.8 [0.0;0.0]	-2.2 [0.0;0.0]
2030	-5.9 [0.0;0.1]	0.0 [0.0;0.0]	-0.7 [0.0;0.0]	-2.3 [0.0;0.0]	-2.9 [0.0;0.1]
2035	-8.1 [-0.2;0.1]	0.0 [0.0;0.0]	-0.9 [0.0;0.0]	-3.2 [-0.1;0.0]	-4.0 [-0.1;0.1]
2040	-9.2 [-0.1;0.0]	0.0 [0.0;0.0]	-1.1 [0.0;0.0]	-3.6 [0.0;0.0]	-4.5 [-0.1;0.0]
Phase-Out-2035-Weak					
2020	-4.6 [-0.2;0.1]	0.0 [0.0;0.0]	-0.4 [0.0;0.1]	-1.7 [-0.1;0.0]	-2.5 [-0.1;0.0]
2025	-9.4 [-0.2;0.2]	0.0 [0.0;0.0]	-1.0 [0.0;0.0]	-3.3 [-0.1;0.1]	-5.1 [-0.1;0.1]
2030	-13.8 [-0.3;0.1]	0.0 [0.0;0.0]	-1.6 [-0.1;0.0]	-5.3 [-0.1;0.1]	-6.9 [-0.1;0.0]
2035	-18.9 [-0.1;0.0]	0.0 [0.0;0.0]	-2.2 [0.0;0.0]	-7.4 [0.0;0.0]	-9.3 [-0.1;0.0]
2040	-18.9 [0.0;0.0]	0.0 [0.0;0.0]	-2.2 [0.0;0.0]	-7.4 [0.0;0.0]	-9.3 [0.0;0.0]
Phase-Out-2040-Age					
2020	-4.0 [-0.1;0.1]	0.0 [0.0;0.0]	-0.4 [0.0;0.0]	-1.4 [0.0;0.1]	-2.2 [-0.1;0.0]
2025	-7.3 [-0.2;0.1]	0.0 [0.0;0.0]	-0.7 [0.0;0.0]	-2.5 [-0.1;0.0]	-4.1 [-0.1;0.1]
2030	-10.5 [-0.2;0.1]	0.0 [0.0;0.0]	-1.0 [0.0;0.0]	-3.5 [-0.1;0.1]	-6.0 [-0.1;0.0]
2035	-13.8 [-0.1;0.2]	0.0 [0.0;0.0]	-1.5 [0.0;0.0]	-5.3 [-0.1;0.1]	-7.0 [0.0;0.1]
2040	-18.8 [-0.2;0.0]	0.0 [0.0;0.0]	-2.2 [0.0;0.0]	-7.4 [-0.1;0.0]	-9.2 [-0.1;0.0]
Phase-Out-2040-Balanced					
2020	-4.1 [-0.2;0.0]	0.0 [0.0;0.0]	-0.3 [0.0;0.0]	-1.8 [-0.1;0.0]	-2.0 [-0.1;0.0]
2025	-7.5 [-0.2;0.1]	0.0 [0.0;0.0]	-0.6 [0.0;0.0]	-3.5 [-0.1;0.1]	-3.4 [-0.1;0.0]
2030	-10.4 [-0.2;0.0]	0.0 [0.0;0.0]	-1.0 [0.0;0.0]	-4.4 [-0.1;0.0]	-5.0 [-0.1;0.0]
2035	-13.6 [-0.2;0.1]	0.0 [0.0;0.0]	-1.6 [0.0;0.1]	-5.4 [-0.1;0.0]	-6.6 [-0.1;0.0]
2040	-18.7 [-0.1;0.1]	0.0 [0.0;0.0]	-2.2 [0.0;0.0]	-7.3 [0.0;0.1]	-9.2 [-0.1;0.0]
Phase-Out-2035-Strong					
2020	-6.2 [-0.2;0.1]	0.0 [0.0;0.0]	-0.6 [0.0;0.0]	-2.4 [-0.1;0.0]	-3.2 [-0.1;0.1]
2025	-10.5 [-0.1;0.2]	0.0 [0.0;0.0]	-1.1 [0.0;0.0]	-3.7 [0.0;0.1]	-5.7 [-0.1;0.1]
2030	-13.9 [-0.3;0.1]	0.0 [0.0;0.0]	-1.6 [-0.1;0.0]	-5.3 [-0.1;0.1]	-7.0 [-0.1;0.0]
2035	-19.0 [-0.1;0.1]	0.0 [0.0;0.0]	-2.2 [0.0;0.0]	-7.4 [0.0;0.1]	-9.4 [-0.1;0.0]
2040	-18.9 [0.0;0.0]	0.0 [0.0;0.0]	-2.2 [0.0;0.0]	-7.4 [0.0;0.0]	-9.3 [0.0;0.0]

Note: Simulation results for employees in the lignite industry in thousand people. Values for the Null-Scenario are reported as change to the base year 2014 and for the year 2014 actual values are reported and for the year 2014 actual values are reported. Values for other scenarios are differences to the Null-Scenario in the respective year. Values in brackets denote the minimum and maximum difference from the reported value obtained from 1200 simulations.

Table 12: Unemployment rates

Year	Germany	Rest of Germany	Central Germany	Lusatia	Rhineland
			Null-Scenario		
2014	5.67 [-0.00;0.00]	5.32 [0.00;0.00]	9.17 [0.00;0.00]	10.97 [-0.00;0.00]	7.34 [-0.00;0.00]
2020	0.00 [-0.00;0.00]	0.00 [-0.00;0.00]	0.00 [-0.00;0.00]	-0.00 [-0.00;0.00]	0.00 [-0.00;0.00]
2025	0.00 [-0.00;0.00]	0.00 [-0.00;0.00]	0.00 [-0.00;0.00]	-0.00 [-0.00;0.00]	0.00 [-0.00;0.00]
2030	0.00 [-0.00;0.00]	0.00 [-0.00;0.00]	-0.00 [-0.00;0.00]	-0.00 [-0.00;0.00]	-0.00 [-0.00;0.00]
2035	-0.00 [-0.00;0.00]	-0.00 [-0.00;0.00]	-0.00 [-0.00;0.00]	-0.00 [-0.00;0.00]	-0.00 [-0.00;0.00]
2040	-0.00 [-0.00;0.00]	-0.00 [-0.00;0.00]	-0.00 [-0.00;0.00]	-0.00 [-0.00;0.00]	-0.00 [-0.00;0.00]
			Baseline		
2020	0.02 [-0.01;0.01]	0.01 [-0.01;0.01]	0.03 [-0.01;0.01]	0.21 [-0.02;0.03]	0.05 [-0.01;0.01]
2025	0.02 [-0.01;0.01]	0.02 [-0.01;0.01]	0.04 [-0.01;0.01]	0.21 [-0.03;0.02]	0.06 [-0.01;0.01]
2030	0.02 [-0.01;0.01]	0.02 [-0.01;0.01]	0.04 [-0.01;0.01]	0.25 [-0.04;0.04]	0.07 [-0.01;0.01]
2035	0.03 [-0.02;0.01]	0.01 [-0.02;0.02]	0.06 [-0.02;0.01]	0.46 [-0.04;0.04]	0.10 [-0.01;0.01]
2040	0.02 [-0.02;0.02]	0.01 [-0.02;0.02]	0.05 [-0.02;0.01]	0.48 [-0.04;0.03]	0.10 [-0.01;0.01]
			Phase-Out-2035-Weak		
2020	0.06 [-0.02;0.02]	0.06 [-0.02;0.02]	0.08 [-0.02;0.02]	0.20 [-0.04;0.03]	0.10 [-0.02;0.02]
2025	0.10 [-0.03;0.04]	0.09 [-0.03;0.04]	0.14 [-0.03;0.03]	0.44 [-0.05;0.05]	0.21 [-0.03;0.02]
2030	0.12 [-0.04;0.04]	0.10 [-0.04;0.05]	0.18 [-0.05;0.04]	0.81 [-0.07;0.08]	0.24 [-0.04;0.03]
2035	0.10 [-0.05;0.05]	0.08 [-0.05;0.05]	0.16 [-0.05;0.05]	1.07 [-0.07;0.06]	0.25 [-0.05;0.03]
2040	0.06 [-0.06;0.05]	0.04 [-0.06;0.05]	0.10 [-0.06;0.05]	0.89 [-0.06;0.07]	0.18 [-0.05;0.04]
			Phase-Out-2040-Age		
2020	0.06 [-0.02;0.02]	0.06 [-0.02;0.02]	0.08 [-0.02;0.02]	0.17 [-0.04;0.04]	0.10 [-0.01;0.01]
2025	0.10 [-0.03;0.04]	0.09 [-0.03;0.04]	0.13 [-0.03;0.03]	0.25 [-0.05;0.05]	0.18 [-0.03;0.02]
2030	0.12 [-0.04;0.04]	0.11 [-0.04;0.04]	0.16 [-0.04;0.04]	0.35 [-0.06;0.05]	0.24 [-0.04;0.03]
2035	0.13 [-0.04;0.05]	0.11 [-0.05;0.05]	0.18 [-0.05;0.04]	0.69 [-0.07;0.08]	0.24 [-0.04;0.03]
2040	0.11 [-0.05;0.05]	0.09 [-0.05;0.05]	0.16 [-0.05;0.05]	0.95 [-0.07;0.06]	0.24 [-0.05;0.04]
			Phase-Out-2040-Balanced		
2020	0.06 [-0.02;0.02]	0.06 [-0.02;0.02]	0.08 [-0.02;0.02]	0.24 [-0.04;0.03]	0.09 [-0.01;0.01]
2025	0.10 [-0.03;0.04]	0.09 [-0.03;0.04]	0.11 [-0.03;0.03]	0.56 [-0.06;0.06]	0.14 [-0.02;0.02]
2030	0.12 [-0.04;0.04]	0.11 [-0.04;0.04]	0.15 [-0.04;0.04]	0.59 [-0.06;0.06]	0.20 [-0.03;0.03]
2035	0.13 [-0.04;0.05]	0.11 [-0.05;0.05]	0.18 [-0.05;0.04]	0.69 [-0.06;0.07]	0.23 [-0.04;0.03]
2040	0.11 [-0.05;0.05]	0.09 [-0.05;0.05]	0.16 [-0.05;0.05]	0.95 [-0.07;0.06]	0.24 [-0.05;0.04]
			Phase-Out-2035-Strong		
2020	0.07 [-0.02;0.02]	0.06 [-0.02;0.03]	0.10 [-0.02;0.02]	0.43 [-0.04;0.05]	0.14 [-0.02;0.01]
2025	0.10 [-0.03;0.04]	0.08 [-0.03;0.04]	0.14 [-0.03;0.03]	0.52 [-0.06;0.05]	0.23 [-0.03;0.02]
2030	0.11 [-0.04;0.04]	0.09 [-0.04;0.05]	0.17 [-0.05;0.04]	0.79 [-0.06;0.07]	0.23 [-0.04;0.03]
2035	0.10 [-0.05;0.05]	0.07 [-0.05;0.05]	0.15 [-0.05;0.04]	1.07 [-0.07;0.06]	0.25 [-0.05;0.03]
2040	0.05 [-0.06;0.05]	0.03 [-0.06;0.05]	0.09 [-0.06;0.05]	0.88 [-0.06;0.07]	0.17 [-0.05;0.04]

Note: Simulation results for unemployment rates. Values for the Null-Scenario are reported as change to the base year 2014 and for the year 2014 actual values are reported. Values for other scenarios are differences to the Null-Scenario in the respective year. Values in brackets denote the minimum and maximum difference from the reported value obtained from 1200 simulations.

Table 13: Labour Force

Year	Germany	Rest of Germany	Central Germany	Lusatia	Rhineland
Null-Scenario					
2014	45782.6 [0.0;0.0]	40375.7 [0.0;0.0]	1611.5 [0.0;0.0]	521.9 [0.0;0.0]	3273.5 [0.0;0.0]
2020	910.7 [0.0;0.0]	803.1 [-0.0;0.0]	32.1 [-0.0;0.0]	10.4 [-0.0;0.0]	65.1 [-0.0;0.0]
2025	-263.8 [-0.0;0.0]	-232.7 [-0.0;0.0]	-9.3 [-0.0;0.0]	-3.0 [-0.0;0.0]	-18.8 [-0.0;0.0]
2030	-1915.2 [-0.0;0.0]	-1689.1 [-0.0;0.0]	-67.4 [-0.0;0.0]	-21.8 [-0.0;0.0]	-136.9 [-0.0;0.0]
2035	-3194.1 [-0.0;0.0]	-2817.0 [-0.0;0.0]	-112.4 [-0.0;0.0]	-36.4 [-0.0;0.0]	-228.4 [-0.0;0.0]
2040	-3872.6 [-0.0;0.0]	-3415.3 [-0.0;0.0]	-136.3 [-0.0;0.0]	-44.1 [-0.0;0.0]	-276.9 [-0.0;0.0]
Baseline					
2020	-0.0 [-0.0;0.0]	2.1 [-0.8;0.5]	-0.1 [-0.0;0.0]	-1.0 [-0.3;0.5]	-0.9 [-0.2;0.3]
2025	0.0 [-0.0;0.0]	3.5 [-1.4;0.8]	-0.2 [-0.0;0.0]	-1.7 [-0.4;0.8]	-1.5 [-0.3;0.5]
2030	0.0 [-0.0;0.0]	4.5 [-1.8;1.1]	-0.3 [-0.1;0.1]	-2.3 [-0.6;1.1]	-2.0 [-0.4;0.7]
2035	0.0 [-0.0;0.0]	5.4 [-2.1;1.3]	-0.3 [-0.1;0.1]	-2.7 [-0.7;1.3]	-2.3 [-0.5;0.8]
2040	0.0 [-0.0;0.0]	6.1 [-2.4;1.4]	-0.4 [-0.1;0.1]	-3.1 [-0.8;1.4]	-2.7 [-0.6;0.9]
Phase-Out-2035-Weak					
2020	-0.0 [-0.0;0.0]	3.4 [-1.3;0.8]	-0.1 [-0.0;0.0]	-1.9 [-0.5;0.9]	-1.5 [-0.3;0.5]
2025	-0.0 [-0.0;0.0]	5.7 [-2.2;1.2]	-0.1 [-0.0;0.0]	-3.2 [-0.8;1.5]	-2.5 [-0.5;0.8]
2030	0.0 [-0.0;0.0]	7.4 [-2.8;1.6]	-0.1 [-0.1;0.0]	-4.1 [-1.0;1.9]	-3.2 [-0.6;1.0]
2035	0.0 [-0.0;0.0]	8.9 [-3.4;1.9]	-0.1 [-0.1;0.0]	-4.9 [-1.2;2.2]	-3.8 [-0.7;1.2]
2040	0.0 [-0.0;0.0]	10.1 [-3.8;2.2]	-0.2 [-0.1;0.0]	-5.6 [-1.4;2.6]	-4.3 [-0.8;1.3]
Phase-Out-2040-Age					
2020	-0.0 [-0.0;0.0]	3.4 [-1.3;0.8]	-0.1 [-0.0;0.0]	-1.9 [-0.5;0.9]	-1.5 [-0.3;0.5]
2025	-0.0 [-0.0;0.0]	5.7 [-2.2;1.2]	-0.1 [-0.0;0.0]	-3.2 [-0.8;1.5]	-2.5 [-0.5;0.8]
2030	0.0 [-0.0;0.0]	7.4 [-2.8;1.6]	-0.1 [-0.1;0.0]	-4.1 [-1.0;1.9]	-3.2 [-0.6;1.0]
2035	0.0 [-0.0;0.0]	8.9 [-3.4;1.9]	-0.1 [-0.1;0.0]	-4.9 [-1.2;2.2]	-3.8 [-0.7;1.2]
2040	0.0 [-0.0;0.0]	10.1 [-3.8;2.2]	-0.2 [-0.1;0.0]	-5.6 [-1.4;2.6]	-4.3 [-0.8;1.3]
Phase-Out-2040-Balanced					
2020	-0.0 [-0.0;0.0]	3.4 [-1.3;0.8]	-0.1 [-0.0;0.0]	-1.9 [-0.5;0.9]	-1.5 [-0.3;0.5]
2025	-0.0 [-0.0;0.0]	5.7 [-2.2;1.2]	-0.1 [-0.0;0.0]	-3.2 [-0.8;1.5]	-2.5 [-0.5;0.8]
2030	0.0 [-0.0;0.0]	7.4 [-2.8;1.6]	-0.1 [-0.1;0.0]	-4.1 [-1.0;1.9]	-3.2 [-0.6;1.0]
2035	0.0 [-0.0;0.0]	8.9 [-3.4;1.9]	-0.1 [-0.1;0.0]	-4.9 [-1.2;2.2]	-3.8 [-0.7;1.2]
2040	0.0 [-0.0;0.0]	10.1 [-3.8;2.2]	-0.2 [-0.1;0.0]	-5.6 [-1.4;2.6]	-4.3 [-0.8;1.3]
Phase-Out-2035-Strong					
2020	-0.0 [-0.0;0.0]	3.4 [-1.3;0.8]	-0.1 [-0.0;0.0]	-1.9 [-0.5;0.9]	-1.5 [-0.3;0.5]
2025	-0.0 [-0.0;0.0]	5.7 [-2.2;1.2]	-0.1 [-0.0;0.0]	-3.2 [-0.8;1.5]	-2.5 [-0.5;0.8]
2030	0.0 [-0.0;0.0]	7.4 [-2.8;1.6]	-0.1 [-0.1;0.0]	-4.1 [-1.0;1.9]	-3.2 [-0.6;1.0]
2035	0.0 [-0.0;0.0]	8.9 [-3.4;1.9]	-0.1 [-0.1;0.0]	-4.9 [-1.2;2.2]	-3.8 [-0.7;1.2]
2040	0.0 [-0.0;0.0]	10.1 [-3.8;2.2]	-0.2 [-0.1;0.0]	-5.6 [-1.4;2.6]	-4.3 [-0.8;1.3]

Note: Simulation results for the labour force by region in thousand people. Values for the Null-Scenario are reported as change to the base year 2014 and for the year 2014 actual values are reported. Values for other scenarios are differences to the Null-Scenario in the respective year. Values in brackets denote the minimum and maximum difference from the reported value obtained from 1200 simulations.

Table 14: Employees

Year	Germany	Rest of Germany	Central Germany	Lusatia	Rhineland
			Null-Scenario		
2014	43188.7 [0.0;0.0]	38227.0 [0.0;0.0]	1463.8 [0.0;0.0]	464.7 [0.0;0.0]	3033.2 [0.0;0.0]
2020	858.1 [-0.3;0.3]	759.5 [-0.2;0.3]	29.1 [-0.1;0.0]	9.2 [0.0;0.0]	60.3 [0.0;0.0]
2025	-249.6 [-0.3;0.4]	-221.0 [-0.3;0.4]	-8.4 [0.0;0.0]	-2.7 [0.0;0.0]	-17.5 [0.0;0.0]
2030	-1807.1 [-0.4;0.5]	-1599.5 [-0.4;0.5]	-61.2 [0.0;0.0]	-19.5 [0.0;0.0]	-126.9 [0.0;0.0]
2035	-3013.2 [-0.4;0.5]	-2667.1 [-0.4;0.4]	-102.1 [0.0;0.0]	-32.4 [0.0;0.1]	-211.6 [0.0;0.0]
2040	-3653.0 [-0.5;0.5]	-3233.4 [-0.4;0.4]	-123.8 [-0.1;0.0]	-39.3 [0.0;0.0]	-256.5 [0.0;0.1]
			Baseline		
2020	-8.1 [-4.0;3.6]	-3.0 [-4.6;3.6]	-0.6 [-0.1;0.1]	-2.0 [-0.3;0.5]	-2.5 [-0.2;0.3]
2025	-10.0 [-5.4;5.2]	-3.4 [-6.3;5.2]	-0.8 [-0.1;0.2]	-2.6 [-0.3;0.8]	-3.2 [-0.3;0.3]
2030	-10.5 [-6.2;6.3]	-2.4 [-7.2;6.4]	-0.9 [-0.1;0.2]	-3.3 [-0.5;0.8]	-3.9 [-0.4;0.4]
2035	-11.5 [-6.5;7.0]	-0.3 [-7.6;7.4]	-1.2 [-0.2;0.2]	-4.7 [-0.7;1.1]	-5.3 [-0.6;0.7]
2040	-8.1 [-6.3;7.0]	3.5 [-7.3;7.4]	-1.1 [-0.1;0.2]	-5.0 [-0.7;1.3]	-5.5 [-0.6;0.7]
			Phase-Out-2035-Weak		
2020	-28.9 [-10.8;8.7]	-19.9 [-10.6;8.4]	-1.3 [-0.3;0.3]	-2.8 [-0.4;0.8]	-4.9 [-0.5;0.5]
2025	-46.2 [-16.5;14.4]	-29.6 [-16.4;13.9]	-2.3 [-0.6;0.5]	-5.1 [-0.7;1.3]	-9.2 [-0.9;1.1]
2030	-50.9 [-19.2;18.5]	-30.0 [-19.1;17.6]	-2.8 [-0.6;0.7]	-7.7 [-1.0;1.7]	-10.4 [-1.0;1.4]
2035	-44.5 [-20.0;21.9]	-21.2 [-20.0;19.8]	-2.5 [-0.7;0.8]	-9.5 [-1.1;2.0]	-11.3 [-1.2;1.5]
2040	-23.8 [-20.0;23.7]	-3.6 [-20.3;21.3]	-1.5 [-0.6;0.9]	-9.2 [-1.2;2.2]	-9.5 [-1.3;1.5]
			Phase-Out-2040-Age		
2020	-29.0 [-10.4;8.2]	-20.5 [-10.5;7.9]	-1.3 [-0.3;0.3]	-2.6 [-0.4;0.9]	-4.6 [-0.4;0.6]
2025	-46.0 [-16.0;13.2]	-31.8 [-16.0;12.7]	-2.1 [-0.5;0.5]	-4.1 [-0.6;1.4]	-8.0 [-0.7;0.9]
2030	-54.2 [-18.7;16.6]	-35.9 [-18.7;16.1]	-2.5 [-0.6;0.6]	-5.4 [-0.9;1.6]	-10.4 [-1.1;1.3]
2035	-54.6 [-19.4;19.1]	-33.4 [-19.7;18.4]	-2.8 [-0.6;0.7]	-7.7 [-1.0;2.1]	-10.7 [-1.1;1.5]
2040	-47.0 [-19.6;21.6]	-23.7 [-19.9;19.9]	-2.5 [-0.6;0.8]	-9.5 [-1.2;2.2]	-11.3 [-1.1;1.6]
			Phase-Out-2040-Balanced		
2020	-29.5 [-10.8;8.0]	-20.7 [-10.6;7.9]	-1.3 [-0.4;0.2]	-3.0 [-0.4;0.7]	-4.5 [-0.5;0.5]
2025	-46.7 [-16.0;13.1]	-32.1 [-15.9;12.7]	-1.9 [-0.6;0.5]	-5.7 [-0.8;1.4]	-7.0 [-0.7;0.8]
2030	-54.6 [-18.8;16.3]	-36.3 [-18.7;15.9]	-2.5 [-0.7;0.5]	-6.6 [-0.9;1.6]	-9.2 [-1.0;1.2]
2035	-55.1 [-19.7;18.8]	-34.1 [-19.8;18.3]	-2.9 [-0.7;0.7]	-7.7 [-1.0;2.0]	-10.4 [-1.1;1.5]
2040	-47.5 [-19.6;21.5]	-24.2 [-19.9;20.0]	-2.4 [-0.6;0.8]	-9.5 [-1.3;2.2]	-11.4 [-1.2;1.5]
			Phase-Out-2035-Strong		
2020	-31.9 [-11.1;9.3]	-20.1 [-11.1;9.0]	-1.7 [-0.3;0.3]	-4.0 [-0.6;0.9]	-6.1 [-0.6;0.6]
2025	-45.6 [-16.6;14.7]	-28.1 [-16.6;14.1]	-2.3 [-0.5;0.6]	-5.5 [-0.6;1.3]	-9.7 [-0.9;1.2]
2030	-47.8 [-19.3;18.7]	-27.2 [-19.2;17.6]	-2.7 [-0.6;0.7]	-7.6 [-0.9;1.7]	-10.3 [-1.1;1.3]
2035	-41.1 [-20.0;22.0]	-18.1 [-19.9;19.8]	-2.4 [-0.8;0.8]	-9.5 [-1.1;2.0]	-11.1 [-1.2;1.5]
2040	-20.7 [-19.9;23.3]	-0.8 [-20.1;21.2]	-1.4 [-0.6;0.8]	-9.2 [-1.3;2.2]	-9.3 [-1.3;1.5]

Note: Simulation results for the total number of employees by region in thousand people. Values for the Null-Scenario are reported as change to the base year 2014 and for the year 2014 actual values are reported. Values for other scenarios are differences to the Null-Scenario in the respective year. Values in brackets denote the minimum and maximum difference from the reported value obtained from 1200 simulations.

Table 15: Discounted welfare

Year	Germany	Rest of Germany	Central Germany	Lusatia	Rhineland
			Null-Scenario		
2014	100.00 [0.00;0.00]	100.00 [0.00;0.00]	100.00 [0.00;0.00]	100.00 [0.00;0.00]	100.00 [0.00;0.00]
2020	95.31 [-0.91;1.14]	95.31 [-0.91;1.14]	95.31 [-0.91;1.14]	95.31 [-0.91;1.14]	95.31 [-0.91;1.14]
2025	91.57 [-1.61;2.00]	91.57 [-1.61;2.00]	91.57 [-1.61;2.00]	91.57 [-1.61;2.00]	91.56 [-1.62;1.99]
2030	87.97 [-2.26;2.77]	87.97 [-2.26;2.77]	87.97 [-2.26;2.77]	87.97 [-2.26;2.77]	87.97 [-2.26;2.77]
2035	84.52 [-2.86;3.48]	84.52 [-2.86;3.48]	84.52 [-2.86;3.48]	84.52 [-2.86;3.48]	84.52 [-2.86;3.48]
2040	81.20 [-3.42;4.11]	81.20 [-3.42;4.11]	81.20 [-3.42;4.11]	81.20 [-3.42;4.11]	81.20 [-3.42;4.11]
			Baseline		
2020	-0.02 [-0.01;0.01]	-0.02 [-0.01;0.00]	-0.04 [-0.01;0.01]	-0.24 [-0.03;0.02]	-0.07 [-0.01;0.01]
2025	-0.02 [-0.01;0.01]	-0.03 [-0.02;0.00]	-0.03 [-0.02;0.01]	0.00 [-0.04;0.03]	-0.02 [-0.01;0.02]
2030	-0.02 [-0.02;0.01]	-0.02 [-0.01;0.01]	-0.03 [-0.02;0.02]	-0.04 [-0.04;0.07]	-0.04 [-0.02;0.01]
2035	-0.03 [-0.02;0.01]	-0.03 [-0.02;0.01]	-0.07 [-0.03;0.01]	-0.33 [-0.04;0.05]	-0.10 [-0.02;0.01]
2040	-0.02 [-0.01;0.02]	-0.02 [-0.01;0.02]	-0.04 [-0.01;0.02]	-0.14 [-0.04;0.05]	-0.06 [-0.01;0.02]
			Phase-Out-2035-Weak		
2020	-0.05 [-0.03;0.01]	-0.05 [-0.03;0.01]	-0.06 [-0.02;0.02]	-0.09 [-0.06;0.05]	-0.05 [-0.02;0.01]
2025	-0.09 [-0.04;0.02]	-0.08 [-0.03;0.03]	-0.10 [-0.03;0.03]	-0.16 [-0.09;0.07]	-0.21 [-0.03;0.03]
2030	-0.10 [-0.04;0.03]	-0.10 [-0.03;0.03]	-0.17 [-0.03;0.03]	-0.57 [-0.09;0.11]	-0.08 [-0.04;0.04]
2035	-0.10 [-0.03;0.04]	-0.12 [-0.04;0.03]	-0.02 [-0.03;0.04]	-0.08 [-0.07;0.10]	-0.10 [-0.04;0.04]
2040	-0.07 [-0.03;0.04]	-0.08 [-0.02;0.04]	0.02 [-0.03;0.04]	-0.06 [-0.09;0.13]	0.01 [-0.04;0.04]
			Phase-Out-2040-Age		
2020	-0.05 [-0.03;0.01]	-0.05 [-0.03;0.01]	-0.07 [-0.02;0.01]	-0.22 [-0.05;0.05]	-0.07 [-0.02;0.01]
2025	-0.08 [-0.03;0.02]	-0.08 [-0.03;0.02]	-0.10 [-0.03;0.02]	-0.18 [-0.08;0.09]	-0.13 [-0.03;0.03]
2030	-0.09 [-0.03;0.03]	-0.09 [-0.03;0.03]	-0.11 [-0.03;0.03]	-0.16 [-0.08;0.12]	-0.18 [-0.04;0.03]
2035	-0.10 [-0.04;0.04]	-0.11 [-0.04;0.03]	-0.18 [-0.04;0.03]	-0.66 [-0.10;0.14]	-0.10 [-0.03;0.03]
2040	-0.10 [-0.03;0.04]	-0.11 [-0.02;0.04]	-0.02 [-0.04;0.04]	-0.12 [-0.08;0.13]	-0.07 [-0.03;0.05]
			Phase-Out-2040-Balanced		
2020	-0.05 [-0.03;0.01]	-0.05 [-0.03;0.01]	-0.08 [-0.03;0.01]	-0.07 [-0.06;0.05]	-0.09 [-0.02;0.02]
2025	-0.08 [-0.03;0.02]	-0.08 [-0.03;0.02]	-0.08 [-0.03;0.02]	-0.53 [-0.08;0.06]	-0.10 [-0.03;0.03]
2030	-0.09 [-0.03;0.03]	-0.09 [-0.03;0.03]	-0.13 [-0.04;0.02]	-0.11 [-0.07;0.09]	-0.17 [-0.03;0.03]
2035	-0.10 [-0.04;0.04]	-0.11 [-0.04;0.03]	-0.22 [-0.03;0.02]	-0.32 [-0.08;0.12]	-0.13 [-0.04;0.03]
2040	-0.10 [-0.03;0.04]	-0.11 [-0.02;0.04]	0.00 [-0.03;0.04]	-0.14 [-0.07;0.14]	-0.08 [-0.04;0.05]
			Phase-Out-2035-Strong		
2020	-0.06 [-0.03;0.01]	-0.05 [-0.02;0.02]	-0.11 [-0.03;0.01]	-0.48 [-0.06;0.04]	-0.13 [-0.02;0.01]
2025	-0.09 [-0.03;0.02]	-0.09 [-0.03;0.02]	-0.09 [-0.03;0.02]	0.07 [-0.08;0.06]	-0.16 [-0.03;0.03]
2030	-0.09 [-0.03;0.03]	-0.10 [-0.04;0.03]	-0.17 [-0.03;0.03]	-0.58 [-0.08;0.12]	-0.07 [-0.04;0.03]
2035	-0.10 [-0.04;0.04]	-0.11 [-0.03;0.04]	-0.01 [-0.04;0.03]	-0.05 [-0.06;0.11]	-0.07 [-0.04;0.04]
2040	-0.06 [-0.03;0.04]	-0.08 [-0.03;0.04]	0.02 [-0.03;0.03]	-0.06 [-0.09;0.13]	0.02 [-0.03;0.04]

Note: Simulation results for discounted welfare per capita as index. Values for the Null-Scenario are reported as change to the base year 2014. Values for other scenarios are differences to the Null-Scenario in the respective year. Values in brackets denote the minimum and maximum difference from the reported value obtained from 1200 simulations.

Table 16: Discounted cumulative welfare

Year	Germany	Rest of Germany	Central Germany	Lusatia	Rhineland
Null-Scenario					
2014	0.61 [-0.01;0.01]	0.64 [-0.01;0.01]	0.38 [-0.02;0.04]	0.38 [-0.03;0.04]	0.40 [-0.03;0.04]
2020	14.33 [-0.16;0.22]	15.01 [-0.26;0.30]	8.89 [-0.54;0.84]	8.95 [-0.56;0.85]	9.46 [-0.61;0.96]
2025	25.75 [-0.37;0.51]	26.97 [-0.55;0.62]	15.98 [-0.97;1.55]	16.09 [-1.02;1.58]	17.01 [-1.09;1.75]
2030	36.73 [-0.64;0.90]	38.47 [-0.90;1.06]	22.80 [-1.40;2.31]	22.95 [-1.47;2.35]	24.26 [-1.57;2.60]
2035	47.27 [-0.97;1.36]	49.52 [-1.32;1.58]	29.34 [-1.85;3.09]	29.55 [-1.92;3.14]	31.22 [-2.04;3.47]
2040	57.40 [-1.35;1.90]	60.13 [-1.78;2.18]	35.63 [-2.35;3.89]	35.88 [-2.45;3.96]	37.92 [-2.58;4.36]
Baseline					
2020	-0.00 [-0.00;0.00]	-0.00 [-0.00;0.00]	0.00 [-0.00;0.00]	0.01 [-0.00;0.00]	0.00 [-0.00;0.00]
2025	-0.00 [-0.00;0.00]	-0.00 [-0.00;0.00]	-0.00 [-0.00;0.00]	-0.00 [-0.00;0.00]	-0.00 [-0.00;0.00]
2030	-0.00 [-0.00;0.00]	-0.01 [-0.00;0.00]	-0.00 [-0.00;0.00]	-0.00 [-0.00;0.00]	-0.01 [-0.00;0.00]
2035	-0.01 [-0.01;0.00]	-0.01 [-0.00;0.00]	-0.01 [-0.00;0.00]	-0.00 [-0.01;0.01]	-0.01 [-0.00;0.00]
2040	-0.01 [-0.01;0.01]	-0.01 [-0.01;0.01]	-0.01 [-0.01;0.00]	-0.02 [-0.01;0.01]	-0.02 [-0.01;0.00]
Phase-Out-2035-Weak					
2020	-0.00 [-0.00;0.00]	-0.00 [-0.00;0.00]	-0.00 [-0.00;0.00]	0.01 [-0.00;0.00]	0.00 [-0.00;0.00]
2025	-0.01 [-0.00;0.00]	-0.01 [-0.00;0.00]	-0.01 [-0.00;0.00]	0.01 [-0.01;0.01]	-0.00 [-0.00;0.00]
2030	-0.02 [-0.01;0.01]	-0.02 [-0.01;0.01]	-0.01 [-0.01;0.01]	0.00 [-0.01;0.01]	-0.02 [-0.01;0.01]
2035	-0.03 [-0.01;0.01]	-0.04 [-0.01;0.01]	-0.02 [-0.01;0.01]	-0.02 [-0.02;0.02]	-0.03 [-0.01;0.01]
2040	-0.04 [-0.02;0.02]	-0.05 [-0.02;0.02]	-0.02 [-0.01;0.01]	-0.02 [-0.02;0.02]	-0.03 [-0.01;0.01]
Phase-Out-2040-Age					
2020	-0.00 [-0.00;0.00]	-0.00 [-0.00;0.00]	-0.00 [-0.00;0.00]	0.01 [-0.00;0.00]	0.00 [-0.00;0.00]
2025	-0.01 [-0.00;0.00]	-0.01 [-0.00;0.00]	-0.01 [-0.00;0.00]	-0.00 [-0.01;0.01]	-0.00 [-0.00;0.00]
2030	-0.02 [-0.01;0.01]	-0.02 [-0.01;0.01]	-0.02 [-0.01;0.00]	-0.02 [-0.01;0.01]	-0.01 [-0.01;0.01]
2035	-0.03 [-0.01;0.01]	-0.04 [-0.01;0.01]	-0.02 [-0.01;0.01]	-0.03 [-0.02;0.02]	-0.03 [-0.01;0.01]
2040	-0.04 [-0.02;0.01]	-0.05 [-0.02;0.01]	-0.03 [-0.01;0.01]	-0.05 [-0.02;0.03]	-0.04 [-0.01;0.01]
Phase-Out-2040-Balanced					
2020	-0.00 [-0.00;0.00]	-0.00 [-0.00;0.00]	-0.00 [-0.00;0.00]	0.01 [-0.00;0.00]	0.00 [-0.00;0.00]
2025	-0.01 [-0.00;0.00]	-0.01 [-0.00;0.00]	-0.01 [-0.00;0.00]	0.01 [-0.01;0.01]	-0.01 [-0.00;0.00]
2030	-0.02 [-0.01;0.01]	-0.02 [-0.01;0.01]	-0.01 [-0.01;0.00]	-0.02 [-0.01;0.01]	-0.02 [-0.01;0.01]
2035	-0.03 [-0.01;0.01]	-0.04 [-0.01;0.01]	-0.02 [-0.01;0.01]	-0.03 [-0.01;0.02]	-0.03 [-0.01;0.01]
2040	-0.04 [-0.02;0.01]	-0.05 [-0.02;0.01]	-0.03 [-0.01;0.01]	-0.05 [-0.02;0.02]	-0.04 [-0.01;0.01]
Phase-Out-2035-Strong					
2020	-0.00 [-0.00;0.00]	-0.00 [-0.00;0.00]	-0.00 [-0.00;0.00]	0.02 [-0.00;0.00]	0.00 [-0.00;0.00]
2025	-0.01 [-0.00;0.00]	-0.01 [-0.00;0.00]	-0.01 [-0.00;0.00]	-0.01 [-0.01;0.00]	-0.01 [-0.00;0.00]
2030	-0.02 [-0.01;0.01]	-0.03 [-0.01;0.01]	-0.02 [-0.01;0.01]	-0.00 [-0.01;0.01]	-0.02 [-0.01;0.01]
2035	-0.03 [-0.01;0.01]	-0.04 [-0.01;0.01]	-0.02 [-0.01;0.01]	-0.02 [-0.02;0.01]	-0.03 [-0.01;0.01]
2040	-0.04 [-0.02;0.02]	-0.05 [-0.02;0.02]	-0.02 [-0.01;0.01]	-0.03 [-0.02;0.02]	-0.03 [-0.01;0.01]

Note: Simulation results for stationary discounted cumulative welfare per capita in utils. Values for the Null-Scenario are reported as change to the base year 2014 and for the year 2014 initial values are reported. Values for other scenarios are differences to the Null-Scenario in the respective year. Values in brackets denote the minimum and maximum difference from the reported value obtained from 1200 simulations.

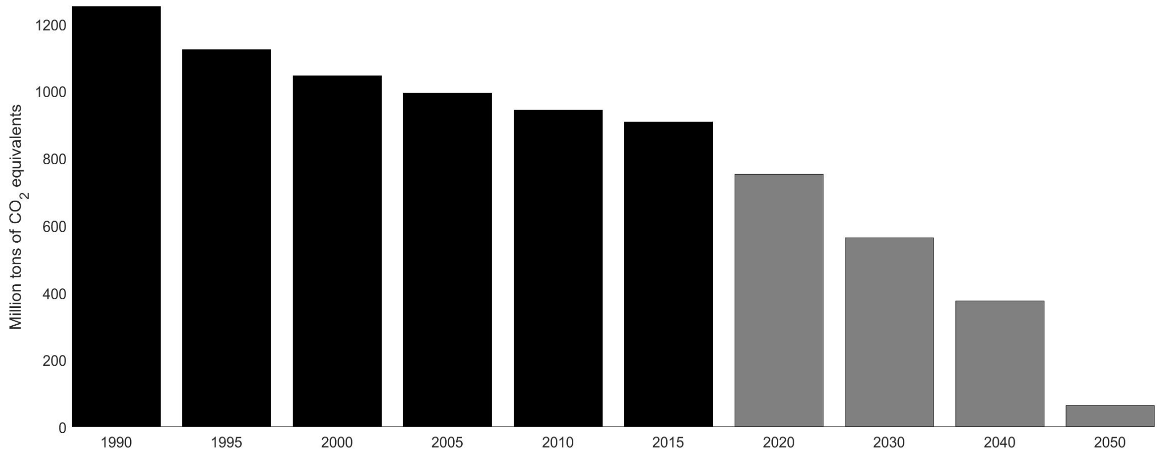
Table 17: Real consumption per capita

Year	Germany	Rest of Germany	Central Germany	Lusatia	Rhineland
			Null-Scenario		
2014	100.00 [0.00;0.00]	100.00 [0.00;0.00]	100.00 [0.00;0.00]	100.00 [0.00;0.00]	100.00 [0.00;0.00]
2020	104.58 [0.00;0.00]	104.58 [0.00;0.00]	104.58 [0.00;0.00]	104.59 [0.00;0.00]	104.58 [0.00;0.00]
2025	108.56 [0.00;0.00]	108.56 [0.00;0.00]	108.56 [0.00;0.00]	108.57 [0.00;0.01]	108.56 [0.00;0.00]
2030	112.70 [0.00;0.00]	112.70 [0.00;0.00]	112.70 [0.00;0.00]	112.70 [0.00;0.00]	112.70 [0.00;0.00]
2035	116.99 [0.00;0.00]	116.99 [0.00;0.00]	116.99 [0.00;0.00]	116.99 [0.00;0.00]	116.99 [0.00;0.00]
2040	121.44 [0.00;0.00]	121.44 [0.00;0.00]	121.44 [0.00;0.00]	121.44 [0.00;0.00]	121.44 [0.00;0.00]
			Baseline		
2020	-0.02 [-0.01;0.01]	-0.01 [-0.01;0.01]	-0.05 [-0.01;0.01]	-0.39 [-0.02;0.02]	-0.08 [-0.01;0.01]
2025	-0.02 [-0.02;0.01]	-0.02 [-0.01;0.01]	-0.05 [-0.02;0.01]	-0.21 [-0.03;0.03]	-0.06 [-0.02;0.01]
2030	-0.03 [-0.02;0.02]	-0.03 [-0.02;0.01]	-0.07 [-0.02;0.02]	-0.35 [-0.04;0.04]	-0.09 [-0.02;0.01]
2035	-0.04 [-0.03;0.02]	-0.03 [-0.02;0.02]	-0.12 [-0.02;0.02]	-0.85 [-0.04;0.03]	-0.18 [-0.02;0.02]
2040	-0.03 [-0.03;0.02]	-0.02 [-0.02;0.03]	-0.10 [-0.02;0.02]	-0.69 [-0.04;0.04]	-0.15 [-0.02;0.02]
			Phase-Out-2035-Weak		
2020	-0.05 [-0.02;0.02]	-0.05 [-0.02;0.02]	-0.08 [-0.02;0.02]	-0.28 [-0.05;0.04]	-0.08 [-0.02;0.02]
2025	-0.10 [-0.04;0.03]	-0.09 [-0.04;0.03]	-0.15 [-0.04;0.03]	-0.56 [-0.07;0.06]	-0.30 [-0.04;0.03]
2030	-0.13 [-0.05;0.05]	-0.13 [-0.05;0.04]	-0.27 [-0.05;0.04]	-1.33 [-0.09;0.06]	-0.20 [-0.04;0.05]
2035	-0.14 [-0.05;0.06]	-0.14 [-0.05;0.06]	-0.11 [-0.06;0.06]	-0.96 [-0.11;0.09]	-0.25 [-0.06;0.06]
2040	-0.09 [-0.06;0.07]	-0.10 [-0.05;0.07]	-0.05 [-0.04;0.06]	-0.96 [-0.09;0.09]	-0.11 [-0.05;0.05]
			Phase-Out-2040-Age		
2020	-0.05 [-0.02;0.02]	-0.05 [-0.02;0.01]	-0.09 [-0.03;0.01]	-0.39 [-0.04;0.03]	-0.10 [-0.02;0.02]
2025	-0.09 [-0.04;0.03]	-0.09 [-0.04;0.03]	-0.14 [-0.04;0.03]	-0.49 [-0.07;0.06]	-0.21 [-0.04;0.02]
2030	-0.13 [-0.05;0.05]	-0.13 [-0.05;0.04]	-0.19 [-0.05;0.04]	-0.62 [-0.08;0.09]	-0.30 [-0.05;0.04]
2035	-0.15 [-0.06;0.05]	-0.14 [-0.05;0.06]	-0.30 [-0.05;0.05]	-1.51 [-0.11;0.10]	-0.24 [-0.06;0.05]
2040	-0.15 [-0.06;0.06]	-0.16 [-0.06;0.06]	-0.11 [-0.06;0.06]	-1.04 [-0.08;0.10]	-0.23 [-0.06;0.06]
			Phase-Out-2040-Balanced		
2020	-0.05 [-0.02;0.02]	-0.05 [-0.02;0.01]	-0.09 [-0.02;0.01]	-0.28 [-0.06;0.04]	-0.12 [-0.02;0.01]
2025	-0.09 [-0.04;0.04]	-0.09 [-0.04;0.03]	-0.11 [-0.04;0.03]	-1.01 [-0.07;0.04]	-0.16 [-0.04;0.03]
2030	-0.13 [-0.05;0.04]	-0.13 [-0.05;0.04]	-0.20 [-0.04;0.04]	-0.68 [-0.07;0.05]	-0.28 [-0.04;0.04]
2035	-0.15 [-0.06;0.05]	-0.14 [-0.05;0.06]	-0.35 [-0.04;0.04]	-1.08 [-0.07;0.09]	-0.26 [-0.05;0.05]
2040	-0.15 [-0.06;0.07]	-0.16 [-0.06;0.06]	-0.09 [-0.05;0.06]	-1.08 [-0.09;0.10]	-0.24 [-0.06;0.06]
			Phase-Out-2035-Strong		
2020	-0.06 [-0.02;0.02]	-0.05 [-0.02;0.02]	-0.13 [-0.02;0.02]	-0.77 [-0.05;0.03]	-0.17 [-0.02;0.02]
2025	-0.10 [-0.04;0.03]	-0.09 [-0.03;0.04]	-0.14 [-0.04;0.03]	-0.36 [-0.08;0.06]	-0.26 [-0.04;0.03]
2030	-0.12 [-0.05;0.05]	-0.12 [-0.05;0.05]	-0.27 [-0.05;0.04]	-1.34 [-0.08;0.07]	-0.19 [-0.05;0.05]
2035	-0.14 [-0.06;0.05]	-0.14 [-0.05;0.05]	-0.10 [-0.06;0.05]	-0.93 [-0.11;0.08]	-0.21 [-0.06;0.06]
2040	-0.09 [-0.06;0.06]	-0.09 [-0.05;0.07]	-0.05 [-0.05;0.05]	-0.95 [-0.09;0.09]	-0.10 [-0.05;0.05]

Note: Simulation results for real consumption per capita as index. Values for the Null-Scenario are reported as change to the base year 2014. Values for other scenarios are differences to the Null-Scenario in the respective year. Values in brackets denote the minimum and maximum difference from the reported value obtained from 1200 simulations.

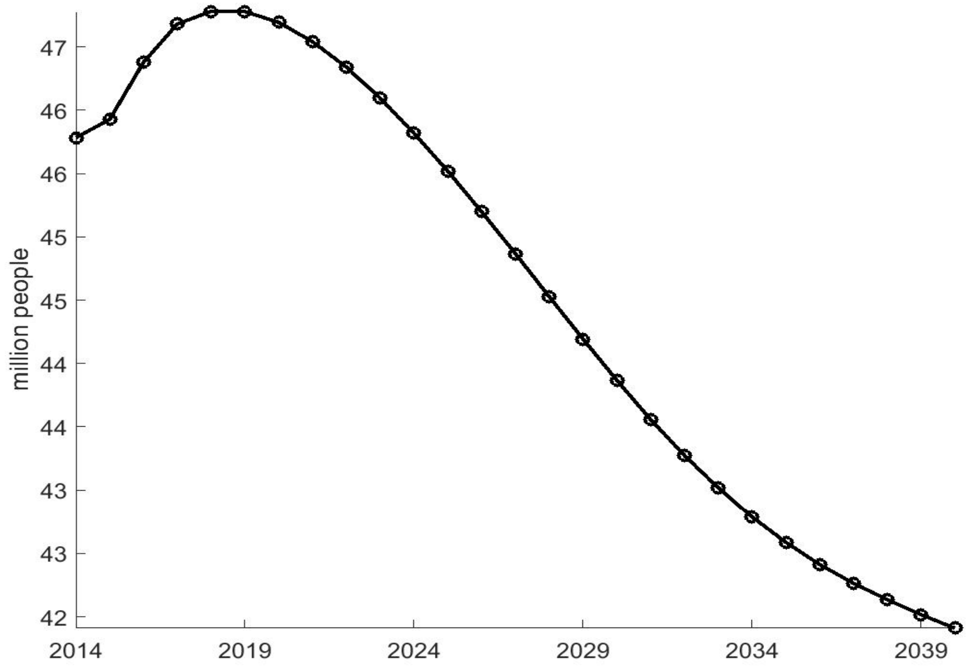
C Figures

Figure 5: Greenhouse gas emissions of Germany



Note: Greenhouse gas emissions in Germany. Black bars are historical values and grey bars are national targets.
Sources: German Environment Agency, National Inventory Reports for the German Greenhouse Gas Inventory 1990 to 2016 (as of 01/2018) and initial forecast for 2017 (UBA press release 08/2018).

Figure 6: Labour force projection



Sources: Eurostat, OECD.

Figure 7: Model diagram labour market

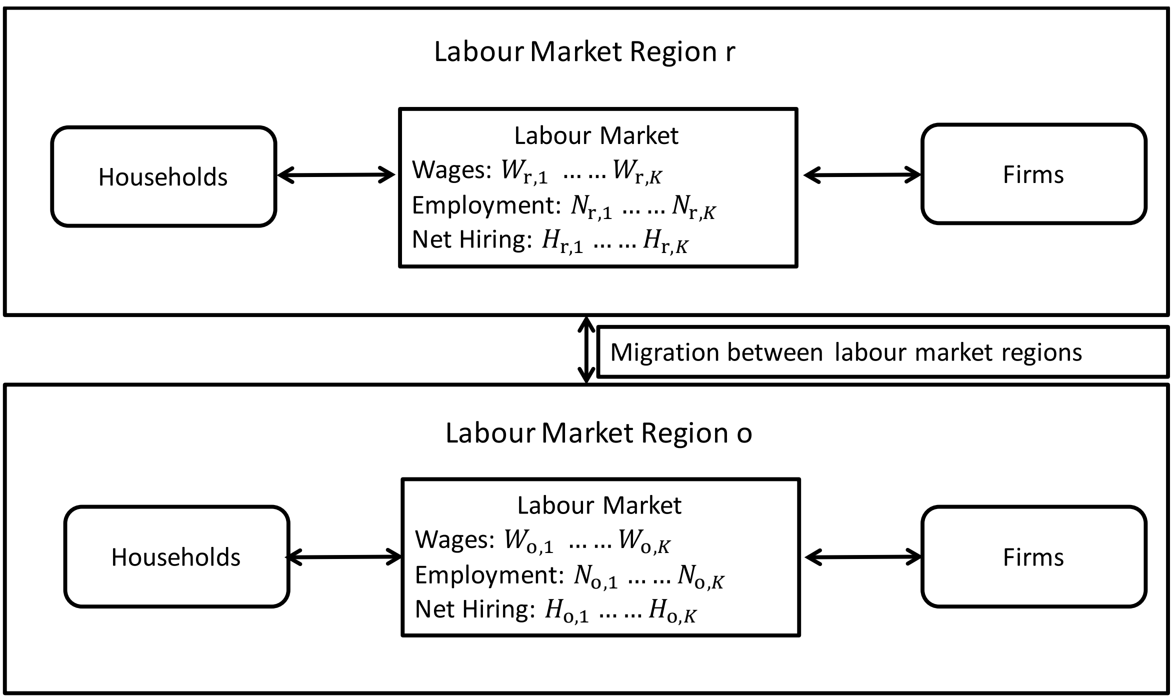


Figure 8: Model diagram production

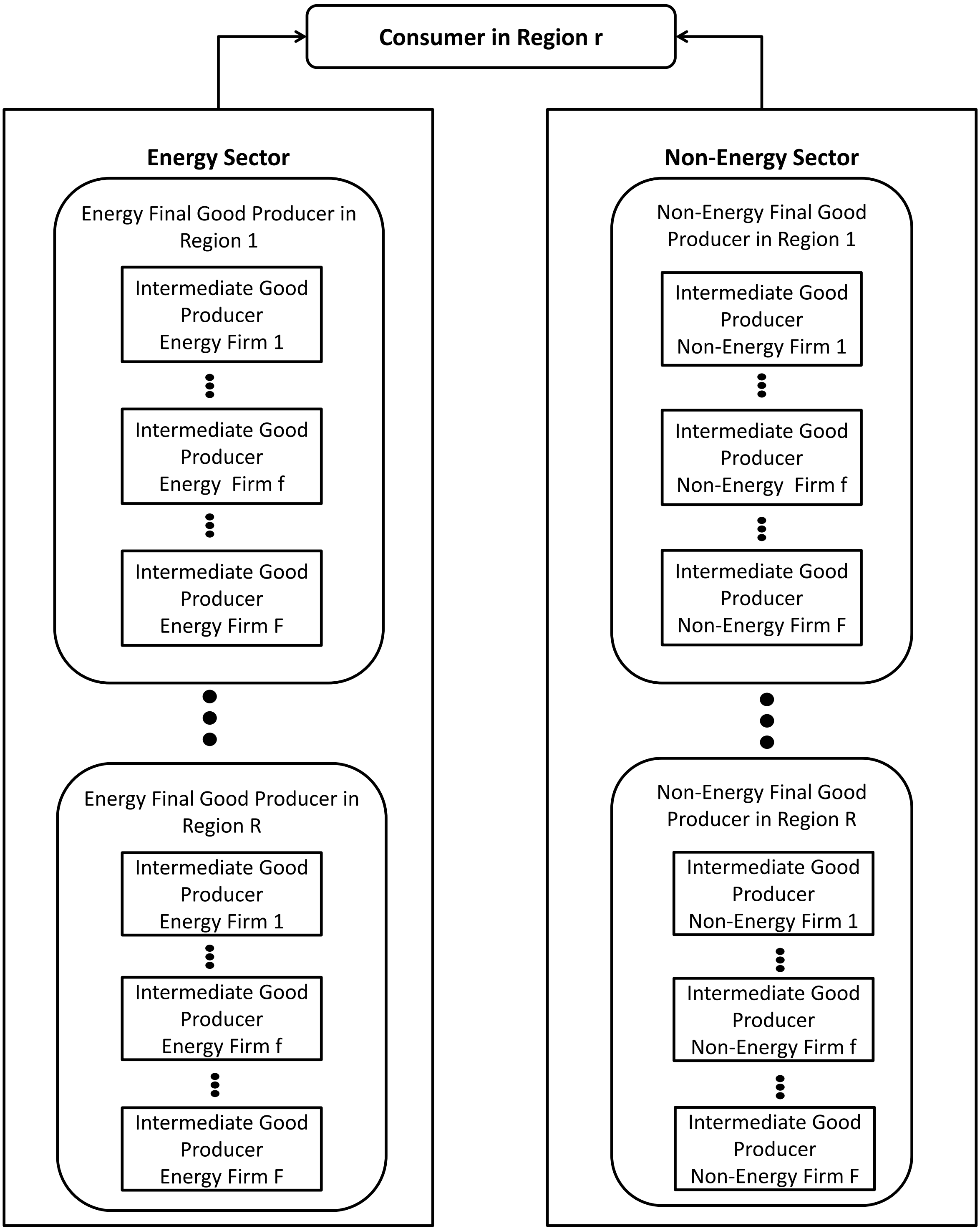
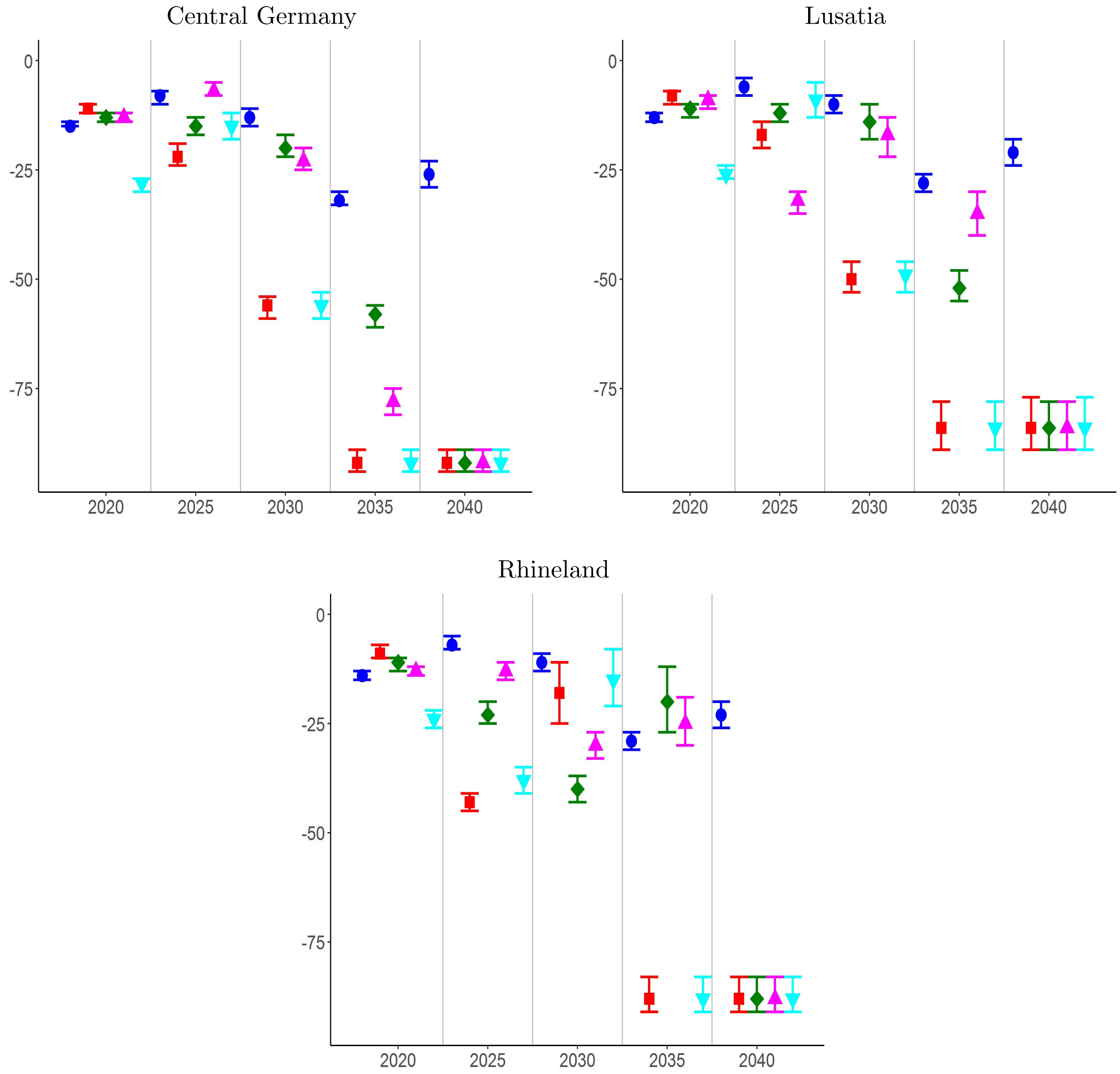
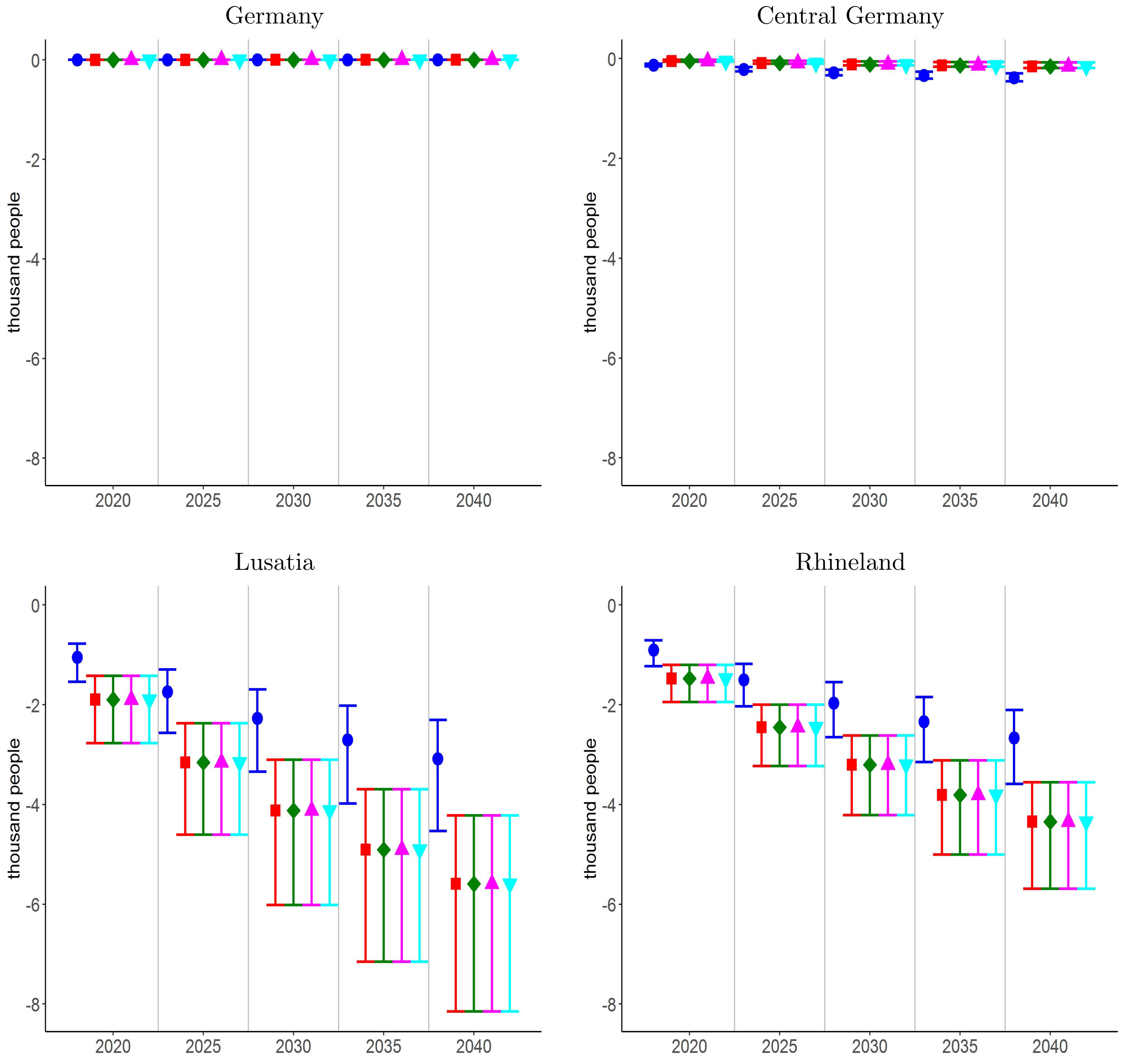


Figure 9: Simulation results for regional lignite coal specific productivity



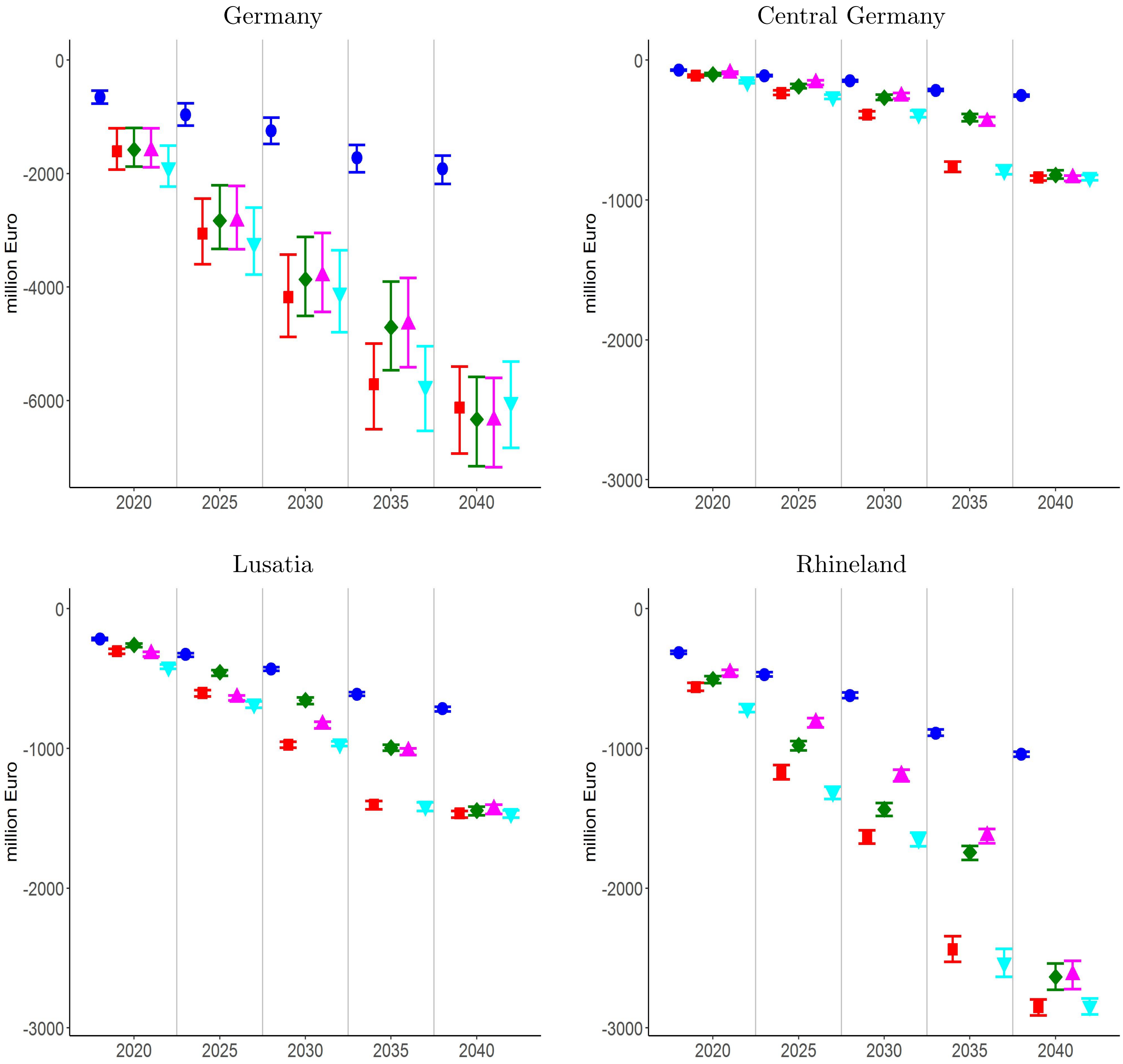
Note: Difference compared to the Null-Scenario in percentage points, Baseline (blue circle), Phase-Out-2035-Weak (red square), Phase-Out-2040-Age (green diamond), Phase-Out-2040-Balanced (magenta triangle point-up) and Phase-Out-2035-Strong (cyan triangle point-down). Horizontal lines indicate the maximum and minimum value observed for 1200 simulations.

Figure 10: Simulation results for labour force



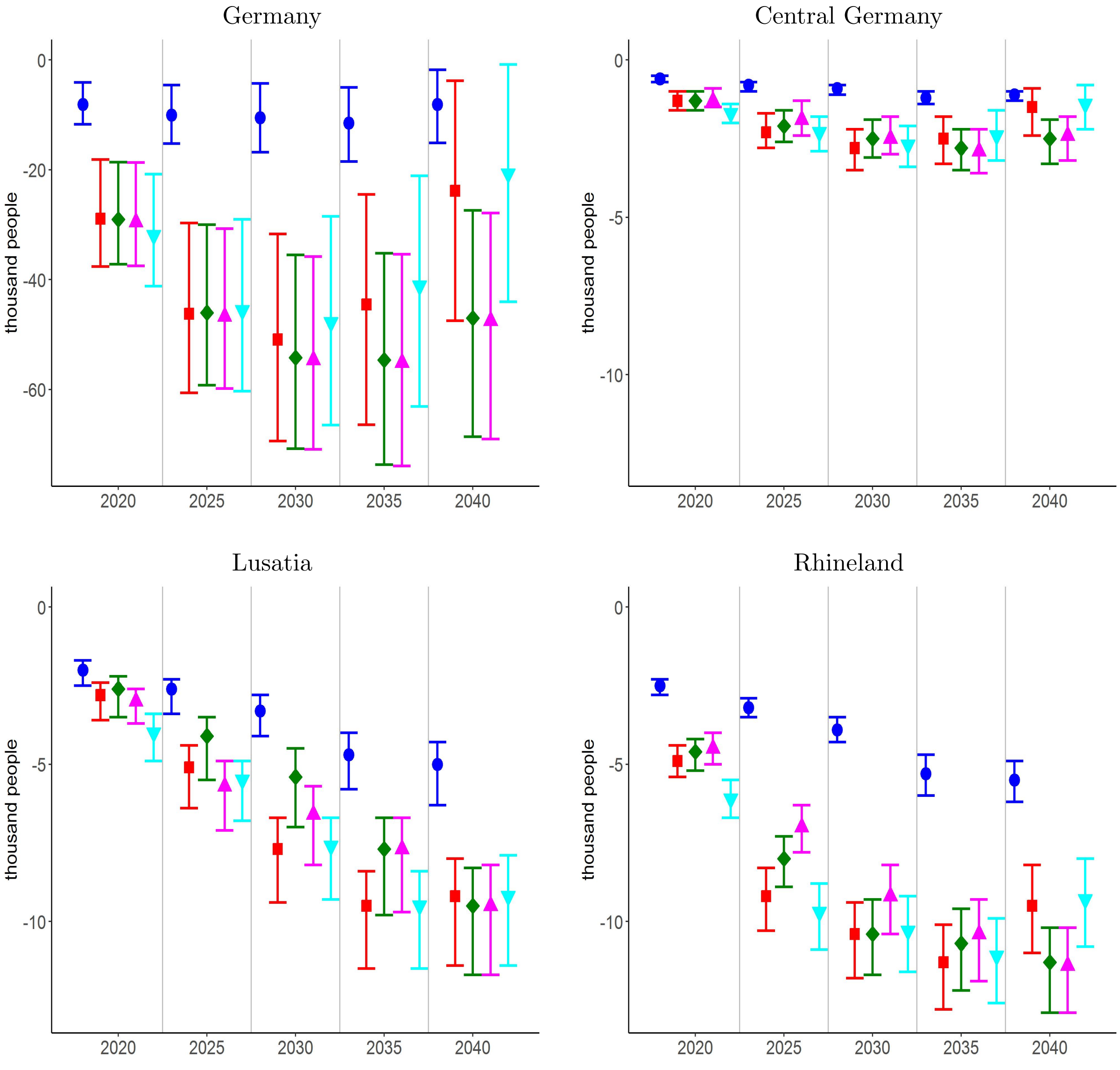
Note: Difference compared to the Null-Scenario in thousand people, Baseline (blue circle), Phase-Out-2035-Weak (red square), Phase-Out-2040-Age (green diamond), Phase-Out-2040-Balanced (magenta triangle point-up) and Phase-Out-2035-Strong (cyan triangle point-down). Horizontal lines indicate the maximum and minimum value observed for 1200 simulations.

Figure 11: Simulation results for labour income



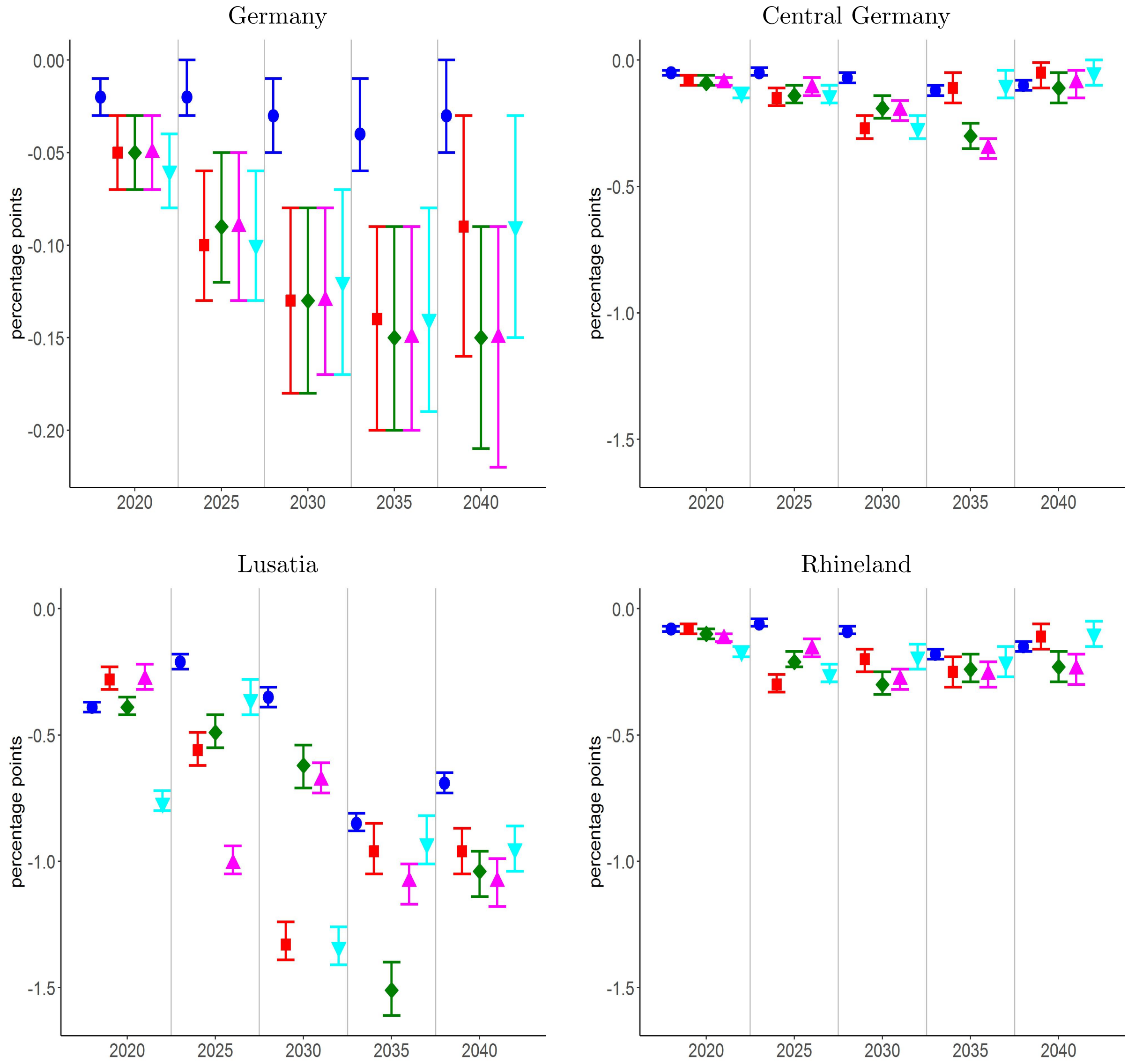
Note: Difference compared to the Null-Scenario in million euro, Baseline (blue circle), Phase-Out-2035-Weak (red square), Phase-Out-2040-Age (green diamond), Phase-Out-2040-Balanced (magenta triangle point-up) and Phase-Out-2035-Strong (cyan triangle point-down). Horizontal lines indicate the maximum and minimum value observed for 1200 simulations.

Figure 12: Simulation results for total employment



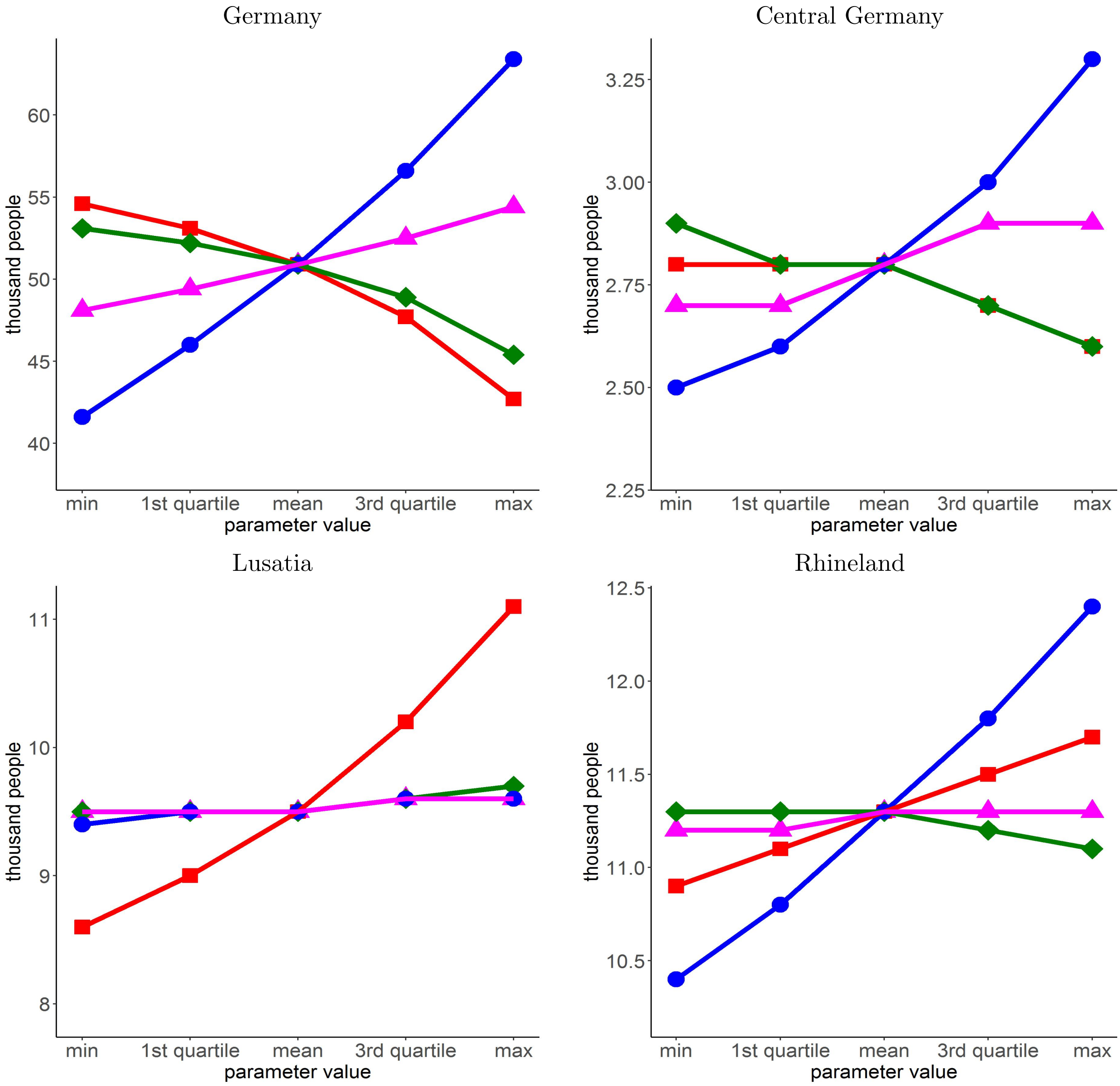
Note: Difference compared to the Null-Scenario in thousand people, Baseline (blue circle), Phase-Out-2035-Weak (red square), Phase-Out-2040-Age (green diamond), Phase-Out-2040-Balanced (magenta triangle point-up) and Phase-Out-2035-Strong (cyan triangle point-down). Horizontal lines indicate the maximum and minimum value observed for 1200 simulations.

Figure 13: Simulation results for consumption



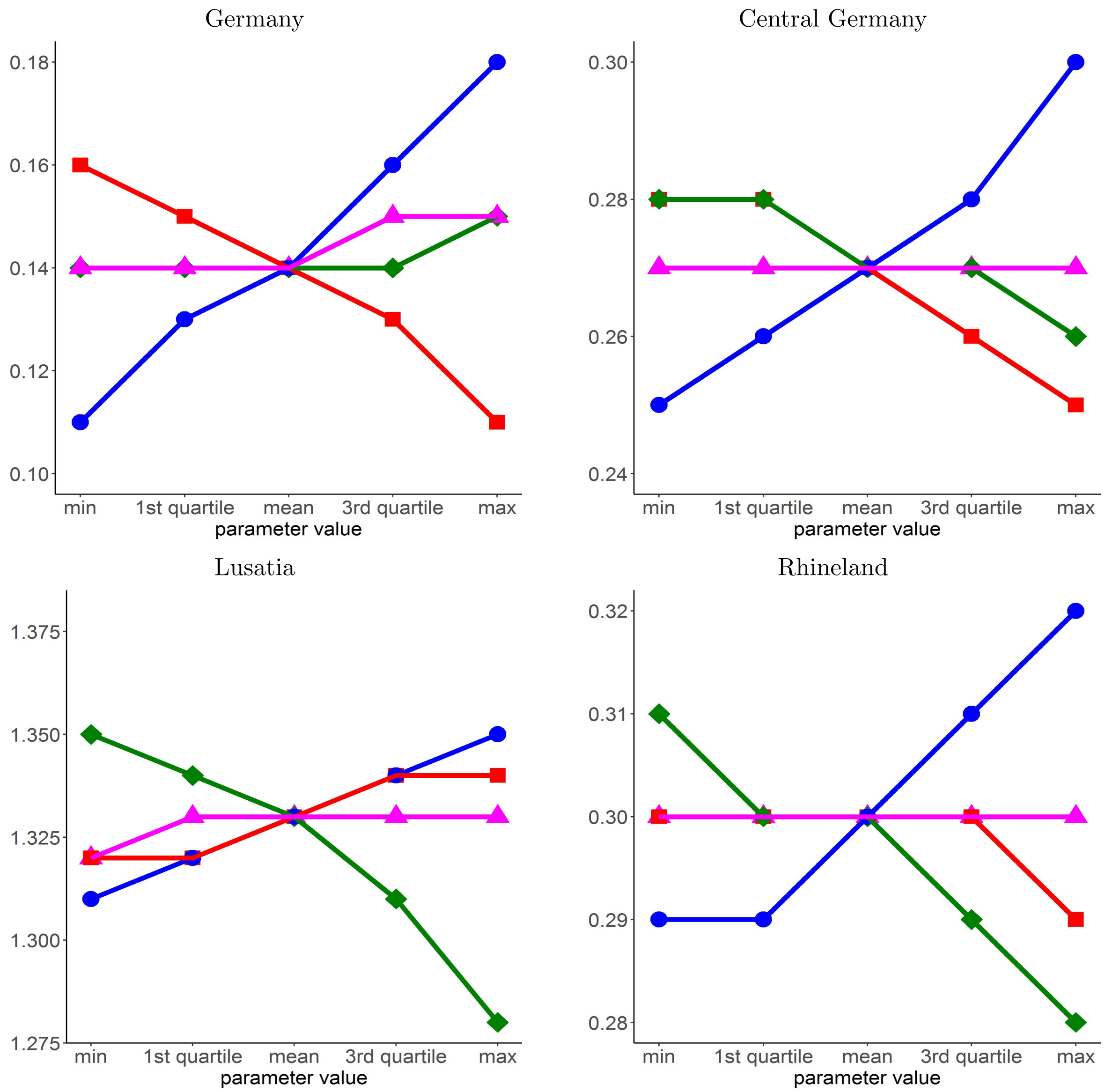
Note: Difference compared to the Null-Scenario in percentage points, Baseline (blue circle), Phase-Out-2035-Weak (red square), Phase-Out-2040-Age (green diamond), Phase-Out-2040-Balanced (magenta triangle point-up) and Phase-Out-2035-Strong (cyan triangle point-down). Horizontal lines indicate the maximum and minimum value observed for 1200 simulations.

Figure 14: Sensitivity analysis for maximum employment drop



Note: Difference compared to the Null-Scenario in thousand people, Baseline (blue circle), Phase-Out-2035-Weak (red square), Phase-Out-2040-Age (green diamond), Phase-Out-2040-Balanced (magenta triangle point-up) and Phase-Out-2035-Strong (cyan triangle point-down). Horizontal lines indicate the maximum and minimum value observed for 1200 simulations.

Figure 15: Sensitivity analysis for maximum consumption drop



Note: Change in maximum real consumption per capita drop between 2014 to 2040 for Phase-Out-2035-Weak compared to the Null-Scenario in percentage points changing the value of only one parameter. The most important parameters for the maximum German cumulative consumption drop in descending order (compare with legend) are: persistence in unemployment benefits ρ^b (blue circle), home bias non-energy I^H_{NE} (red square), persistence of market power ρ^λ (green diamond), inverse Frisch elasticity σ^L (magenta triangle point-up). We report the change in the maximum drop for the minimum, first quartile, median/mean, third quartile and maximum parameter value.

Power Generation and Structural Change

Quantifying Economic Effects of the Coal Phase-Out in Germany

Online Appendix*

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Updated version, November 2020

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1 Model Equations

1.1 National aggregates

This section collects all the equations of the model associated with national aggregates.

national resource constraint

$$y_t = c_t + g_t \tag{1}$$

national consumption

$$c_t = \sum_{r=1}^{R} \gamma^c_{r\,t}\, {w^{pop}_r}_t\, c_{r\,t} \tag{2}$$

national gross value-added

$$y_t = \sum_{r=1}^{R} \sum_{k=1}^{K} {w^{pop}_r}_t\, \gamma_{r,k_t}\, y_{r,k_t} \tag{3}$$

national government budget constraint

$$g_t + b_t\, u_t + tr_t = tax_t \tag{4}$$

$$tax_t = \sum_{r=1}^{R} \sum_{k=1}^{K} (\gamma_{r,k,t}\, \tau^l\, w_{r,k,t}\, n_{r,k,t} + y_{r,k,t}\, w^{pop}_{r,t}\, \gamma_{r,k,t}\, \tau_{r,k,t}) \tag{5}$$

national real unemployment benefits

$$b_t = (\rho^b)^{\frac{1}{4}}\, b_{t-1} + (1 - (\rho^b)^{\frac{1}{4}})\, \zeta^w\, w_{t-1} \tag{6}$$

national employment rate

$$n_t = \sum_{r=1}^{R} \sum_{k=1}^{K} w^{pop}_{r,t}\, n_{r,k,t} \tag{7}$$

national hiring rate

$$h_t = \sum_{r=1}^{R} \sum_{k=1}^{K} w^{pop}_{r,t}\, h_{r,k,t} \tag{8}$$

national unemployment rate

$$u_t = 1 - \sum_{r=1}^{R} w_{r,t}^{pop}\, n_{r,t} \tag{9}$$

national wage bill

$$n_t\, w_t = \sum_{r=1}^{R} \gamma_{r,t}^{c}\, n_{r,t}\, w_{r,t} \tag{10}$$

1.2 Regional aggregates

This section collects all equations of the model associated with regional aggregates.

regional price index for consumption

$$\gamma_{r,t}^{c} = \sum_{k=1}^{K} \left(\omega_k^c\, \gamma_{r,k_t}^{1-\eta^c}\right)^{\frac{1}{1-\eta^c}} \tag{11}$$

regional budget constraint

$$\gamma_{r,t}^{c}\, c_{r,t} = \sum_{k=1}^{K} (\gamma_{r,k,t}\, y_{r,k,t}\, \left(1-\tau_{r,k,t}\right) - \tau^l\, \gamma_{r,k,t}\, n_{r,k,t}\, w_{r,k,t}) + \gamma_{r,t}^{c}\, (b_{r,t}\, u_{r,t} + tr_t) \tag{12}$$

regional wage bill

$$\gamma_{r,t}^{c}\, n_{r,t}\, w_{r,t} = \sum_{k=1}^{K} \gamma_{r,k,t}\, w_{r,k,t}\, n_{r,k,t} \tag{13}$$

regional aggregate production

$$y_{r,t} = \sum_{k=1}^{K} \gamma_{r,k,t}\, y_{r,k,t} \tag{14}$$

regional employment rate

$$n_{r,t} = \sum_{k=1}^{K} n_{r,k,t} \tag{15}$$

regional unemployment rate

$$u_{r,t} = 1 - n_{r,t} \tag{16}$$

regional unemployed looking for a job

$$u^{s}_{r,t} = 1 - (1 - \frac{\delta}{\mu^{pop}_{r,t}})\, n_{r,t-1} \tag{17}$$

regional hiring rate

$$h_{r,t} = \sum_{k=1}^{K} h_{r,k,t} \tag{18}$$

law of motion for population weight

$$w^{pop}_{r,t} = \rho^{pop} w^{pop}_{r,t-1} + (1-\rho^{pop})\, \frac{\bar{\epsilon}^{pop}_{r}}{\sum_{d=1}^{R} \bar{\epsilon}^{pop}_{d}} \tag{19}$$

law of motion for living preferences

$$\epsilon^{pop}_{r,t} = \rho^{pop} \epsilon^{pop}_{r,t-1} + (1-\rho^{pop})\, \sigma^{\epsilon^{pop}}_{r} \bar{U}_{r}\, \exp(\eta^{\epsilon^{pop}}_{r}) \tag{20}$$

regional population growth

$$\mu^{pop}_{r,t} = \frac{w^{pop}_{r,t}}{w^{pop}_{r,t-1}} \mu^{pop}_{t} \tag{21}$$

1.3 Regional energy sector

This section collects all the equations of the model associated with the regional energy input sector.

regional energy production function

$$y_{r,k,t} = \left(\sum_{s=1}^{S} \phi^{\frac{1}{\eta^{b}}}_{r,k,s} y^{\frac{\eta^{b}-1}{\eta^{b}}}_{r,k,st} \right)^{\frac{\eta^{b}}{\eta^{b}-1}} \tag{22}$$

input production function

$$y_{r,k,s,t} = \epsilon_{r,k,s,t} \left(a_{r,k,s}\, n^{\alpha_{r,k,s}}_{r,k,s,t} - \frac{1}{\psi}\, mc^{h}_{r,k,s,t}\, h^{\psi}_{r,k,s,t} \right) \tag{23}$$

wage from first-order condition of households

$$w_{r,k,s,t} = \frac{b_{t} + \gamma^{c}_{r,t}\, A^{L}_{r,k,s}\, n^{\sigma^{L}_{r,k,s}}_{r,k,s,t}}{(1-\tau^{l})\, \gamma_{r,k,s,t}} \tag{24}$$

law of motion for labour

$$n_{r,k,s,t} = h_{r,k,s,t} + \left(1 - \frac{\delta}{\mu^{pop}_{r,t}}\right) n_{r,k,s,t-1} \tag{25}$$

marginal hiring cost

$$mc^h_{r,k,s,t} = B^h_{r,k,s} \left(\Psi + (1-\Psi)\left(\frac{h_{r,t}}{u^s_{r,t-1}}\right)^v\right) \tag{26}$$

first-order condition for employment

$$\frac{1}{\lambda_{r,k,t}}\left(\alpha_{r,k,s}\, a_{r,k,s}\, \epsilon_{r,k,s,t}\, (1-\tau_{r,k,s,t})\, n^{\alpha_{r,k,s}-1}_{r,k,s,t} - mc^h_{r,k,s,t}\, \epsilon_{r,k,s,t}\, (1-\tau_{r,k,s,t})\, h^{\psi-1}_{r,k,s,t}\right)$$
$$+ \left(\mu^{pop}_{r,t+1} - \delta\right) \beta\, \mu^z\, \pi^c\, \frac{1}{\lambda_{r,k,t+1}} \frac{\gamma_{r,k,s,t+1}}{\gamma_{r,k,s,t}} (1-\tau_{r,k,s,t+1})\, \epsilon_{r,k,s,t+1}\, mc^h_{r,k,s,t+1}\, h^{\psi-1}_{r,k,s,t+1} = w_{r,k,s,t} \tag{27}$$

marginal product for input of energy production

$$\gamma_{r,k,s,t} = \phi^{\frac{1}{\eta^b}}_{r,k,s} \left(\frac{y_{r,k,s,t}}{y_{r,k,t}}\right)^{\frac{1}{\eta^b}} \gamma_{r,k,t} \tag{28}$$

taxes on regional production

$$\tau_{r,k,s,t} = \rho^\tau\, \tau_{r,k,s_{t-1}} + (1-\rho^\tau)\, \bar{\tau}_{r,k,s}\, exp\left(\eta^\tau_{r,k,s_t}\right) \tag{29}$$

tax revenues from regional energy production

$$\tau_{r,k,t}\, \gamma_{r,k,t}\, y_{r,k,t} = \sum_{s=1}^{S} \tau_{r,k,s,t}\, \gamma_{r,k,s,t}\, y_{r,k,s,t} \tag{30}$$

law of motion for markups

$$\lambda_{r,k,s,t} = \rho^\lambda\, \lambda_{r,k,s,t-1} + (1-\rho^\lambda)\, \sigma^\lambda_{r,s,k} \phi^\lambda\, \epsilon^{pop}_{r,t}. \tag{31}$$

regional energy wages

$$\gamma_{r,k,t}\, w^*_{r,k,t} = \sum_{s=1}^{S} w^*_{r,k,s,t}\, \gamma_{r,k,s,t} \tag{32}$$

regional energy employment rate

$$n_{r,k,t} = \sum_{s=1}^{S} n_{r,k,s,t} \tag{33}$$

regional energy hiring rate

$$h_{r,k_t} = \sum_{s=1}^{S} h_{r,k,s,t} \tag{34}$$

regional marginal energy hiring costs

$$\gamma_{r,k,t}\, mc^h_{r,k,t} = \sum_{s=1}^{S} mc^h_{r,k,s,t}\, \gamma_{r,k,s,t} \tag{35}$$

1.4 Regional non-energy sector

This section collects all the equations of the model associated with the regional energy input sector.

production function

$$y_{r,k,t} = \epsilon_{r,k,t} \left(a_{r,k}\, n_{r,k,t}^{\alpha_{r,k}} - \frac{1}{\psi}\, mc^h_{r,k,t}\, h^{\psi}_{r,k,t} \right) \tag{36}$$

wage from first-order condition of households

$$w_{r,k,t} = \frac{b_t + \gamma^c_{r,t}\, A^L_{r,k}\, n_{r,k,t}^{\sigma^L_{r,k}}}{\left(1 - \tau^l\right)\, \gamma_{r,k,t}} \tag{37}$$

law of motion for labour

$$n_{r,k,t} = h_{r,k,t} + \left(1 - \frac{\delta}{\mu^{pop}_{r,t}}\right) n_{r,k,t-1} \tag{38}$$

marginal hiring cost

$$mc^h_{r,k,t} = B^h_{r,k} \left(\Psi + (1 - \Psi) \left(\frac{h_{r,t}}{u_{r,t-1}} \right)^{v} \right) \tag{39}$$

first-order condition for employment

$$\frac{1}{\lambda_{r,k,t}} \left(\alpha_{r,k}\, a_{r,k}\, \epsilon_{r,k,t}\, \left(1-\tau_{r,k,t}\right)\, n_{r,k,t}^{\alpha_{r,k}-1} - mc_{r,k,t}^{h}\, \epsilon_{r,k,t}\, \left(1-\tau_{r,k,t}\right)\, h_{r,k,t}^{\psi-1}\right)$$
$$+\frac{1}{\lambda_{r,k,t+1}}\, \left(\mu_{r,t+1}^{pop}-\delta\right)\, \beta\, \mu^{z}\, \pi^{c}\, \frac{\gamma_{r,k,t+1}}{\gamma_{r,k,t}}\, \left(1-\tau_{r,k,t+1}\right)\, \epsilon_{r,k,t+1}\, mc_{r,k,t+1}^{h}\, h_{r,k,t+1}^{\psi-1} = w_{r,k,t} \quad (40)$$

taxes on regional production

$$\tau_{r,k,t} = \rho^{\tau}\, \tau_{r,k_{t-1}} + \left(1-\rho^{\tau}\right)\, \bar{\tau}_{r,k}\, exp\left(\eta_{r,k_t}^{\tau}\right) \quad (41)$$

law of motion for markups

$$\lambda_{r,k,t} = \rho^{\lambda}\, \lambda_{r,k,t-1} + \left(1-\rho^{\lambda}\right)\sigma_{r,k}^{\lambda}\phi^{\lambda}\, \epsilon_{r,t}^{pop}. \quad (42)$$

1.5 Household demand equations

This section collects all the equations of the model associated with household demand.

regional demand for sector consumption

$$c_{r,k,t} = \omega_{k}^{c}\, \left(\frac{\gamma_{r,k_t}^{c}}{\gamma_{r\,t}^{c}}\right)^{\left(-\eta^{c}\right)}\, c_{r,t} \quad (43)$$

regional sector consumption price index

$$\gamma_{r,k_t}^{c} = \sum_{d=1}^{N} \left(\omega_{r,d,k}^{d}\, \gamma_{d,k_t}{}^{1-\eta_{k}^{m}}\right)^{\frac{1}{1-\eta_{k}^{m}}} \quad (44)$$

regional demand for consumption from other regions

$$c_{r,d,k,t} = \omega_{r,d,k}^{d}\, \left(\frac{\gamma_{d,k,t}}{\gamma_{r,k,t}^{c}}\right)^{\left(-\eta_{k}^{m}\right)}\, c_{r,k,t} \quad (45)$$

market clearing

$$\left(1-\tau_{r,k_t}\right)\, w_{r\ \ t}^{pop}\, y_{r,k_t} = \sum_{d=1}^{R} w_{d,t}^{pop}\, c_{r,d,k,t} \quad (46)$$

2 National Aggregates, Derivation and Scaling

2.1 Government

The national government consumes G_t, pays lump-sum transfers Tr_t, and unemployment benefits ($U_t B_t$) financed by tax revenues (Tax). We assume a balanced government budget

$$P_t^c G_t + P_t^c U_t B_t + P_t^c Tr_t = P_t^c Tax_t, \tag{47}$$

$$P_t^c Tax_t = \sum_{n=1}^{N} \sum_{k=1}^{K} (\tau^l \, P_{r,k,t} \, W_{r,k,t} \, N_{r,k,t} + \tau_{r,k,t} \, P_{r,k,t} \, Y_{r,k,t}) \tag{48}$$

Unemployment benefits are adjusted according to the development of national wages and with a backward-looking component to reflect rigidity in the adjustment of long-term unemployment benefits and wages. This specification allows for a sluggish adjustment of benefits, reflecting empirical evidence.

$$B_t = (\rho^b)^{\frac{1}{4}} B_{t-1} + (1 - (\rho^b)^{\frac{1}{4}}) \zeta^w W_{t-1} \tag{49}$$

2.2 Market clearing

We assume market clearing. All products produced in a given period are consumed and firms have no access to an inventory technology. Therefore, sectoral production in one region is the sum of regional consumption from all regions.

$$Y_{r,k,t} \, (1 - \tau_{r,k,t}) = \sum_{o} C_{r,o,k,t}. \tag{50}$$

Consumption expenditures in one region and one sector is the sum of the products consumed from different regions purchased for the respective price.

$$P_{r,k,t}^C \, C_{r,k,t} = \sum_{o} P_{o,k,t} \, C_{r,o,k,t}, \tag{51}$$

$$P_{r,t}^C \, C_{r,t} = \sum_{k} P_{r,k,t}^C \, C_{r,k,t}. \tag{52}$$

Overall regional consumption expenditures have to be equal to the sectoral consumption expenditures. Note that the budget constraint of the representative household requires that a household's income from work, net profits and government transfers has to equal its consumption expenditure. If we sum all regional budget constraints, we get an expression for the gross value-added as from the expenditure approach

$$P_t^C Y_t = P_t^C C_t + P_t^C G_t. \tag{53}$$

Total gross value-added from the production approach in the economy $P_t^C Y_t$ is the sum of all goods evaluated at their market price

$$P_t^C Y_t = \sum_r \sum_k P_{r,k,t} Y_{r,k,t}. \tag{54}$$

2.3 National aggregates

The national consumption, gross value-added and government expenditures are given by the following identities:

$$P_t^c C_t = \sum_{r=1}^{R} P_{r,t}^c C_{r,t}, \tag{55}$$

$$P_t^c Y_t = \sum_{r=1}^{R} \sum_{k=1}^{K} P_{r,k,t} Y_{r,k,t}, \tag{56}$$

$$P_t^c Y_t = P_t^c G_t + P_t^c C_t. \tag{57}$$

2.4 Scaling of variables

In the following we refer to the vector of endogenous variables in the model by Z_t. To make the model trend stationary. we assume that all real non-stationary variables grow with a common trend z_t with the growth rate $\mu^z = \frac{z_t}{z_{t-1}}$. Furthermore, all nominal variables are scaled by the consumption price level P_t^c with trend inflation $\pi^c = \frac{P_t^c}{P_{t-1}^c}$ and are transformed into regional per capita variables.

$$C_t = z_t \, pop_t \, c_t \tag{58}$$

$$Y_{r,k,t} = z_t \, pop_{r,t} \, y_{r,k,t} \tag{59}$$

$$A_{r,k,t} = z_t \, pop_{r,t}^{1-\alpha_{r,k}} \, a_{r,k} \tag{60}$$

$$MC_{r,k,t}^h = z_t \, pop_{r,t}^{1-\psi} \, mc_{r,k,t}^h \tag{61}$$

$$W_{r,k,t} = P_{r,k,t} \, z_t \, w_{r,k,t} \tag{62}$$

$$P_{r,k,t} = \gamma_{r,k,t} \, P_t^c \tag{63}$$

$$P_{r,t}^c = \gamma_{r,t}^c \, P_t^c \tag{64}$$

(65)

2.5 Population growth, migration and labour market flows

The working age population pop_t in Germany at time t is the previous working age population pop_{t-1} minus exits EX_t plus entries EN_t in the respective period. The gross growth rate μ_t^{pop} of the working age population is defined by $\frac{pop_t}{pop_{t-1}}$. It is easy to see that the growth rate of the working age population is determined by the entry rate $en_t = \frac{EN_t}{pop_{t-1}}$ and exit rate $ex_t = \frac{EX_t}{pop_{t-1}}$.

$$pop_t = pop_{t-1} + EN_t - EX_t, \tag{66}$$

$$\mu_t^{pop} - 1 = en_t - ex_t. \tag{67}$$

The stock of employed and unemployed people grows at the same speed as the working age population itself. A exogenous separation rate δ and endogenous net hiring rate h_t lead to transitions between the state of unemployment and employment. The stock of employed people evolves from newly hired people and already employed as follows

$$N_t = H_t + en_t N_{t-1} - ex_t N_{t-1} + N_{t-1} - \delta\, N_{t-1}, \tag{68}$$

$$n_t = h_t + (1 - \frac{\delta}{\mu_t^{pop}})\, n_{t-1}. \tag{69}$$

This law of motion holds for every sector and region. Given a sector invariant separation rate, we are able to express the unemployment rate at the beginning of the period in one region by

$$u_t^s = u_{t-1} - \left(1 - \frac{\delta}{\mu_t^{pop}}\right) n_{t-1}. \tag{70}$$

Now we are able to define the job finding probability $x_t = \frac{h_t}{u_t^s}$. Using the definition of the unemployment rate, we get

$$u_t = 1 - n_t, \tag{71}$$

$$u_t = 1 - \left\{h_t + \left(1 - \frac{\delta}{\mu_t^{pop}}\right) n_{t-1}\right\}, \tag{72}$$

$$u_t = (1 - x_t)\, u_{t-1} + (1 - x_t)\, \frac{\delta}{\mu_t^{pop}}\, n_{t-1}, \tag{73}$$

$$u_t = (1 - x_t) \sum_{i=1}^{\infty} \left\{\left(\prod_{j=0}^{i-1} (1 - x_{t-j})\right) \frac{\delta}{\mu_{t-i+1}^{pop}}\, n_{t-i}\right\}. \tag{74}$$

We can use the last expression to define the probability for an individual to be long-term or short-term unemployed. The probability of a person to be unemployed for up to one year in period t is $\prod_{i=1}^{4}(1 - x_{t-i})$. In steady-state this corresponds to

$(1-(1-x)^4)$. The separation rate will be set such that this probability is 63%, to match German data.

The model only considers net migration. Regional population growth $\mu^{pop}_{r,t}$ is given by

$$\mu^{pop}_{r,t} = \frac{pop_{r,t}}{pop_{r,t-1}}, \tag{75}$$

$$\mu^{pop}_{r,t} = \mu^{pop}_{t} \frac{w^{pop}_{r,t}}{w^{pop}_{r,t-1}}. \tag{76}$$

2.6 Producers of intermediate goods in the energy sector

The problem of the producer of intermediate goods in the energy sector is slightly more complicated than the problem of the producer of intermediate goods in the non-energy sector. An producer of intermediate goods in the energy sector can either hire workers for the lignite sector or for the non-lignite sector. Intermediate firms with labour face monopolistic competition and, therefore, choose a production plan considering the demand for their products from the producers of final goods. The optimization problem of the firm is

$$\max_{N_{r,k,s,t}(f)} \sum_{h=0}^{\infty} \beta^h \Big\{ (1-\tau_{r,k,t+h})\, P_{r,k,t+h}(f)\, Y_{r,k,t+h}(f) - W_{r,k,s,t+h}\, N_{r,k,s,t+h}(f) \Big\} \tag{77}$$

$$\text{s.t. } Y_{r,k,t+h}(f) = \Big(\sum_s \phi_{r,k,s}^{\frac{1}{\eta^b}} Y_{r,k,s,t}(f)^{\frac{\eta^b-1}{\eta^b}} \Big)^{\frac{\eta^b}{\eta^b-1}}, \tag{78}$$

$$Y_{r,k,s,t+h}(f) = \epsilon_{r,k,s,t+h} \Big(A_{r,k,s,t+h}(f) N_{r,k,s,t+h}(f)^{\alpha_{r,k,s}} - \frac{1}{\Psi} MC^h_{r,k,s,t+h}(f) H_{r,k,s,t+h}(f)^{\Psi} \Big), \tag{79}$$

$$MC^h_{r,k,s,t+h} = B^h_{r,k,s} \left\{ \psi + (1-\psi) \left(\frac{H_{r,t+h}}{U^s_{r,t+h}} \right)^{v} \right\} pop^{1-\psi}_{r,t+h}, \tag{80}$$

$$H_{r,k,s,t+h}(f) = N_{r,k,t+h}(f) - \Big(\mu^{pop}_{r,t} - \delta \Big) N_{r,k,t+h-1}(f), \tag{81}$$

$$P_{r,k,t+h}(f) = \left(\frac{Y_{r,k,t+h}(f)}{Y_{r,k,t+h}} \right)^{\frac{1-\lambda_{r,k,t+h}}{\lambda_{r,k,t+h}}} P_{r,k,t+h}. \tag{82}$$

We can use the envelope theorem to obtain the following first-order condition with respect to $N_{r,k,s,t}(f)$

$$W_{r,k,s,t} = (1-\tau_{r,k,t})\frac{\mathrm{d}Y_{r,k,t}(f)}{\mathrm{d}Y_{r,k,s,t}(f)}\,\frac{\mathrm{d}Y_{r,k,s,t}(f)}{\mathrm{d}N_{r,k,s,t}(f)}\left(\frac{\mathrm{d}P_{r,k,t}(f)}{\mathrm{d}Y_{r,k,t}(f)}\,Y_{r,k,t}(f)+P_{r,k,t}(f)\right),\dots$$
$$+\,\beta\,(1-\tau_{r,k,t+1})\frac{\mathrm{d}Y_{r,k,s,t+1}(f)}{\mathrm{d}N_{r,k,s,t}(f)}\,\frac{\mathrm{d}Y_{r,k,s,t+1}(f)}{\mathrm{d}N_{r,k,s,t}(f)}\left(\frac{\mathrm{d}P_{r,k,t+1}(f)}{\mathrm{d}Y_{r,k,t+1}(f)}\,Y_{r,k,t+1}(f)+P_{r,k,t+1}(f)\right), \tag{83}$$

$$\frac{\mathrm{d}Y_{r,k,t}(f)}{\mathrm{d}Y_{r,k,s,t}(f)} = \phi_{r,k,s}^{\frac{1}{\eta^b}}\left(\frac{Y_{r,k,t}(f)}{Y_{r,k,s,t}(f)}\right)^{\frac{1}{\eta^b}},$$
$$\frac{\mathrm{d}Y_{r,k,s,t}(f)}{\mathrm{d}N_{r,k,s,t}(f)} = \epsilon_{r,k,s,t}\,z_t\left(\alpha_{r,k,s}\,A_{r,k,s,t}\,N_{r,k,s,t}^{\alpha_{r,k,s}-1} - MC_{r,k,s,t}^{h}\,H_{r,k,s,t}^{\Psi-1}\right),$$
$$\frac{\mathrm{d}Y_{r,k,s,t+1}(f)}{\mathrm{d}N_{r,k,s,t}(f)} = (\mu_{r,t+1}^{pop}-\delta)MC_{r,k,s,t+1}^{h}\,\epsilon_{r,k,s,t+1}\,z_{t+1}\,H_{r,k,s,t+1}^{\Psi-1},$$
$$\frac{\mathrm{d}P_{r,k,t}(f)}{\mathrm{d}Y_{r,k,t}(f)} = \frac{1-\lambda_{r,k,t}}{\lambda_{r,k,t}}\left(\frac{Y_{r,k,t}(f)}{Y_{r,k,t}}\right)^{\frac{1-\lambda_{r,k,t}}{\lambda_{r,k,t}}}P_{r,k,t}\,\frac{1}{Y_{r,k,t}(f)}.$$

Replacing all derivatives with their respective expressions we obtain the following first order condition:

$$\frac{P_{r,k,s,t}}{\lambda_{r,k,t}}\,\alpha_{r,k,s}\,A_{r,k,s,t}\,(1-\tau_{r,k,t})\,N_{r,k,s,t}^{\alpha_{r,k,s}-1} - \frac{P_{r,k,s,t}}{\lambda_{r,k,t}}\,MC_{r,k,t}^{h}\,\epsilon_{r,k,t}\,H_{r,k,s,t}^{\Psi-1}\dots \tag{84}$$
$$+\frac{P_{r,k,s,t+1}}{\lambda_{r,k,t+1}}\,(\mu_{r,t+1}^{pop}-\delta)\,\beta\frac{\lambda_{r,k,t}}{\lambda_{r,k,t+1}}\,MC_{r,k,s,t+1}^{h}\,\epsilon_{r,k,s,t+1}\,(1-\tau_{r,k,t+1})H_{r,k,s,t+1}^{\Psi-1} = W_{r,k,s,t},$$
$$P_{r,k,s,t} = \phi_{r,k,s}^{\frac{1}{\eta^b}}\left(\frac{Y_{r,k,t}(f)}{Y_{r,k,s,t}(f)}\right)^{\frac{1}{\eta^b}}P_{r,k,t}. \tag{85}$$

For the non-energy sector, $\frac{\mathrm{d}Y_{r,k,t}(f)}{\mathrm{d}Y_{r,k,s,t}(f)} = 1$ and the index s can be omitted.

3 Sensitivity analysis

Most of the structural model parameters are calibrated to match the German economy in 2014. The remaining ones, such as the inverse Frisch elasticity of substitution σ^L, are taken from the literature or are estimated, e.g. the persistence in unemployment benefits ρ^b. It is important to quantify how sensitive the reported results are with respect to these parameters. We construct an interval with the 95%, 97.5%, 102.5% and 105% values of the calibrated parameter value. For the persistence in regional attractiveness $\rho^{\epsilon^{pop}}$ we construct an interval around the implied average time an employee stays in the labour force. The interval around the discount factor is constructed around the implied interest rate $R = \frac{\mu^z \pi^c}{\beta}$ in a model with bonds. The sensitivity analysis is conducted for the following parameters: Discount factor β, elasticity of substitution between lignite coal and non-lignite coal η^b, regional elasticity of substitution for energy products η^m_E, regional elasticity of substitution for non-energy products η^m_{NE}, home bias energy products I^{Home}_E, home bias non-energy products I^{Home}_{NE}, share of hiring costs in wage sum $\frac{\kappa}{w\,n}$, long-run market power $\bar{\lambda}_l$, persistence in unemployment benefits ρ^b, persistence in regional attractiveness ρ^{pop}_ϵ, persistence in market power ρ^λ, inverse Frisch elasticity σ^L, labour market tightness hiring cost elasticity v and long-run job finding rate $x = \frac{h}{u}$.

In order to evaluate the sensitivity of the results with respect to each parameter, we report the maximum drop in the employment rate between the Null-Scenario and the respective scenario[1] for the time period 2014–2040 (see Tables 9–24). A one percent change in the inverse Frisch elasticity does not change the maximum drop in the employment rate by more than one percent (see Table 9). Labour supply reacts less to changes in wages if the Frisch elasticity is lower and vice versa. Wages react more to labour supply changes if the Frisch elasticity is lower. In Table 10 the maximum percentage drop in real regional wages are reported for different values of the inverse Frisch elasticity. A lower Frisch elasticity leads to more volatile wages and less volatile labour.

The persistence parameter for unemployment benefits determines how fast unemployment benefits react to changes in wages. We do not distinguish between long-term unemployment benefits and short-term unemployment benefits. A one percent increase in the persistence of unemployment benefits increases the maximum drop in the employment rate by up to 5 percent (see Table 11). A higher persistence in the adjustment of unemployment benefits leads to a lower adjustment of wages required by workers. Recovery in the model is achieved through migration and lower wages and a higher persistence in unemployment benefits leads to a slower adjustment process.

The sensitivity of employment to the elasticity of substitution between lignite coal and non-lignite coal η^b is very low, as reported in Table 12. A higher elasticity of substitution will increase the employment effects and indicates that less gross valued added from non-lignite coal is required to replace lignite coal to produce energy. Therefore, fewer people will find a job in the non-lignite coal energy sector. The results regarding employment rates are also very insensitive to variations in the regional elasticity of substitution between energy and non-energy products (see Table 13 and Table 14). An increase in the elasticity of substitution between energy and non-energy products will

[1]The maximum drop in employment is defined as follows: $\min\left(\left\{n^{Scenario}_{r,t} - n^{Null-Scenario}_{r,t}\right\}^{144}_{t=1}\right)$.

increase the ability of households to replace energy products by non-energy products while deriving the same utility. A one percent increase in the elasticity of substitution leads to a less than one percent reduction in the maximum drop in employment (see Table 15). Variations in the home bias for energy products also have no impact on the employment effects, as shown in Table 16. A one percent change in the home bias for non-energy products will trigger a more than one percent change in the maximum drop in the national employment rate (see Table 17). A higher home bias will reduce the maximum employment drop in the rest of Germany and Central Germany, but increase the maximum drop in Lusatia and the Rhineland. It is harder to generate new jobs in the non-energy sector for Lusatia and the Rhineland if demand from the rest of Germany for non-energy products is lower.

Market power will increase the maximum drop in employment, as shown in Table 18. Most of the increase is caused by a higher drop in the rest of Germany. In Central Germany, the Rhineland, and Lusatia, the impact on the maximum drop is negligible. A higher persistence in market power determines how quickly firms adjust their mark-ups in response to the change of attractiveness of the region they operate in. As stated before, attractiveness determines migration flows and affects the market power. A lower persistence leads to a faster adjustment of market power. Table 19 reports the results of the sensitivity analysis for the persistence parameter in market power. Firms will adjust their desired mark-up not as quickly according to their new market power if the persistence parameter is higher. As is known from standard micro theory, higher market power leads to lower output and lower demand for labour. Therefore, a slower adjustment to the new market power by firms will reduce the maximum drop in the employment rate.

The speed of migration in the model is determined by the persistence in the attractiveness of the region. As described before, we assume that entrants to the labour force decide where to live and work. We assume that after 22.5 years (roughly half the time an individual stays in the labour force) the labour force is populated to 50% by individuals who have chosen their working and living place after the coal phase-out path was announced. We construct the interval around the half-life an individual stays in the labour force (22.5 years) to compute the respective persistence parameters ρ_{ϵ}^{pop}. Table 20 shows that the maximum drop in employment changes are less than one percent if the half-time an individual stays in the labour force changes by one percent. A higher persistence in attractiveness leads to lower drops in the employment rate. A lower persistence implies that a higher share of people migrate each period. They only consider long-run developments in their decisions. This result reveals that it is not possible to change this parameter without altering the assumption about the process of migration. Reducing the persistence in the attractiveness of regions implies a higher share of population migrating each period. Altering the parameter requires altering the assumption about when individuals decide about their living and working place.

In Blanchard & Galí (2010) the elasticity of hiring costs with respect to the job finding rate is assumed to be unity. In Table 21 we document the sensitivity of the maximum drop in employment with respect to the elasticity of hiring costs. The results suggest that the drop in employment is only marginally affected by the elasticity of marginal hiring costs to the job finding rate. The quarterly job finding rate in Germany is assumed to be 22.43% and determines the exogenous separation rate in each period. This parameter implicitly determines steady-state hiring costs. A higher job finding rate will increase the exogenous separation rate. A higher long-run job finding rate will increase the maximum drop in the employment rate (see Table 22). It is easier to find new workers for firms and, therefore, incentives to do labour herding are reduced. The same argumentation holds for the share of hiring costs relative to the wage sum (see Table 23). An increase in the discount factor leads to a higher maximum drop in the employment rate (see Table 24). A lower decrease in the discount factor implies that future profits have a lower present value for firms. Their incentive to herd labour to increase future profits is lower.

4 Tables

Table 1: Regional and lignite specific productivity

Year	Germany	Rest of Germany	Central Germany	Lusatia	Rhineland
Null-Scenario					
2014	- [-;-]	100.00 [0.00;0.00]	100.00 [0.00;0.00]	100.00 [0.00;0.00]	100.00 [0.00;0.00]
2020	- [-;-]	-71.00 [-3.00;3.00]	0.00 [0.00;0.00]	0.00 [0.00;0.00]	0.00 [0.00;0.00]
2025	- [-;-]	-67.00 [-6.00;5.00]	0.00 [0.00;0.00]	0.00 [0.00;0.00]	0.00 [0.00;0.00]
2030	- [-;-]	-67.00 [-5.00;5.00]	0.00 [0.00;0.00]	0.00 [0.00;0.00]	0.00 [0.00;0.00]
2035	- [-;-]	-67.00 [-5.00;5.00]	0.00 [0.00;0.00]	0.00 [0.00;0.00]	0.00 [0.00;0.00]
2040	- [-;-]	-67.00 [-5.00;5.00]	0.00 [0.00;0.00]	0.00 [0.00;0.00]	0.00 [0.00;0.00]
Baseline					
2020	- [-;-]	-1.00 [-1.00;0.00]	-15.00 [-1.00;0.00]	-13.00 [-1.00;1.00]	-14.00 [-1.00;1.00]
2025	- [-;-]	0.00 [0.00;1.00]	-8.00 [-1.00;2.00]	-6.00 [-2.00;2.00]	-7.00 [-2.00;1.00]
2030	- [-;-]	-1.00 [-1.00;0.00]	-13.00 [-2.00;2.00]	-10.00 [-2.00;2.00]	-11.00 [-2.00;2.00]
2035	- [-;-]	-1.00 [-1.00;0.00]	-32.00 [-2.00;1.00]	-28.00 [-2.00;2.00]	-29.00 [-2.00;2.00]
2040	- [-;-]	-1.00 [-1.00;0.00]	-26.00 [-3.00;3.00]	-21.00 [-3.00;3.00]	-23.00 [-3.00;3.00]
Phase-Out-2035-Weak					
2020	- [-;-]	-1.00 [-1.00;0.00]	-11.00 [-1.00;1.00]	-8.00 [-1.00;2.00]	-9.00 [-2.00;1.00]
2025	- [-;-]	-1.00 [-1.00;0.00]	-22.00 [-3.00;2.00]	-17.00 [-3.00;3.00]	-43.00 [-2.00;2.00]
2030	- [-;-]	-1.00 [-1.00;0.00]	-56.00 [-2.00;3.00]	-50.00 [-4.00;3.00]	-18.00 [-7.00;7.00]
2035	- [-;-]	-1.00 [-1.00;1.00]	-92.00 [-3.00;2.00]	-84.00 [-6.00;5.00]	-88.00 [-5.00;3.00]
2040	- [-;-]	-1.00 [-1.00;1.00]	-92.00 [-3.00;2.00]	-84.00 [-7.00;5.00]	-88.00 [-5.00;3.00]
Phase-Out-2040-Age					
2020	- [-;-]	-1.00 [-1.00;0.00]	-13.00 [-1.00;1.00]	-11.00 [-1.00;2.00]	-11.00 [-1.00;2.00]
2025	- [-;-]	-1.00 [-1.00;0.00]	-15.00 [-2.00;2.00]	-12.00 [-2.00;2.00]	-23.00 [-3.00;2.00]
2030	- [-;-]	-1.00 [-1.00;0.00]	-20.00 [-3.00;2.00]	-14.00 [-4.00;4.00]	-40.00 [-3.00;3.00]
2035	- [-;-]	-1.00 [-1.00;0.00]	-58.00 [-2.00;3.00]	-52.00 [-4.00;3.00]	-20.00 [-8.00;7.00]
2040	- [-;-]	-1.00 [-1.00;1.00]	-92.00 [-3.00;2.00]	-84.00 [-6.00;5.00]	-88.00 [-5.00;3.00]
Phase-Out-2040-Balanced					
2020	- [-;-]	-1.00 [-1.00;1.00]	-13.00 [-1.00;1.00]	-9.00 [-1.00;2.00]	-13.00 [-1.00;1.00]
2025	- [-;-]	-1.00 [-1.00;0.00]	-7.00 [-2.00;1.00]	-32.00 [-2.00;3.00]	-13.00 [-2.00;2.00]
2030	- [-;-]	-1.00 [-1.00;0.00]	-23.00 [-3.00;2.00]	-17.00 [-4.00;5.00]	-30.00 [-3.00;3.00]
2035	- [-;-]	-1.00 [-1.00;0.00]	-78.00 [-3.00;3.00]	-35.00 [-5.00;5.00]	-25.00 [-6.00;5.00]
2040	- [-;-]	-1.00 [-1.00;1.00]	-92.00 [-3.00;2.00]	-84.00 [-6.00;5.00]	-88.00 [-5.00;3.00]
Phase-Out-2035-Strong					
2020	- [-;-]	-1.00 [-1.00;1.00]	-28.00 [-1.00;2.00]	-26.00 [-2.00;1.00]	-24.00 [-2.00;2.00]
2025	- [-;-]	-1.00 [-1.00;0.00]	-15.00 [-3.00;3.00]	-9.00 [-4.00;4.00]	-38.00 [-3.00;3.00]
2030	- [-;-]	-1.00 [-1.00;0.00]	-56.00 [-3.00;3.00]	-49.00 [-3.00;4.00]	-15.00 [-7.00;6.00]
2035	- [-;-]	-1.00 [-1.00;1.00]	-92.00 [-3.00;2.00]	-84.00 [-6.00;5.00]	-88.00 [-5.00;3.00]
2040	- [-;-]	-1.00 [-1.00;1.00]	-92.00 [-3.00;2.00]	-84.00 [-7.00;5.00]	-88.00 [-5.00;3.00]

Note: Simulation results for regional lignite productivity. Values in brackets denote the minimum and maximum difference from the reported value obtained from 1200 simulations.

Table 2: Net electricity generation in lignite sector

Year	Germany	Rest of Germany	Central Germany	Lusatia	Rhineland
			Null-Scenario		
2014	100.00 [0.00;0.00]	- [-;-]	100.00 [0.00;0.00]	100.00 [0.00;0.00]	100.00 [0.00;0.00]
2020	107.00 [0.00;0.00]	- [-;-]	107.00 [0.00;0.00]	107.00 [0.00;0.00]	107.00 [0.00;0.00]
2025	108.00 [0.00;0.00]	- [-;-]	108.00 [0.00;0.00]	108.00 [0.00;0.00]	108.00 [0.00;0.00]
2030	108.00 [0.00;0.00]	- [-;-]	108.00 [0.00;0.00]	108.00 [0.00;0.00]	108.00 [0.00;0.00]
2035	109.00 [0.00;0.00]	- [-;-]	109.00 [0.00;0.00]	109.00 [0.00;0.00]	109.00 [0.00;0.00]
2040	111.00 [0.00;0.00]	- [-;-]	111.00 [0.00;0.00]	111.00 [0.00;0.00]	111.00 [0.00;0.00]
			Baseline		
2020	81.00 [-1.00;0.00]	- [-;-]	81.00 [-1.00;0.00]	81.00 [-1.00;0.00]	81.00 [-1.00;0.00]
2025	81.00 [0.00;0.00]	- [-;-]	82.00 [0.00;1.00]	81.00 [0.00;0.00]	82.00 [0.00;1.00]
2030	72.00 [0.00;1.00]	- [-;-]	72.00 [0.00;0.00]	71.00 [0.00;0.00]	72.00 [0.00;1.00]
2035	48.00 [-1.00;0.00]	- [-;-]	48.00 [-1.00;0.00]	48.00 [-1.00;0.00]	48.00 [-1.00;0.00]
2040	48.00 [0.00;1.00]	- [-;-]	48.00 [0.00;1.00]	48.00 [0.00;1.00]	48.00 [0.00;1.00]
			Phase-Out-2035-Weak		
2020	80.00 [0.00;0.00]	- [-;-]	81.00 [0.00;0.00]	81.00 [0.00;0.00]	79.00 [0.00;0.00]
2025	44.00 [0.00;0.00]	- [-;-]	56.00 [0.00;0.00]	56.00 [0.00;0.00]	32.00 [-1.00;0.00]
2030	23.00 [0.00;0.00]	- [-;-]	16.00 [-1.00;0.00]	16.00 [-1.00;0.00]	30.00 [-1.00;0.00]
2035	0.00 [0.00;0.00]	- [-;-]	0.00 [0.00;0.00]	0.00 [0.00;0.00]	0.00 [0.00;0.00]
2040	0.00 [0.00;0.00]	- [-;-]	0.00 [0.00;0.00]	0.00 [0.00;0.00]	0.00 [0.00;0.00]
			Phase-Out-2040-Age		
2020	80.00 [0.00;0.00]	- [-;-]	81.00 [0.00;0.00]	81.00 [0.00;0.00]	79.00 [0.00;0.00]
2025	61.00 [0.00;0.00]	- [-;-]	70.00 [0.00;1.00]	69.00 [0.00;0.00]	54.00 [0.00;0.00]
2030	41.00 [0.00;0.00]	- [-;-]	55.00 [0.00;0.00]	54.00 [0.00;0.00]	28.00 [-1.00;0.00]
2035	21.00 [0.00;1.00]	- [-;-]	15.00 [0.00;1.00]	15.00 [0.00;1.00]	26.00 [-1.00;0.00]
2040	0.00 [0.00;0.00]	- [-;-]	0.00 [0.00;0.00]	0.00 [0.00;0.00]	0.00 [0.00;0.00]
			Phase-Out-2040-Balanced		
2020	80.00 [0.00;0.00]	- [-;-]	83.00 [0.00;0.00]	79.00 [-1.00;0.00]	79.00 [0.00;0.00]
2025	61.00 [0.00;0.00]	- [-;-]	80.00 [0.00;0.00]	44.00 [0.00;0.00]	67.00 [0.00;0.00]
2030	43.00 [0.00;0.00]	- [-;-]	54.00 [0.00;0.00]	41.00 [0.00;0.00]	41.00 [0.00;0.00]
2035	22.00 [0.00;0.00]	- [-;-]	2.00 [-1.00;0.00]	22.00 [0.00;0.00]	28.00 [-1.00;0.00]
2040	0.00 [0.00;0.00]	- [-;-]	0.00 [0.00;0.00]	0.00 [0.00;0.00]	0.00 [0.00;0.00]
			Phase-Out-2035-Strong		
2020	60.00 [0.00;0.00]	- [-;-]	60.00 [0.00;0.00]	60.00 [0.00;1.00]	60.00 [0.00;0.00]
2025	44.00 [0.00;0.00]	- [-;-]	56.00 [0.00;0.00]	56.00 [0.00;0.00]	32.00 [0.00;0.00]
2030	23.00 [0.00;0.00]	- [-;-]	17.00 [0.00;1.00]	16.00 [-1.00;0.00]	30.00 [-1.00;0.00]
2035	0.00 [0.00;0.00]	- [-;-]	0.00 [0.00;0.00]	0.00 [0.00;0.00]	0.00 [0.00;0.00]
2040	0.00 [0.00;0.00]	- [-;-]	0.00 [0.00;0.00]	0.00 [0.00;0.00]	0.00 [0.00;0.00]

Note: Simulation results for net electricity generation by lignite relative to 2014 values. Values in brackets denote the minimum and maximum difference from the reported value obtained from 1200 simulations.

Table 3: Employees in non-lignite sector

Year	Germany	Rest of Germany	Central Germany	Lusatia	Rhineland
Null-Scenario					
2014	297.4 [0.0;0.0]	259.5 [0.0;0.0]	10.8 [0.0;0.0]	2.9 [0.0;0.0]	24.2 [0.0;0.0]
2020	6.2 [0.0;0.0]	5.4 [0.0;0.0]	0.2 [0.0;0.0]	0.1 [0.0;0.0]	0.5 [0.0;0.0]
2025	-1.3 [0.0;0.0]	-1.2 [0.0;0.0]	0.0 [0.0;0.0]	0.0 [0.0;0.0]	-0.1 [0.0;0.0]
2030	-12.1 [0.0;0.0]	-10.6 [0.0;0.0]	-0.4 [0.0;0.0]	-0.1 [0.0;0.0]	-1.0 [0.0;0.0]
2035	-20.4 [0.0;0.0]	-17.8 [0.0;0.0]	-0.7 [0.0;0.0]	-0.2 [0.0;0.0]	-1.7 [0.0;0.0]
2040	-24.8 [0.0;0.0]	-21.7 [0.0;0.0]	-0.9 [0.0;0.0]	-0.2 [0.0;0.0]	-2.0 [0.0;0.0]
Baseline					
2020	2.6 [-0.1;0.2]	2.3 [-0.1;0.1]	0.1 [0.0;0.0]	0.0 [0.0;0.0]	0.2 [0.0;0.1]
2025	3.5 [-0.1;0.1]	3.2 [-0.1;0.1]	0.1 [0.0;0.0]	0.0 [0.0;0.0]	0.2 [0.0;0.0]
2030	4.7 [-0.2;0.2]	4.3 [-0.1;0.2]	0.1 [0.0;0.0]	0.0 [0.0;0.0]	0.3 [-0.1;0.0]
2035	6.3 [-0.2;0.4]	5.6 [-0.2;0.2]	0.2 [0.0;0.1]	0.0 [0.0;0.0]	0.5 [0.0;0.1]
2040	6.7 [-0.3;0.2]	6.1 [-0.2;0.2]	0.2 [0.0;0.0]	0.0 [0.0;0.0]	0.4 [-0.1;0.0]
Phase-Out-2035-Weak					
2020	4.0 [-0.3;0.3]	3.6 [-0.2;0.2]	0.2 [0.0;0.1]	0.0 [0.0;0.0]	0.2 [-0.1;0.0]
2025	7.5 [-0.3;0.4]	6.8 [-0.3;0.3]	0.2 [0.0;0.0]	0.0 [0.0;0.0]	0.5 [0.0;0.1]
2030	10.2 [-0.2;0.5]	9.2 [-0.2;0.4]	0.3 [0.0;0.1]	0.0 [0.0;0.0]	0.7 [0.0;0.1]
2035	11.7 [-0.5;0.3]	10.6 [-0.4;0.3]	0.3 [0.0;0.0]	0.0 [-0.1;0.0]	0.8 [-0.1;0.0]
2040	12.3 [-0.4;0.5]	11.1 [-0.4;0.4]	0.4 [0.0;0.1]	0.0 [0.0;0.0]	0.8 [-0.1;0.1]
Phase-Out-2040-Age					
2020	3.3 [-0.2;0.1]	3.0 [-0.2;0.1]	0.1 [0.0;0.0]	0.0 [0.0;0.0]	0.2 [0.0;0.0]
2025	5.6 [-0.3;0.2]	5.2 [-0.2;0.2]	0.1 [0.0;0.0]	0.0 [0.0;0.0]	0.3 [-0.1;0.0]
2030	7.9 [-0.4;0.3]	7.2 [-0.3;0.3]	0.2 [0.0;0.0]	0.0 [0.0;0.0]	0.5 [-0.1;0.0]
2035	10.1 [-0.4;0.4]	9.1 [-0.3;0.3]	0.3 [0.0;0.1]	0.0 [-0.1;0.0]	0.7 [-0.1;0.0]
2040	11.7 [-0.4;0.5]	10.6 [-0.4;0.4]	0.3 [-0.1;0.0]	0.0 [0.0;0.0]	0.8 [0.0;0.1]
Phase-Out-2040-Balanced					
2020	3.3 [-0.2;0.1]	3.0 [-0.2;0.1]	0.1 [0.0;0.0]	0.0 [0.0;0.0]	0.2 [0.0;0.0]
2025	5.7 [-0.2;0.3]	5.2 [-0.2;0.2]	0.1 [0.0;0.0]	0.0 [0.0;0.0]	0.4 [0.0;0.1]
2030	7.8 [-0.4;0.3]	7.1 [-0.3;0.3]	0.2 [0.0;0.0]	0.0 [0.0;0.0]	0.5 [-0.1;0.0]
2035	9.9 [-0.5;0.3]	9.0 [-0.3;0.3]	0.2 [-0.1;0.0]	0.0 [-0.1;0.0]	0.7 [-0.1;0.0]
2040	11.6 [-0.5;0.4]	10.5 [-0.4;0.3]	0.3 [-0.1;0.0]	0.0 [0.0;0.0]	0.8 [0.0;0.1]
Phase-Out-2035-Strong					
2020	5.2 [-0.3;0.1]	4.7 [-0.2;0.1]	0.2 [0.0;0.0]	0.0 [0.0;0.0]	0.3 [-0.1;0.0]
2025	7.9 [-0.3;0.2]	7.2 [-0.3;0.2]	0.2 [0.0;0.0]	0.0 [0.0;0.0]	0.5 [0.0;0.0]
2030	10.3 [-0.3;0.4]	9.3 [-0.3;0.3]	0.3 [0.0;0.1]	0.0 [0.0;0.0]	0.7 [-0.1;0.1]
2035	11.8 [-0.5;0.4]	10.7 [-0.4;0.4]	0.3 [0.0;0.0]	0.0 [-0.1;0.0]	0.8 [-0.1;0.0]
2040	12.3 [-0.4;0.5]	11.1 [-0.4;0.4]	0.4 [0.0;0.1]	0.0 [0.0;0.0]	0.8 [-0.1;0.1]

Note: Simulation results for employees in the non-lignite industry in thousand people. Values for the Null-Scenario are reported as change to the base year 2014 and for the year 2014 actual values are reported. Values for other scenarios are differences to the Null-Scenario in the respective year. Values in brackets denote the minimum and maximum difference from the reported value obtained from 1200 simulations.

Table 4: Employees in non-energy sector

Year	Germany	Rest of Germany	Central Germany	Lusatia	Rhineland
			Null-Scenario		
2014	42870.0 [0.0;0.0]	37966.9 [0.0;0.0]	1450.6 [0.0;0.0]	453.7 [0.0;0.0]	2998.8 [0.0;0.0]
2020	852.1 [-0.2;0.3]	754.6 [-0.2;0.3]	28.9 [0.0;0.0]	9.0 [0.0;0.0]	59.6 [0.0;0.0]
2025	-247.4 [-0.3;0.5]	-219.2 [-0.3;0.4]	-8.3 [0.0;0.1]	-2.6 [0.0;0.0]	-17.3 [0.0;0.0]
2030	-1793.5 [-0.6;0.5]	-1588.3 [-0.4;0.5]	-60.7 [-0.1;0.0]	-19.0 [0.0;0.0]	-125.5 [-0.1;0.0]
2035	-2990.7 [-0.4;0.5]	-2648.6 [-0.4;0.5]	-101.2 [0.0;0.0]	-31.7 [0.0;0.0]	-209.2 [0.0;0.0]
2040	-3625.8 [-0.5;0.5]	-3211.1 [-0.4;0.4]	-122.7 [-0.1;0.0]	-38.4 [0.0;0.0]	-253.6 [0.0;0.1]
			Baseline		
2020	-7.6 [-3.8;3.5]	-5.3 [-4.5;3.5]	-0.4 [-0.1;0.1]	-0.8 [-0.3;0.5]	-1.1 [-0.2;0.3]
2025	-9.1 [-5.3;5.0]	-6.6 [-6.2;5.1]	-0.4 [-0.2;0.1]	-0.9 [-0.4;0.7]	-1.2 [-0.3;0.3]
2030	-9.2 [-6.0;6.2]	-6.6 [-7.1;6.3]	-0.3 [-0.1;0.2]	-1.0 [-0.5;0.9]	-1.3 [-0.3;0.4]
2035	-9.7 [-6.5;6.9]	-6.1 [-7.8;7.2]	-0.4 [-0.2;0.2]	-1.4 [-0.7;1.1]	-1.8 [-0.6;0.6]
2040	-5.7 [-6.5;6.9]	-2.6 [-7.3;7.3]	-0.2 [-0.1;0.3]	-1.4 [-0.7;1.3]	-1.5 [-0.7;0.7]
			Phase-Out-2035-Weak		
2020	-28.2 [-10.7;8.5]	-23.4 [-10.6;8.3]	-1.1 [-0.4;0.3]	-1.1 [-0.4;0.8]	-2.6 [-0.4;0.5]
2025	-44.4 [-16.5;14.1]	-36.4 [-16.4;13.8]	-1.6 [-0.6;0.4]	-1.8 [-0.7;1.3]	-4.6 [-0.9;1.0]
2030	-47.3 [-18.8;18.5]	-39.2 [-19.1;17.2]	-1.5 [-0.5;0.7]	-2.4 [-1.0;1.7]	-4.2 [-0.9;1.3]
2035	-37.4 [-20.1;22.0]	-31.9 [-20.0;19.7]	-0.6 [-0.7;0.8]	-2.1 [-1.1;1.9]	-2.8 [-1.1;1.5]
2040	-17.2 [-20.3;23.7]	-14.7 [-20.4;21.3]	0.3 [-0.8;0.8]	-1.8 [-1.2;2.3]	-1.0 [-1.2;1.5]
			Phase-Out-2040-Age		
2020	-28.5 [-10.7;7.9]	-23.5 [-10.5;7.8]	-1.1 [-0.4;0.2]	-1.2 [-0.5;0.8]	-2.7 [-0.4;0.4]
2025	-44.6 [-15.9;12.7]	-37.0 [-15.9;12.5]	-1.6 [-0.5;0.4]	-1.7 [-0.7;1.3]	-4.3 [-0.7;0.8]
2030	-51.8 [-18.4;16.1]	-43.2 [-18.7;15.7]	-1.7 [-0.5;0.6]	-1.9 [-0.8;1.7]	-5.0 [-1.0;1.2]
2035	-51.1 [-19.6;19.1]	-42.7 [-19.8;18.2]	-1.6 [-0.7;0.7]	-2.4 [-1.1;2.0]	-4.4 [-1.0;1.5]
2040	-39.8 [-19.6;21.9]	-34.2 [-19.8;19.8]	-0.6 [-0.7;0.8]	-2.1 [-1.2;2.3]	-2.9 [-1.2;1.5]
			Phase-Out-2040-Balanced		
2020	-28.7 [-10.6;8.0]	-23.7 [-10.5;7.8]	-1.1 [-0.4;0.2]	-1.2 [-0.4;0.7]	-2.7 [-0.4;0.5]
2025	-45.0 [-15.7;12.8]	-37.3 [-15.8;12.5]	-1.5 [-0.5;0.4]	-2.2 [-0.7;1.4]	-4.0 [-0.7;0.8]
2030	-52.1 [-18.3;15.9]	-43.4 [-18.6;15.6]	-1.7 [-0.5;0.5]	-2.2 [-0.9;1.7]	-4.8 [-0.9;1.2]
2035	-51.5 [-19.4;18.8]	-43.2 [-19.7;18.0]	-1.5 [-0.7;0.7]	-2.3 [-1.1;2.0]	-4.5 [-1.1;1.5]
2040	-40.6 [-20.0;21.5]	-34.8 [-20.0;19.7]	-0.6 [-0.8;0.7]	-2.2 [-1.3;2.2]	-3.0 [-1.2;1.5]
			Phase-Out-2035-Strong		
2020	-30.8 [-11.0;9.2]	-24.8 [-11.1;8.9]	-1.2 [-0.3;0.4]	-1.6 [-0.5;0.9]	-3.2 [-0.5;0.6]
2025	-43.1 [-16.4;14.6]	-35.3 [-16.5;13.9]	-1.5 [-0.5;0.5]	-1.8 [-0.6;1.3]	-4.5 [-0.9;1.1]
2030	-44.2 [-18.9;18.8]	-36.5 [-19.1;17.3]	-1.4 [-0.5;0.7]	-2.3 [-1.0;1.7]	-4.0 [-0.9;1.3]
2035	-33.9 [-20.0;22.1]	-28.9 [-19.9;19.7]	-0.5 [-0.7;0.8]	-2.0 [-1.0;2.0]	-2.5 [-1.1;1.5]
2040	-14.0 [-20.0;23.5]	-11.9 [-20.1;21.2]	0.5 [-0.7;0.9]	-1.8 [-1.3;2.2]	-0.8 [-1.3;1.5]

Note: Simulation results for employees in non-energy sector in thousand people. Values for the Null-Scenario are reported as change to the base year 2014 and for the year 2014 actual values are reported. Values for other scenarios are differences to the Null-Scenario in the respective year. Values in brackets denote the minimum and maximum difference from the reported value obtained from 1200 simulations.

Table 5: Real gross value-added total

Year	Germany	Rest of Germany	Central Germany	Lusatia	Rhineland
			Null-Scenario		
2014	2631268 [0;0]	2332970 [0;0]	71090 [0;0]	22606 [0;0]	204602 [0;0]
2020	175310 [-10;15]	155419 [-9;13]	4740 [-1;0]	1509 [0;0]	13642 [-1;2]
2025	208876 [-20;24]	185183 [-17;22]	5646 [-1;1]	1797 [0;0]	16250 [-2;2]
2030	210052 [-27;30]	186225 [-24;27]	5678 [-1;1]	1807 [0;0]	16342 [-2;3]
2035	232242 [-31;30]	205899 [-28;27]	6277 [-1;1]	1998 [0;1]	18068 [-2;3]
2040	293908 [-30;31]	260573 [-28;27]	7944 [0;2]	2528 [0;1]	22863 [-2;3]
			Baseline		
2020	-552 [-367;236]	276 [-444;275]	-80 [-4;4]	-310 [-31;50]	-438 [-38;48]
2025	-551 [-513;368]	272 [-572;384]	-84 [-10;7]	-314 [-32;61]	-425 [-33;40]
2030	-593 [-694;491]	550 [-807;529]	-112 [-14;8]	-444 [-50;94]	-587 [-52;67]
2035	-914 [-884;621]	1031 [-1083;714]	-185 [-13;10]	-750 [-77;132]	-1010 [-96;121]
2040	-676 [-881;650]	1269 [-1091;734]	-186 [-14;10]	-762 [-77;133]	-997 [-96;112]
			Phase-Out-2035-Weak		
2020	-1335 [-644;507]	-416 [-685;506]	-98 [-15;12]	-323 [-38;72]	-498 [-38;48]
2025	-2713 [-1200;977]	-456 [-1365;1030]	-172 [-35;25]	-631 [-66;124]	-1454 [-124;187]
2030	-3216 [-1433;1294]	-437 [-1582;1317]	-349 [-25;28]	-1165 [-112;205]	-1265 [-91;99]
2035	-3237 [-1571;1533]	112 [-1742;1551]	-292 [-58;44]	-1291 [-107;200]	-1766 [-144;208]
2040	-1973 [-1675;1716]	1234 [-1866;1719]	-267 [-49;44]	-1350 [-132;240]	-1590 [-150;191]
			Phase-Out-2040-Age		
2020	-1366 [-667;493]	-398 [-725;506]	-99 [-15;11]	-341 [-42;78]	-528 [-44;63]
2025	-2472 [-1132;887]	-765 [-1241;909]	-146 [-32;22]	-511 [-63;124]	-1050 [-85;121]
2030	-3179 [-1442;1200]	-775 [-1620;1242]	-192 [-40;29]	-697 [-87;167]	-1515 [-125;175]
2035	-3469 [-1624;1460]	-458 [-1853;1507]	-363 [-27;31]	-1250 [-137;252]	-1398 [-104;133]
2040	-3401 [-1677;1636]	55 [-1892;1662]	-296 [-65;47]	-1361 [-128;239]	-1799 [-144;217]
			Phase-Out-2040-Balanced		
2020	-1383 [-672;491]	-396 [-734;508]	-95 [-15;11]	-333 [-35;70]	-559 [-51;75]
2025	-2506 [-1134;887]	-786 [-1228;905]	-97 [-38;25]	-834 [-84;149]	-789 [-66;88]
2030	-3162 [-1435;1189]	-812 [-1617;1229]	-208 [-33;25]	-824 [-83;154]	-1318 [-121;179]
2035	-3460 [-1629;1450]	-493 [-1867;1504]	-439 [-31;35]	-1107 [-116;218]	-1421 [-116;149]
2040	-3441 [-1691;1635]	24 [-1907;1665]	-288 [-62;49]	-1367 [-130;241]	-1810 [-145;216]
			Phase-Out-2035-Strong		
2020	-1782 [-742;569]	-182 [-851;615]	-170 [-12;12]	-589 [-58;93]	-841 [-66;90]
2025	-2695 [-1120;963]	-541 [-1234;984]	-170 [-34;25]	-595 [-54;102]	-1389 [-110;148]
2030	-3017 [-1426;1298]	-270 [-1565;1319]	-347 [-24;28]	-1166 [-114;212]	-1234 [-91;95]
2035	-3036 [-1540;1520]	237 [-1684;1526]	-282 [-58;45]	-1287 [-107;199]	-1704 [-136;185]
2040	-1760 [-1654;1705]	1425 [-1859;1709]	-262 [-48;44]	-1348 [-132;241]	-1575 [-154;191]

Note: Simulation results for real gross value-added in million euros. Values for the Null-Scenario are reported as change to the base year 2014 and for the year 2014 actual values are reported. Values for other scenarios are differences to the Null-Scenario in the respective year. Values in brackets denote the minimum and maximum difference from the reported value obtained from 1200 simulations.

Table 6: Real gross value-added in lignite sector

Year	Germany	Rest of Germany	Central Germany	Lusatia	Rhineland
Null-Scenario					
2014	2448 [0;0]	56 [0;0]	295 [0;0]	873 [0;0]	1224 [0;0]
2020	105 [0;0]	-54 [0;0]	20 [0;0]	58 [0;0]	81 [0;0]
2025	135 [0;1]	-55 [0;1]	24 [0;0]	69 [0;0]	97 [0;0]
2030	136 [0;0]	-55 [0;0]	24 [0;0]	69 [0;0]	98 [0;0]
2035	157 [0;0]	-55 [0;0]	27 [0;0]	77 [0;0]	108 [0;0]
2040	212 [0;0]	-55 [0;0]	33 [0;0]	97 [0;0]	137 [0;0]
Baseline					
2020	-605 [-6;1]	0 [0;0]	-74 [0;0]	-222 [-2;1]	-309 [-4;0]
2025	-634 [-1;10]	0 [-1;0]	-78 [0;1]	-233 [-1;4]	-323 [0;5]
2030	-873 [-2;3]	0 [0;0]	-107 [0;1]	-320 [-1;1]	-446 [-1;1]
2035	-1457 [-25;3]	0 [0;0]	-180 [-3;0]	-533 [-9;2]	-744 [-13;1]
2040	-1518 [-3;12]	0 [0;0]	-187 [-1;1]	-555 [-1;5]	-776 [-1;6]
Phase-Out-2035-Weak					
2020	-636 [-1;2]	0 [0;0]	-74 [0;0]	-223 [-1;1]	-339 [0;1]
2025	-1534 [-4;4]	0 [-1;0]	-153 [0;0]	-454 [-1;2]	-927 [-4;3]
2030	-2024 [-1;3]	0 [0;0]	-270 [-1;1]	-800 [-4;3]	-954 [-5;7]
2035	-2603 [-2;1]	0 [0;0]	-322 [0;0]	-949 [-1;1]	-1332 [-1;0]
2040	-2659 [0;0]	0 [0;0]	-328 [0;0]	-970 [0;0]	-1361 [0;0]
Phase-Out-2040-Age					
2020	-635 [-1;3]	0 [0;1]	-74 [0;0]	-223 [-1;1]	-338 [0;1]
2025	-1119 [-1;2]	0 [-1;0]	-114 [0;0]	-339 [-1;2]	-666 [0;0]
2030	-1601 [-2;4]	0 [0;0]	-158 [0;0]	-469 [-1;2]	-974 [-2;2]
2035	-2111 [-1;2]	0 [0;0]	-279 [-1;1]	-823 [-4;4]	-1009 [-5;6]
2040	-2658 [-1;1]	0 [0;0]	-328 [0;0]	-969 [0;1]	-1361 [-1;0]
Phase-Out-2040-Balanced					
2020	-645 [0;2]	0 [0;1]	-70 [0;0]	-237 [0;1]	-338 [0;0]
2025	-1147 [-1;2]	0 [-1;0]	-83 [0;0]	-559 [0;2]	-505 [-1;0]
2030	-1564 [-2;2]	0 [0;0]	-160 [0;1]	-584 [-2;1]	-820 [-1;0]
2035	-2059 [-3;2]	0 [0;0]	-315 [-1;2]	-760 [-1;1]	-984 [-3;0]
2040	-2658 [-2;1]	0 [0;0]	-328 [0;0]	-969 [-1;1]	-1361 [-1;0]
Phase-Out-2035-Strong					
2020	-1124 [-2;2]	0 [0;1]	-138 [0;0]	-411 [-1;1]	-575 [-1;0]
2025	-1540 [-2;2]	0 [0;0]	-153 [0;0]	-455 [-1;1]	-932 [-2;1]
2030	-2022 [-3;1]	0 [0;0]	-270 [-1;1]	-799 [-4;3]	-953 [-6;5]
2035	-2603 [-1;1]	0 [0;0]	-322 [0;0]	-949 [0;1]	-1332 [-1;0]
2040	-2659 [0;0]	0 [0;0]	-328 [0;0]	-970 [0;0]	-1361 [0;0]

Note: Simulation results for gross value-added at constant prices in the lignite industry in million euros. Values for the Null-Scenario are reported as change to the base year 2014 and for the year 2014 actual values are reported. Values for other scenarios are differences to the Null-Scenario in the respective year. Values in brackets denote the minimum and maximum difference from the reported value obtained from 1200 simulations.

Table 7: Real gross labour income

Year	Germany	Rest of Germany	Central Germany	Lusatia	Rhineland
Null-Scenario					
2014	1482827 [0;0]	1312983 [0;0]	40342 [0;0]	12267 [0;0]	117235 [0;0]
2020	98766 [-12;11]	87442 [-9;11]	2689 [-3;0]	818 [0;0]	7817 [0;0]
2025	117634 [-10;11]	104142 [-10;12]	3205 [0;0]	975 [0;0]	9312 [-1;0]
2030	118288 [-16;12]	104724 [-15;14]	3222 [-1;0]	979 [0;0]	9363 [-1;0]
2035	130789 [-15;13]	115790 [-15;12]	3562 [0;0]	1085 [0;3]	10352 [-1;0]
2040	165535 [-21;18]	146555 [-17;14]	4507 [-3;0]	1372 [0;0]	13101 [-1;4]
Baseline					
2020	-647 [-108;120]	-47 [-114;106]	-71 [-4;4]	-216 [-7;9]	-313 [-11;11]
2025	-962 [-200;190]	-55 [-215;183]	-111 [-5;5]	-326 [-8;18]	-470 [-16;14]
2030	-1244 [-232;232]	-47 [-237;225]	-147 [-6;6]	-430 [-12;15]	-620 [-20;19]
2035	-1716 [-223;263]	0 [-221;245]	-215 [-8;5]	-611 [-13;13]	-890 [-25;19]
2040	-1912 [-229;271]	94 [-256;262]	-252 [-6;9]	-713 [-10;23]	-1041 [-18;18]
Phase-Out-2035-Weak					
2020	-1607 [-407;322]	-630 [-379;304]	-112 [-9;11]	-304 [-16;20]	-561 [-30;27]
2025	-3059 [-618;537]	-1049 [-572;486]	-236 [-19;13]	-603 [-19;25]	-1171 [-51;51]
2030	-4177 [-749;704]	-1184 [-705;641]	-389 [-24;24]	-973 [-22;21]	-1631 [-45;51]
2035	-5712 [-717;791]	-1107 [-754;727]	-764 [-38;35]	-1403 [-27;34]	-2438 [-94;89]
2040	-6124 [-724;809]	-971 [-715;750]	-839 [-14;23]	-1464 [-17;32]	-2850 [-53;60]
Phase-Out-2040-Age					
2020	-1579 [-386;300]	-714 [-370;277]	-102 [-9;9]	-259 [-10;17]	-504 [-22;29]
2025	-2830 [-621;499]	-1212 [-590;459]	-187 [-16;14]	-455 [-14;26]	-976 [-29;38]
2030	-3863 [-747;644]	-1505 [-704;594]	-268 [-20;18]	-655 [-20;27]	-1435 [-45;48]
2035	-4706 [-801;760]	-1559 [-758;694]	-410 [-26;27]	-994 [-21;23]	-1743 [-45;56]
2040	-6330 [-749;825]	-1430 [-789;765]	-821 [-33;26]	-1444 [-27;35]	-2635 [-96;93]
Phase-Out-2040-Balanced					
2020	-1599 [-398;291]	-722 [-372;276]	-94 [-12;6]	-324 [-14;19]	-459 [-21;22]
2025	-2838 [-621;495]	-1225 [-587;459]	-164 [-19;13]	-636 [-16;20]	-813 [-30;37]
2030	-3801 [-755;635]	-1523 [-708;590]	-259 [-25;16]	-828 [-19;28]	-1191 [-39;45]
2035	-4655 [-817;756]	-1572 [-766;695]	-441 [-34;28]	-1018 [-18;29]	-1624 [-47;56]
2040	-6349 [-746;824]	-1452 [-783;766]	-843 [-16;22]	-1433 [-31;36]	-2621 [-100;101]
Phase-Out-2035-Strong					
2020	-1897 [-387;335]	-616 [-358;297]	-154 [-10;11]	-416 [-16;14]	-711 [-28;28]
2025	-3230 [-628;550]	-974 [-597;504]	-262 [-16;15]	-681 [-18;28]	-1313 [-40;50]
2030	-4104 [-750;694]	-1105 [-707;637]	-386 [-24;22]	-966 [-17;18]	-1647 [-45;54]
2035	-5749 [-707;784]	-1013 [-751;727]	-788 [-37;28]	-1413 [-26;35]	-2535 [-100;99]
2040	-6030 [-717;806]	-886 [-705;746]	-837 [-15;23]	-1464 [-20;32]	-2843 [-53;60]

Note: Simulation results for real gross labour income in Germany in million euros. Values for the Null-Scenario are reported as change to the base year 2014 and for the year 2014 actual values are reported. Values for other scenarios are differences to the Null-Scenario in the respective year. Values in brackets denote the minimum and maximum difference from the reported value obtained from 1200 simulations.

Table 8: Real gross labour income in lignite sector

Year	Germany	Rest of Germany	Central Germany	Lusatia	Rhineland
			Null-Scenario		
2014	1428 [0;0]	28 [0;0]	161 [0;0]	524 [0;0]	715 [0;0]
2020	62 [0;0]	-23 [0;0]	7 [0;0]	31 [0;0]	47 [0;0]
2025	77 [0;0]	-28 [0;0]	14 [0;0]	38 [0;0]	53 [0;0]
2030	81 [0;0]	-28 [0;0]	13 [0;0]	37 [0;0]	59 [0;0]
2035	92 [0;0]	-28 [0;0]	12 [0;0]	44 [0;0]	64 [0;0]
2040	123 [0;0]	-28 [0;0]	18 [0;0]	57 [0;0]	76 [0;0]
			Baseline		
2020	-272 [-2;15]	0 [0;0]	-28 [0;0]	-103 [-1;7]	-141 [-1;8]
2025	-401 [-2;2]	0 [0;0]	-45 [0;0]	-152 [-1;1]	-204 [-1;1]
2030	-539 [-4;6]	0 [0;0]	-63 [0;1]	-200 [-2;1]	-276 [-2;7]
2035	-763 [-11;7]	0 [0;0]	-85 [0;1]	-286 [-6;2]	-392 [-8;7]
2040	-878 [-7;4]	0 [0;0]	-104 [-1;0]	-327 [-1;2]	-447 [-7;2]
			Phase-Out-2035-Weak		
2020	-398 [-18;5]	0 [0;0]	-36 [-1;6]	-140 [-8;1]	-222 [-9;1]
2025	-816 [-14;11]	0 [0;0]	-86 [0;1]	-274 [-7;7]	-456 [-9;9]
2030	-1169 [-14;9]	0 [0;0]	-135 [-6;1]	-431 [-6;7]	-603 [-6;2]
2035	-1511 [-4;2]	0 [0;0]	-173 [0;0]	-565 [0;1]	-773 [-4;1]
2040	-1551 [0;0]	0 [0;0]	-179 [0;0]	-581 [0;0]	-791 [0;0]
			Phase-Out-2040-Age		
2020	-351 [-9;8]	0 [0;0]	-35 [0;0]	-118 [-1;7]	-198 [-8;1]
2025	-643 [-14;3]	0 [0;0]	-63 [-1;0]	-210 [-8;1]	-370 [-7;5]
2030	-925 [-16;6]	0 [0;0]	-90 [-1;0]	-297 [-8;6]	-538 [-8;2]
2035	-1209 [-9;10]	0 [0;0]	-133 [0;1]	-446 [-8;6]	-630 [-2;5]
2040	-1548 [-6;1]	0 [0;0]	-179 [0;0]	-581 [-3;0]	-788 [-3;1]
			Phase-Out-2040-Balanced		
2020	-358 [-16;2]	0 [0;0]	-28 [0;0]	-148 [-8;1]	-182 [-8;1]
2025	-653 [-11;6]	0 [0;0]	-54 [0;0]	-289 [-6;6]	-310 [-8;2]
2030	-911 [-9;5]	0 [0;0]	-89 [0;1]	-363 [-4;2]	-459 [-8;2]
2035	-1194 [-15;6]	0 [0;0]	-143 [-1;5]	-450 [-7;1]	-601 [-8;1]
2040	-1545 [-4;3]	0 [0;0]	-179 [0;0]	-578 [0;3]	-788 [-4;0]
			Phase-Out-2035-Strong		
2020	-541 [-14;9]	0 [0;0]	-54 [-1;0]	-199 [-8;1]	-288 [-7;8]
2025	-895 [-6;11]	0 [0;0]	-94 [-1;0]	-302 [-2;6]	-499 [-6;8]
2030	-1176 [-19;4]	0 [0;0]	-135 [-6;0]	-431 [-6;5]	-610 [-8;1]
2035	-1514 [-3;4]	0 [0;0]	-173 [0;0]	-565 [0;3]	-776 [-3;1]
2040	-1551 [0;0]	0 [0;0]	-179 [0;0]	-581 [0;0]	-791 [0;0]

Note: Simulation results for real gross labour income in the lignite industry in million euros. Values for the Null-Scenario are reported as change to the base year 2014 and for the year 2014 actual values are reported. Values for other scenarios are differences to the Null-Scenario in the respective year. Values in brackets denote the minimum and maximum difference from the reported value obtained from 1200 simulations.

Table 9: Sensitivity analysis for inverse Frisch elasticity

σ^L	Baseline	Phase-Out-2035-Weak	Phase-Out-2040-Age	Phase-Out-2040-Balanced	Phase-Out-2035-Strong
			Germany		
0.2375	0.0272	0.1175	0.1303	0.1310	0.1100
0.2437	0.0271	0.1168	0.1295	0.1302	0.1094
0.2500	0.0270	0.1162	0.1286	0.1294	0.1087
0.2562	0.0270	0.1155	0.1277	0.1285	0.1081
0.2625	0.0269	0.1148	0.1268	0.1277	0.1074
			Rest of Germany		
0.2375	0.0173	0.0970	0.1130	0.1146	0.0895
0.2437	0.0172	0.0964	0.1123	0.1139	0.0889
0.2500	0.0172	0.0958	0.1115	0.1131	0.0884
0.2562	0.0171	0.0953	0.1107	0.1124	0.0878
0.2625	0.0171	0.0947	0.1099	0.1116	0.0872
			Central Germany		
0.2375	0.0599	0.1774	0.1845	0.1870	0.1687
0.2437	0.0596	0.1763	0.1833	0.1857	0.1676
0.2500	0.0593	0.1752	0.1820	0.1844	0.1665
0.2562	0.0590	0.1741	0.1808	0.1831	0.1654
0.2625	0.0587	0.1730	0.1795	0.1818	0.1643
			Lusatia		
0.2375	0.4801	1.0709	0.9523	0.9491	1.0676
0.2437	0.4793	1.0697	0.9511	0.9479	1.0665
0.2500	0.4787	1.0685	0.9500	0.9468	1.0654
0.2562	0.4779	1.0673	0.9488	0.9456	1.0642
0.2625	0.4772	1.0660	0.9476	0.9443	1.0631
			Rhineland		
0.2375	0.1036	0.2559	0.2452	0.2467	0.2497
0.2437	0.1032	0.2548	0.2440	0.2455	0.2486
0.2500	0.1028	0.2536	0.2428	0.2443	0.2476
0.2562	0.1025	0.2525	0.2416	0.2431	0.2465
0.2625	0.1021	0.2514	0.2404	0.2420	0.2454

Note: Sensitivity analysis for the maximum increase in the unemployment rate in percentage points between 2014 and 2040 compared to the Null-Scenario for the respective region.

Table 10: Sensitivity analysis for wages depending on inverse Frisch elasticity

σ^L	Baseline	Phase-Out-2035-Weak	Phase-Out-2040-Age	Phase-Out-2040-Balanced	Phase-Out-2035-Strong
Germany					
0.2375	-0.119	-0.387	-0.332	-0.332	-0.390
0.2437	-0.122	-0.390	-0.332	-0.335	-0.393
0.2500	-0.122	-0.393	-0.338	-0.335	-0.396
0.2562	-0.122	-0.393	-0.338	-0.338	-0.396
0.2625	-0.125	-0.396	-0.341	-0.341	-0.399
Rest of Germany					
0.2375	-0.003	-0.067	-0.035	-0.035	-0.070
0.2437	-0.006	-0.067	-0.035	-0.038	-0.070
0.2500	-0.006	-0.070	-0.038	-0.038	-0.073
0.2562	-0.006	-0.070	-0.038	-0.038	-0.073
0.2625	-0.006	-0.070	-0.041	-0.041	-0.073
Central Germany					
0.2375	-0.573	-2.112	-1.974	-2.043	-2.115
0.2437	-0.577	-2.126	-1.985	-2.057	-2.130
0.2500	-0.581	-2.137	-1.999	-2.068	-2.141
0.2562	-0.584	-2.148	-2.010	-2.079	-2.152
0.2625	-0.591	-2.159	-2.021	-2.090	-2.163
Lusatia					
0.2375	-4.985	-10.621	-10.356	-10.257	-10.625
0.2437	-4.981	-10.628	-10.363	-10.265	-10.632
0.2500	-4.977	-10.640	-10.375	-10.272	-10.644
0.2562	-4.973	-10.647	-10.382	-10.280	-10.651
0.2625	-4.970	-10.655	-10.390	-10.287	-10.659
Rhineland					
0.2375	-0.724	-2.230	-1.948	-1.930	-2.230
0.2437	-0.727	-2.238	-1.959	-1.943	-2.241
0.2500	-0.732	-2.248	-1.969	-1.953	-2.251
0.2562	-0.735	-2.256	-1.979	-1.964	-2.259
0.2625	-0.737	-2.266	-1.990	-1.971	-2.266

Note: Sensitivity analysis for the maximum drop in wages in percentage points between 2014 and 2040 compared to the Null-Scenario for the respective region.

Table 11: Sensitivity analysis for AR(1) for unemployment benefits

ρ^b	Baseline	Phase-Out-2035-Weak	Phase-Out-2040-Age	Phase-Out-2040-Balanced	Phase-Out-2035-Strong
			Germany		
0.8075	0.0191	0.0950	0.1072	0.1082	0.0868
0.8287	0.0228	0.1049	0.1166	0.1175	0.0970
0.8500	0.0270	0.1162	0.1286	0.1294	0.1087
0.8712	0.0320	0.1292	0.1426	0.1431	0.1223
0.8925	0.0382	0.1444	0.1593	0.1596	0.1383
			Rest of Germany		
0.8075	0.0119	0.0746	0.0946	0.0958	0.0684
0.8287	0.0141	0.0846	0.1023	0.1034	0.0767
0.8500	0.0172	0.0958	0.1115	0.1131	0.0884
0.8712	0.0212	0.1089	0.1256	0.1270	0.1020
0.8925	0.0260	0.1241	0.1422	0.1434	0.1179
			Central Germany		
0.8075	0.0513	0.1535	0.1591	0.1617	0.1440
0.8287	0.0549	0.1636	0.1697	0.1722	0.1545
0.8500	0.0593	0.1752	0.1820	0.1844	0.1665
0.8712	0.0645	0.1887	0.1966	0.1987	0.1806
0.8925	0.0707	0.2043	0.2137	0.2157	0.1970
			Lusatia		
0.8075	0.4699	1.0394	0.9209	0.9177	1.0360
0.8287	0.4738	1.0528	0.9343	0.9311	1.0495
0.8500	0.4787	1.0685	0.9500	0.9468	1.0654
0.8712	0.4845	1.0868	0.9686	0.9654	1.0840
0.8925	0.4916	1.1084	0.9909	0.9876	1.1061
			Rhineland		
0.8075	0.0955	0.2265	0.2209	0.2172	0.2201
0.8287	0.0989	0.2391	0.2283	0.2297	0.2328
0.8500	0.1028	0.2536	0.2428	0.2443	0.2476
0.8712	0.1076	0.2707	0.2601	0.2616	0.2650
0.8925	0.1134	0.2910	0.2810	0.2824	0.2857

Note: Sensitivity analysis for the maximum increase in the unemployment rate in percentage points between 2014 and 2040 compared to the Null-Scenario for the respective region.

Table 12: Sensitivity analysis for elasticity of substitution between lignite and non-lignite

η^b	Baseline	Phase-Out-2035-Weak	Phase-Out-2040-Age	Phase-Out-2040-Balanced	Phase-Out-2035-Strong
			Germany		
19.5700	0.0270	0.1163	0.1285	0.1293	0.1088
20.0850	0.0270	0.1163	0.1285	0.1293	0.1088
20.6000	0.0270	0.1162	0.1286	0.1294	0.1087
21.1150	0.0270	0.1162	0.1286	0.1294	0.1087
21.6300	0.0270	0.1161	0.1286	0.1294	0.1087
			Rest of Germany		
19.5700	0.0172	0.0959	0.1115	0.1131	0.0884
20.0850	0.0172	0.0959	0.1115	0.1131	0.0884
20.6000	0.0172	0.0958	0.1115	0.1131	0.0884
21.1150	0.0172	0.0958	0.1115	0.1131	0.0884
21.6300	0.0172	0.0958	0.1115	0.1132	0.0883
			Central Germany		
19.5700	0.0594	0.1753	0.1822	0.1846	0.1668
20.0850	0.0593	0.1752	0.1821	0.1845	0.1667
20.6000	0.0593	0.1752	0.1820	0.1844	0.1665
21.1150	0.0592	0.1751	0.1820	0.1843	0.1664
21.6300	0.0592	0.1751	0.1820	0.1842	0.1664
			Lusatia		
19.5700	0.4792	1.0703	0.9522	0.9489	1.0679
20.0850	0.4789	1.0690	0.9511	0.9478	1.0666
20.6000	0.4787	1.0685	0.9500	0.9468	1.0654
21.1150	0.4784	1.0673	0.9490	0.9458	1.0642
21.6300	0.4782	1.0663	0.9481	0.9449	1.0630
			Rhineland		
19.5700	0.1031	0.2548	0.2437	0.2451	0.2486
20.0850	0.1030	0.2542	0.2432	0.2447	0.2481
20.6000	0.1028	0.2536	0.2428	0.2443	0.2476
21.1150	0.1027	0.2532	0.2424	0.2439	0.2471
21.6300	0.1026	0.2527	0.2420	0.2436	0.2466

Note: Sensitivity analysis for the maximum increase in the unemployment rate in percentage points between 2014 and 2040 compared to the Null-Scenario for the respective region.

Table 13: Sensitivity analysis for regional elasticity of substitution energy

η_E^m	Baseline	Phase-Out-2035-Weak	Phase-Out-2040-Age	Phase-Out-2040-Balanced	Phase-Out-2035-Strong
			Germany		
760.0000	0.0270	0.1162	0.1286	0.1294	0.1087
780.0000	0.0270	0.1162	0.1286	0.1294	0.1087
800.0000	0.0270	0.1162	0.1286	0.1294	0.1087
820.0000	0.0270	0.1162	0.1286	0.1294	0.1087
840.0000	0.0270	0.1162	0.1286	0.1294	0.1087
			Rest of Germany		
760.0000	0.0172	0.0959	0.1115	0.1131	0.0884
780.0000	0.0172	0.0958	0.1115	0.1131	0.0884
800.0000	0.0172	0.0958	0.1115	0.1131	0.0884
820.0000	0.0172	0.0958	0.1115	0.1131	0.0884
840.0000	0.0172	0.0958	0.1115	0.1131	0.0884
			Central Germany		
760.0000	0.0593	0.1752	0.1820	0.1844	0.1665
780.0000	0.0593	0.1752	0.1820	0.1844	0.1665
800.0000	0.0593	0.1752	0.1820	0.1844	0.1665
820.0000	0.0593	0.1752	0.1820	0.1844	0.1665
840.0000	0.0593	0.1752	0.1820	0.1844	0.1665
			Lusatia		
760.0000	0.4786	1.0684	0.9500	0.9468	1.0653
780.0000	0.4787	1.0685	0.9500	0.9468	1.0653
800.0000	0.4787	1.0685	0.9500	0.9468	1.0654
820.0000	0.4787	1.0685	0.9500	0.9468	1.0654
840.0000	0.4787	1.0685	0.9501	0.9469	1.0654
			Rhineland		
760.0000	0.1028	0.2536	0.2428	0.2443	0.2475
780.0000	0.1028	0.2536	0.2428	0.2443	0.2476
800.0000	0.1028	0.2536	0.2428	0.2443	0.2476
820.0000	0.1029	0.2536	0.2428	0.2443	0.2476
840.0000	0.1029	0.2537	0.2428	0.2443	0.2476

Note: Sensitivity analysis for the maximum increase in the unemployment rate in percentage points between 2014 and 2040 compared to the Null-Scenario for the respective region.

Table 14: Sensitivity analysis for regional elasticity of substitution non-energy

η^m_{NE}	Baseline	Phase-Out-2035-Weak	Phase-Out-2040-Age	Phase-Out-2040-Balanced	Phase-Out-2035-Strong
			Germany		
1.0735	0.0257	0.1141	0.1264	0.1272	0.1066
1.1017	0.0264	0.1152	0.1276	0.1283	0.1077
1.1300	0.0270	0.1162	0.1286	0.1294	0.1087
1.1582	0.0277	0.1172	0.1296	0.1304	0.1097
1.1865	0.0282	0.1181	0.1305	0.1313	0.1106
			Rest of Germany		
1.0735	0.0160	0.0937	0.1093	0.1110	0.0863
1.1017	0.0166	0.0948	0.1104	0.1121	0.0874
1.1300	0.0172	0.0958	0.1115	0.1131	0.0884
1.1582	0.0177	0.0968	0.1124	0.1141	0.0893
1.1865	0.0182	0.0977	0.1134	0.1150	0.0902
			Central Germany		
1.0735	0.0582	0.1736	0.1802	0.1824	0.1650
1.1017	0.0588	0.1744	0.1811	0.1834	0.1658
1.1300	0.0593	0.1752	0.1820	0.1844	0.1665
1.1582	0.0598	0.1761	0.1829	0.1853	0.1673
1.1865	0.0602	0.1768	0.1837	0.1862	0.1680
			Lusatia		
1.0735	0.4760	1.0621	0.9441	0.9408	1.0590
1.1017	0.4773	1.0654	0.9471	0.9438	1.0622
1.1300	0.4787	1.0685	0.9500	0.9468	1.0654
1.1582	0.4799	1.0714	0.9527	0.9496	1.0683
1.1865	0.4810	1.0743	0.9553	0.9522	1.0711
			Rhineland		
1.0735	0.1017	0.2514	0.2406	0.2421	0.2453
1.1017	0.1023	0.2526	0.2417	0.2433	0.2465
1.1300	0.1028	0.2536	0.2428	0.2443	0.2476
1.1582	0.1034	0.2546	0.2438	0.2453	0.2486
1.1865	0.1038	0.2556	0.2447	0.2462	0.2496

Note: Sensitivity analysis for the maximum increase in the unemployment rate in percentage points between 2014 and 2040 compared to the Null-Scenario for the respective region.

Table 15: Sensitivity analysis for elasticity of substitution between energy and non-energy products

η^c	Baseline	Phase-Out-2035-Weak	Phase-Out-2040-Age	Phase-Out-2040-Balanced	Phase-Out-2035-Strong
			Germany		
0.7125	0.0280	0.1178	0.1299	0.1306	0.1106
0.7312	0.0275	0.1171	0.1292	0.1299	0.1097
0.7500	0.0270	0.1162	0.1286	0.1294	0.1087
0.7687	0.0265	0.1155	0.1279	0.1287	0.1079
0.7875	0.0262	0.1146	0.1274	0.1282	0.1070
			Rest of Germany		
0.7125	0.0177	0.0976	0.1129	0.1145	0.0903
0.7312	0.0175	0.0968	0.1122	0.1138	0.0894
0.7500	0.0172	0.0958	0.1115	0.1131	0.0884
0.7687	0.0170	0.0951	0.1108	0.1124	0.0875
0.7875	0.0166	0.0942	0.1103	0.1119	0.0865
			Central Germany		
0.7125	0.0599	0.1765	0.1830	0.1853	0.1680
0.7312	0.0596	0.1758	0.1825	0.1849	0.1673
0.7500	0.0593	0.1752	0.1820	0.1844	0.1665
0.7687	0.0589	0.1747	0.1816	0.1839	0.1659
0.7875	0.0587	0.1741	0.1812	0.1836	0.1652
			Lusatia		
0.7125	0.4791	1.0696	0.9509	0.9477	1.0667
0.7312	0.4788	1.0691	0.9504	0.9472	1.0661
0.7500	0.4787	1.0685	0.9500	0.9468	1.0654
0.7687	0.4784	1.0679	0.9495	0.9463	1.0647
0.7875	0.4781	1.0674	0.9490	0.9459	1.0641
			Rhineland		
0.7125	0.1034	0.2550	0.2438	0.2453	0.2491
0.7312	0.1031	0.2543	0.2434	0.2449	0.2483
0.7500	0.1028	0.2536	0.2428	0.2443	0.2476
0.7687	0.1027	0.2531	0.2422	0.2438	0.2469
0.7875	0.1024	0.2524	0.2418	0.2433	0.2462

Note: Sensitivity analysis for the maximum increase in the unemployment rate in percentage points between 2014 and 2040 compared to the Null-Scenario for the respective region.

Table 16: Sensitivity analysis for home bias energy

I_E^{Home}	Baseline	Phase-Out-2035-Weak	Phase-Out-2040-Age	Phase-Out-2040-Balanced	Phase-Out-2035-Strong
			Germany		
0.4750	0.0270	0.1162	0.1286	0.1294	0.1087
0.4875	0.0270	0.1162	0.1286	0.1294	0.1087
0.5000	0.0270	0.1162	0.1286	0.1294	0.1087
0.5125	0.0270	0.1162	0.1286	0.1294	0.1087
0.5250	0.0270	0.1162	0.1286	0.1294	0.1087
			Rest of Germany		
0.4750	0.0172	0.0958	0.1115	0.1131	0.0884
0.4875	0.0172	0.0958	0.1115	0.1131	0.0884
0.5000	0.0172	0.0958	0.1115	0.1131	0.0884
0.5125	0.0172	0.0958	0.1115	0.1131	0.0884
0.5250	0.0172	0.0958	0.1115	0.1131	0.0884
			Central Germany		
0.4750	0.0593	0.1752	0.1820	0.1844	0.1665
0.4875	0.0593	0.1752	0.1820	0.1844	0.1665
0.5000	0.0593	0.1752	0.1820	0.1844	0.1665
0.5125	0.0593	0.1752	0.1820	0.1844	0.1665
0.5250	0.0593	0.1752	0.1820	0.1844	0.1665
			Lusatia		
0.4750	0.4787	1.0685	0.9500	0.9468	1.0654
0.4875	0.4787	1.0685	0.9500	0.9468	1.0654
0.5000	0.4787	1.0685	0.9500	0.9468	1.0654
0.5125	0.4787	1.0685	0.9500	0.9468	1.0654
0.5250	0.4787	1.0685	0.9500	0.9468	1.0654
			Rhineland		
0.4750	0.1028	0.2536	0.2428	0.2443	0.2476
0.4875	0.1028	0.2536	0.2428	0.2443	0.2476
0.5000	0.1028	0.2536	0.2428	0.2443	0.2476
0.5125	0.1028	0.2536	0.2428	0.2443	0.2476
0.5250	0.1028	0.2536	0.2428	0.2443	0.2476

Note: Sensitivity analysis for the maximum increase in the unemployment rate in percentage points between 2014 and 2040 compared to the Null-Scenario for the respective region.

Table 17: Sensitivity analysis for home bias non-energy

I_{NE}^{Home}	Baseline	Phase-Out-2035-Weak	Phase-Out-2040-Age	Phase-Out-2040-Balanced	Phase-Out-2035-Strong
Germany					
0.8075	0.0328	0.1247	0.1372	0.1380	0.1170
0.8287	0.0304	0.1212	0.1337	0.1344	0.1136
0.8500	0.0270	0.1162	0.1286	0.1294	0.1087
0.8712	0.0220	0.1088	0.1211	0.1218	0.1014
0.8925	0.0143	0.0973	0.1093	0.1100	0.0901
Rest of Germany					
0.8075	0.0228	0.1053	0.1210	0.1226	0.0977
0.8287	0.0204	0.1013	0.1170	0.1186	0.0938
0.8500	0.0172	0.0958	0.1115	0.1131	0.0884
0.8712	0.0126	0.0879	0.1035	0.1052	0.0806
0.8925	0.0064	0.0761	0.0915	0.0932	0.0689
Central Germany					
0.8075	0.0619	0.1780	0.1852	0.1890	0.1690
0.8287	0.0610	0.1771	0.1843	0.1874	0.1683
0.8500	0.0593	0.1752	0.1820	0.1844	0.1665
0.8712	0.0562	0.1714	0.1777	0.1793	0.1630
0.8925	0.0507	0.1637	0.1695	0.1703	0.1556
Lusatia					
0.8075	0.4718	1.0670	0.9497	0.9465	1.0641
0.8287	0.4762	1.0696	0.9515	0.9484	1.0666
0.8500	0.4787	1.0685	0.9500	0.9468	1.0654
0.8712	0.4774	1.0607	0.9426	0.9393	1.0576
0.8925	0.4701	1.0426	0.9258	0.9224	1.0394
Rhineland					
0.8075	0.1036	0.2587	0.2481	0.2495	0.2530
0.8287	0.1036	0.2569	0.2460	0.2475	0.2510
0.8500	0.1028	0.2536	0.2428	0.2443	0.2476
0.8712	0.1007	0.2482	0.2373	0.2389	0.2419
0.8925	0.0963	0.2392	0.2287	0.2297	0.2326

Note: Sensitivity analysis for the maximum increase in the unemployment rate in percentage points between 2014 and 2040 compared to the Null-Scenario for the respective region.

Table 18: Sensitivity analysis for market power

$\bar{\lambda}$	Baseline	Phase-Out-2035-Weak	Phase-Out-2040-Age	Phase-Out-2040-Balanced	Phase-Out-2035-Strong
			Germany		
1.1875	0.0265	0.1095	0.1202	0.1207	0.1029
1.2188	0.0268	0.1128	0.1243	0.1249	0.1058
1.2500	0.0270	0.1162	0.1286	0.1294	0.1087
1.2813	0.0272	0.1199	0.1333	0.1342	0.1119
1.3125	0.0273	0.1240	0.1385	0.1395	0.1153
			Rest of Germany		
1.1875	0.0164	0.0895	0.1034	0.1048	0.0829
1.2188	0.0167	0.0925	0.1073	0.1088	0.0855
1.2500	0.0172	0.0958	0.1115	0.1131	0.0884
1.2813	0.0176	0.0994	0.1163	0.1178	0.0914
1.3125	0.0181	0.1034	0.1222	0.1233	0.0948
			Central Germany		
1.1875	0.0578	0.1670	0.1723	0.1741	0.1595
1.2188	0.0586	0.1710	0.1770	0.1791	0.1629
1.2500	0.0593	0.1752	0.1820	0.1844	0.1665
1.2813	0.0598	0.1798	0.1874	0.1900	0.1705
1.3125	0.0602	0.1846	0.1932	0.1960	0.1746
			Lusatia		
1.1875	0.4788	1.0663	0.9456	0.9441	1.0633
1.2188	0.4796	1.0671	0.9477	0.9455	1.0643
1.2500	0.4787	1.0685	0.9500	0.9468	1.0654
1.2813	0.4790	1.0700	0.9525	0.9488	1.0669
1.3125	0.4799	1.0708	0.9548	0.9502	1.0677
			Rhineland		
1.1875	0.1007	0.2498	0.2375	0.2387	0.2444
1.2188	0.1018	0.2517	0.2401	0.2414	0.2459
1.2500	0.1028	0.2536	0.2428	0.2443	0.2476
1.2813	0.1035	0.2558	0.2457	0.2474	0.2493
1.3125	0.1040	0.2582	0.2498	0.2508	0.2512

Note: Sensitivity analysis for the maximum increase in the unemployment rate in percentage points between 2014 and 2040 compared to the Null-Scenario for the respective region.

Table 19: Sensitivity analysis for AR(1) for market power

ρ^{λ}	Baseline	Phase-Out-2035-Weak	Phase-Out-2040-Age	Phase-Out-2040-Balanced	Phase-Out-2035-Strong
			Germany		
0.8550	0.0277	0.1209	0.1329	0.1336	0.1135
0.8775	0.0274	0.1191	0.1311	0.1319	0.1116
0.9000	0.0270	0.1162	0.1286	0.1294	0.1087
0.9225	0.0263	0.1117	0.1244	0.1252	0.1043
0.9450	0.0252	0.1036	0.1168	0.1175	0.0962
			Rest of Germany		
0.8550	0.0182	0.1010	0.1162	0.1178	0.0935
0.8775	0.0178	0.0990	0.1143	0.1160	0.0915
0.9000	0.0172	0.0958	0.1115	0.1131	0.0884
0.9225	0.0163	0.0910	0.1070	0.1086	0.0835
0.9450	0.0145	0.0821	0.0986	0.1002	0.0747
			Central Germany		
0.8550	0.0594	0.1795	0.1859	0.1883	0.1708
0.8775	0.0593	0.1778	0.1843	0.1867	0.1691
0.9000	0.0593	0.1752	0.1820	0.1844	0.1665
0.9225	0.0592	0.1712	0.1783	0.1807	0.1625
0.9450	0.0589	0.1639	0.1713	0.1737	0.1553
			Lusatia		
0.8550	0.4721	1.0578	0.9407	0.9374	1.0547
0.8775	0.4747	1.0621	0.9444	0.9412	1.0590
0.9000	0.4787	1.0685	0.9500	0.9468	1.0654
0.9225	0.4850	1.0788	0.9591	0.9559	1.0757
0.9450	0.4972	1.0981	0.9764	0.9732	1.0949
			Rhineland		
0.8550	0.1021	0.2556	0.2444	0.2460	0.2495
0.8775	0.1024	0.2549	0.2438	0.2454	0.2488
0.9000	0.1028	0.2536	0.2428	0.2443	0.2476
0.9225	0.1036	0.2518	0.2412	0.2427	0.2457
0.9450	0.1051	0.2483	0.2380	0.2395	0.2423

Note: Sensitivity analysis for the maximum increase in the unemployment rate in percentage points between 2014 and 2040 compared to the Null-Scenario for the respective region.

Table 20: Sensitivity analysis for AR(1) attractiveness

ρ_ϵ^{pop}	Baseline	Phase-Out-2035-Weak	Phase-Out-2040-Age	Phase-Out-2040-Balanced	Phase-Out-2035-Strong
Germany					
0.9921	0.0277	0.1207	0.1338	0.1346	0.1132
0.9923	0.0273	0.1184	0.1311	0.1319	0.1110
0.9925	0.0270	0.1162	0.1286	0.1294	0.1087
0.9927	0.0267	0.1141	0.1261	0.1268	0.1067
0.9929	0.0265	0.1120	0.1237	0.1245	0.1046
Rest of Germany					
0.9921	0.0180	0.1010	0.1175	0.1191	0.0935
0.9923	0.0176	0.0984	0.1145	0.1161	0.0909
0.9925	0.0172	0.0958	0.1115	0.1131	0.0884
0.9927	0.0168	0.0935	0.1086	0.1102	0.0860
0.9929	0.0164	0.0911	0.1062	0.1075	0.0836
Central Germany					
0.9921	0.0588	0.1789	0.1863	0.1887	0.1702
0.9923	0.0590	0.1771	0.1841	0.1865	0.1684
0.9925	0.0593	0.1752	0.1820	0.1844	0.1665
0.9927	0.0595	0.1735	0.1800	0.1823	0.1648
0.9929	0.0597	0.1718	0.1780	0.1804	0.1631
Lusatia					
0.9921	0.4627	1.0459	0.9253	0.9221	1.0427
0.9923	0.4709	1.0574	0.9379	0.9347	1.0543
0.9925	0.4787	1.0685	0.9500	0.9468	1.0654
0.9927	0.4862	1.0792	0.9617	0.9585	1.0761
0.9929	0.4936	1.0896	0.9731	0.9699	1.0864
Rhineland					
0.9921	0.1007	0.2545	0.2437	0.2452	0.2484
0.9923	0.1019	0.2541	0.2432	0.2447	0.2480
0.9925	0.1028	0.2536	0.2428	0.2443	0.2476
0.9927	0.1039	0.2533	0.2424	0.2439	0.2472
0.9929	0.1048	0.2529	0.2419	0.2435	0.2468

Note: Sensitivity analysis for the maximum increase in the unemployment rate in percentage points between 2014 and 2040 compared to the Null-Scenario for the respective region.

Table 21: Sensitivity analysis for elasticity of marginal hiring costs to labour market tightness

v	Baseline	Phase-Out-2035-Weak	Phase-Out-2040-Age	Phase-Out-2040-Balanced	Phase-Out-2035-Strong
Germany					
0.9500	0.0270	0.1161	0.1285	0.1293	0.1087
0.9750	0.0270	0.1162	0.1286	0.1293	0.1087
1.0000	0.0270	0.1162	0.1286	0.1294	0.1087
1.0250	0.0271	0.1162	0.1287	0.1294	0.1088
1.0500	0.0271	0.1163	0.1287	0.1295	0.1088
Rest of Germany					
0.9500	0.0172	0.0958	0.1114	0.1130	0.0883
0.9750	0.0172	0.0958	0.1114	0.1131	0.0883
1.0000	0.0172	0.0958	0.1115	0.1131	0.0884
1.0250	0.0172	0.0959	0.1115	0.1132	0.0884
1.0500	0.0172	0.0959	0.1116	0.1132	0.0884
Central Germany					
0.9500	0.0593	0.1751	0.1820	0.1843	0.1665
0.9750	0.0593	0.1752	0.1820	0.1844	0.1665
1.0000	0.0593	0.1752	0.1820	0.1844	0.1665
1.0250	0.0593	0.1753	0.1821	0.1844	0.1666
1.0500	0.0593	0.1753	0.1821	0.1845	0.1666
Lusatia					
0.9500	0.4786	1.0684	0.9499	0.9467	1.0653
0.9750	0.4786	1.0684	0.9500	0.9468	1.0653
1.0000	0.4787	1.0685	0.9500	0.9468	1.0654
1.0250	0.4787	1.0685	0.9501	0.9469	1.0654
1.0500	0.4787	1.0686	0.9501	0.9469	1.0655
Rhineland					
0.9500	0.1028	0.2535	0.2427	0.2442	0.2475
0.9750	0.1028	0.2536	0.2427	0.2443	0.2475
1.0000	0.1028	0.2536	0.2428	0.2443	0.2476
1.0250	0.1029	0.2537	0.2428	0.2444	0.2476
1.0500	0.1029	0.2538	0.2429	0.2444	0.2477

Note: Sensitivity analysis for the maximum increase in the unemployment rate in percentage points between 2014 and 2040 compared to the Null-Scenario for the respective region.

Table 22: Sensitivity analysis for job finding rate

$\frac{h}{u}$	Baseline	Phase-Out-2035-Weak	Phase-Out-2040-Age	Phase-Out-2040-Balanced	Phase-Out-2035-Strong
			Germany		
0.2131	0.0263	0.1131	0.1258	0.1266	0.1061
0.2187	0.0266	0.1147	0.1272	0.1279	0.1075
0.2243	0.0270	0.1162	0.1286	0.1294	0.1087
0.2299	0.0273	0.1177	0.1300	0.1306	0.1100
0.2355	0.0277	0.1192	0.1312	0.1318	0.1112
			Rest of Germany		
0.2131	0.0167	0.0929	0.1087	0.1104	0.0858
0.2187	0.0169	0.0944	0.1102	0.1118	0.0871
0.2243	0.0172	0.0958	0.1115	0.1131	0.0884
0.2299	0.0174	0.0973	0.1128	0.1144	0.0896
0.2355	0.0176	0.0987	0.1140	0.1156	0.0908
			Central Germany		
0.2131	0.0583	0.1708	0.1781	0.1803	0.1629
0.2187	0.0589	0.1731	0.1802	0.1824	0.1648
0.2243	0.0593	0.1752	0.1820	0.1844	0.1665
0.2299	0.0597	0.1772	0.1838	0.1863	0.1682
0.2355	0.0601	0.1793	0.1856	0.1881	0.1700
			Lusatia		
0.2131	0.4771	1.0632	0.9466	0.9422	1.0617
0.2187	0.4779	1.0660	0.9484	0.9446	1.0637
0.2243	0.4787	1.0685	0.9500	0.9468	1.0654
0.2299	0.4803	1.0703	0.9511	0.9488	1.0670
0.2355	0.4809	1.0724	0.9523	0.9505	1.0683
			Rhineland		
0.2131	0.1018	0.2512	0.2411	0.2425	0.2458
0.2187	0.1023	0.2524	0.2420	0.2435	0.2467
0.2243	0.1028	0.2536	0.2428	0.2443	0.2476
0.2299	0.1032	0.2549	0.2436	0.2451	0.2483
0.2355	0.1038	0.2560	0.2443	0.2458	0.2491

Note: Sensitivity analysis for the maximum increase in the unemployment rate in percentage points between 2014 and 2040 compared to the Null-Scenario for the respective region.

Table 23: Sensitivity analysis for share of hiring costs to wage bill

$\frac{\kappa}{w\,n}$	Baseline	Phase-Out-2035-Weak	Phase-Out-2040-Age	Phase-Out-2040-Balanced	Phase-Out-2035-Strong
			Germany		
0.0617	0.0273	0.1177	0.1301	0.1307	0.1099
0.0634	0.0272	0.1170	0.1293	0.1300	0.1093
0.0650	0.0270	0.1162	0.1286	0.1294	0.1087
0.0666	0.0269	0.1155	0.1279	0.1287	0.1082
0.0683	0.0267	0.1149	0.1272	0.1280	0.1076
			Rest of Germany		
0.0617	0.0174	0.0973	0.1129	0.1145	0.0895
0.0634	0.0173	0.0966	0.1121	0.1138	0.0889
0.0650	0.0172	0.0958	0.1115	0.1131	0.0884
0.0666	0.0171	0.0952	0.1108	0.1125	0.0878
0.0683	0.0170	0.0946	0.1102	0.1118	0.0873
			Central Germany		
0.0617	0.0595	0.1770	0.1838	0.1863	0.1681
0.0634	0.0594	0.1760	0.1830	0.1854	0.1673
0.0650	0.0593	0.1752	0.1820	0.1844	0.1665
0.0666	0.0591	0.1743	0.1812	0.1835	0.1658
0.0683	0.0590	0.1734	0.1803	0.1825	0.1651
			Lusatia		
0.0617	0.4807	1.0707	0.9516	0.9492	1.0674
0.0634	0.4802	1.0693	0.9510	0.9480	1.0664
0.0650	0.4787	1.0685	0.9500	0.9468	1.0654
0.0666	0.4781	1.0672	0.9490	0.9455	1.0644
0.0683	0.4776	1.0658	0.9480	0.9443	1.0634
			Rhineland		
0.0617	0.1030	0.2551	0.2440	0.2455	0.2486
0.0634	0.1028	0.2544	0.2433	0.2449	0.2481
0.0650	0.1028	0.2536	0.2428	0.2443	0.2476
0.0666	0.1027	0.2530	0.2422	0.2437	0.2471
0.0683	0.1026	0.2524	0.2417	0.2432	0.2466

Note: Sensitivity analysis for the maximum increase in the unemployment rate in percentage points between 2014 and 2040 compared to the Null-Scenario for the respective region.

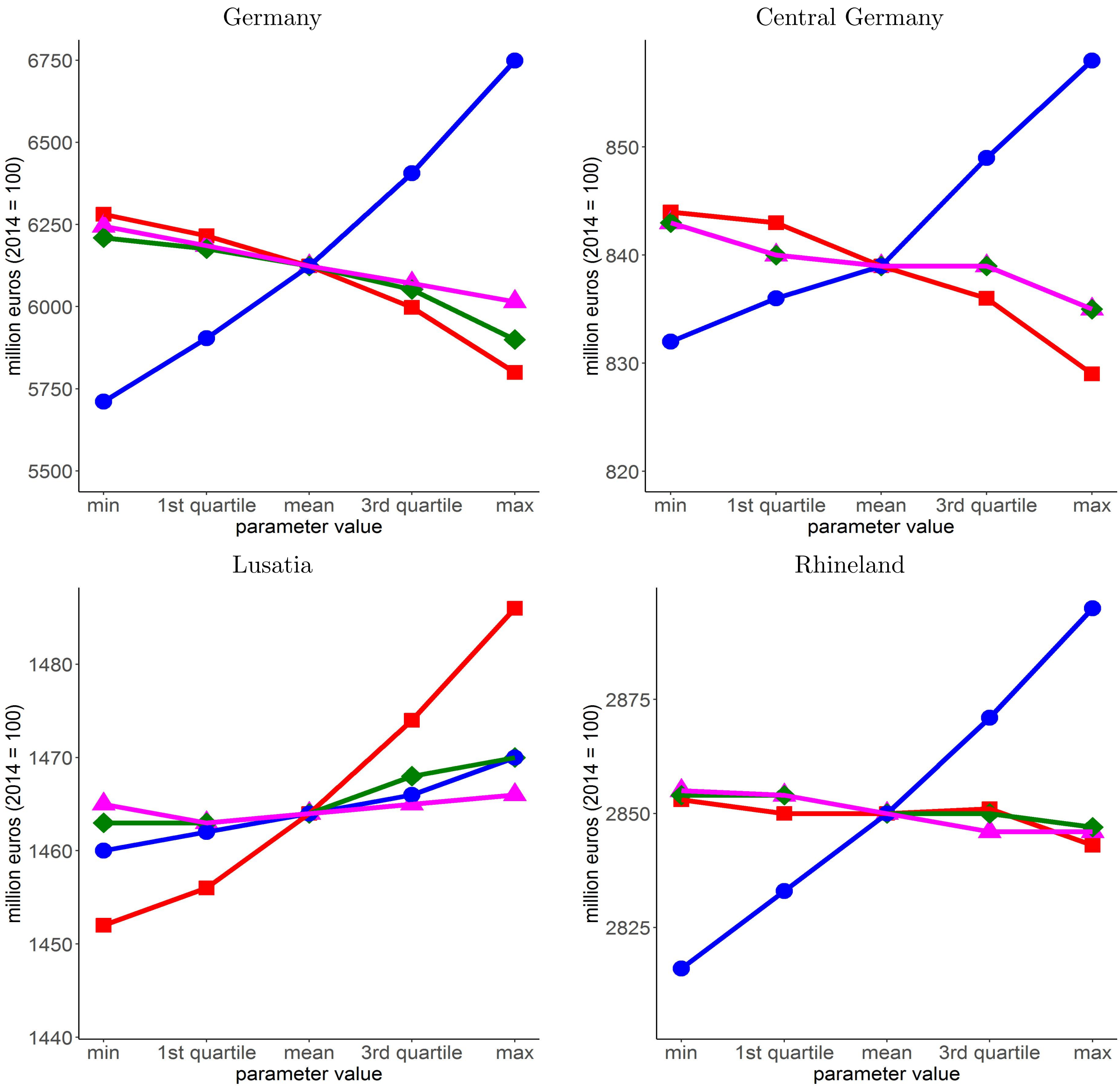
Table 24: Sensitivity analysis for discount factor

β	Baseline	Phase-Out-2035-Weak	Phase-Out-2040-Age	Phase-Out-2040-Balanced	Phase-Out-2035-Strong
			Germany		
0.9984	0.0269	0.1160	0.1283	0.1291	0.1085
0.9982	0.0270	0.1161	0.1285	0.1292	0.1086
0.9980	0.0270	0.1162	0.1286	0.1294	0.1087
0.9977	0.0272	0.1164	0.1288	0.1296	0.1089
0.9975	0.0272	0.1165	0.1289	0.1297	0.1090
			Rest of Germany		
0.9984	0.0171	0.0957	0.1112	0.1129	0.0881
0.9982	0.0171	0.0958	0.1113	0.1130	0.0883
0.9980	0.0172	0.0958	0.1115	0.1131	0.0884
0.9977	0.0172	0.0960	0.1117	0.1133	0.0885
0.9975	0.0173	0.0961	0.1118	0.1135	0.0887
			Central Germany		
0.9984	0.0591	0.1748	0.1817	0.1841	0.1662
0.9982	0.0592	0.1750	0.1819	0.1842	0.1664
0.9980	0.0593	0.1752	0.1820	0.1844	0.1665
0.9977	0.0594	0.1754	0.1823	0.1847	0.1668
0.9975	0.0594	0.1756	0.1824	0.1848	0.1669
			Lusatia		
0.9984	0.4793	1.0673	0.9493	0.9462	1.0648
0.9982	0.4785	1.0675	0.9497	0.9465	1.0650
0.9980	0.4787	1.0685	0.9500	0.9468	1.0654
0.9977	0.4788	1.0690	0.9505	0.9472	1.0659
0.9975	0.4790	1.0693	0.9508	0.9475	1.0662
			Rhineland		
0.9984	0.1026	0.2532	0.2422	0.2437	0.2470
0.9982	0.1028	0.2535	0.2425	0.2440	0.2473
0.9980	0.1028	0.2536	0.2428	0.2443	0.2476
0.9977	0.1029	0.2541	0.2432	0.2448	0.2480
0.9975	0.1030	0.2544	0.2435	0.2451	0.2483

Note: Sensitivity analysis for the maximum increase in the unemployment rate in percentage points between 2014 and 2040 compared to the Null-Scenario for the respective region.

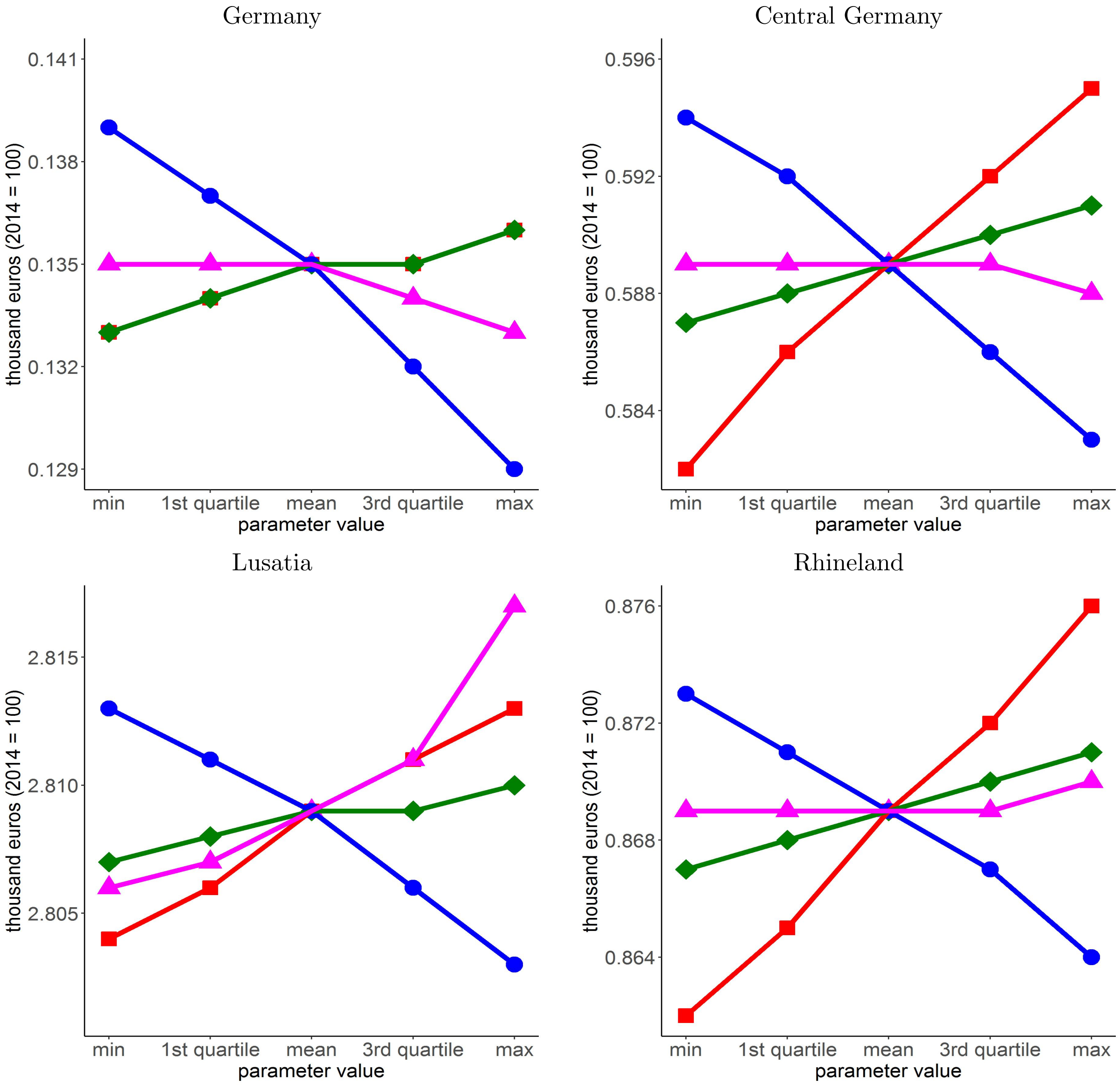
5 Figures

Figure 1: Sensitivity analysis for maximum drop in labour compensation



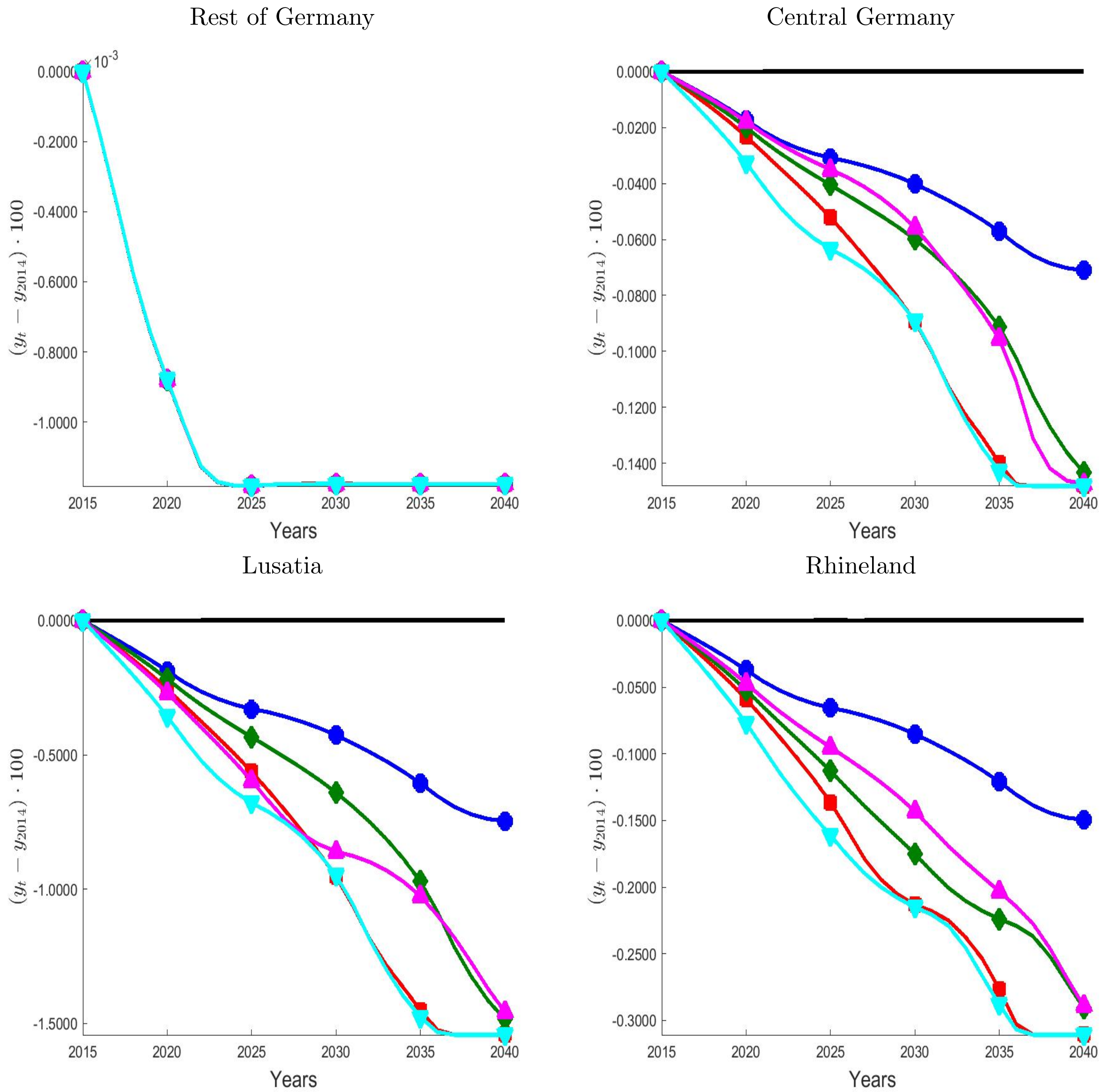
Note: Difference compared to the Null-Scenario in million euro , Baseline (blue circle), Scenario cenario 1 (red square), Phase-Out-2040-Age (green diamond), Phase-Out-2040-Balanced (magenta triangle point-up) and Phase-Out-2035-Strong (cyan triangle point-down). Horizontal lines indicate the maximum and minimum value observed for 1200 simulations.

Figure 2: Sensitivity analysis for maximum drop in wages



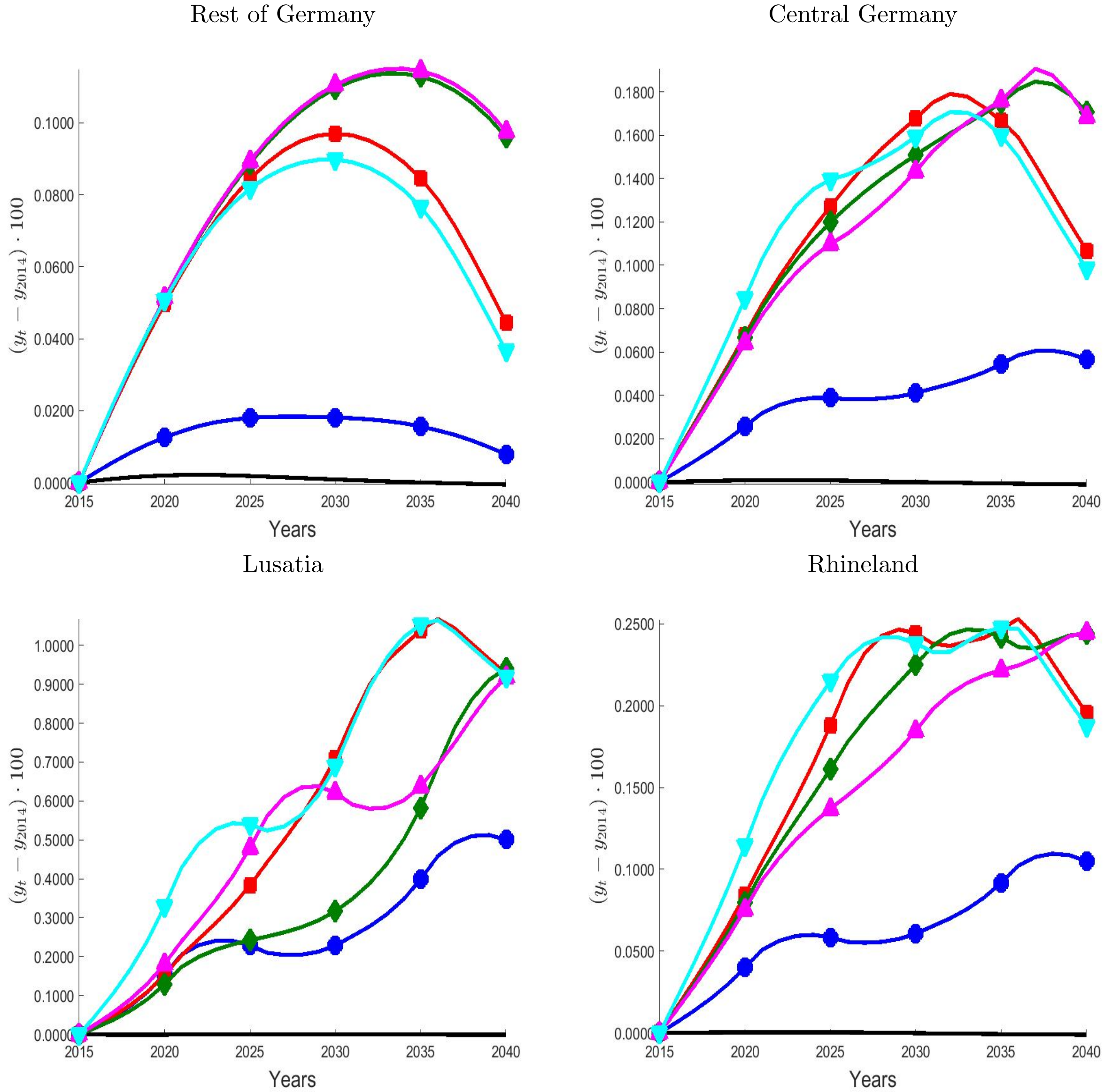
Note: Difference compared to the Null-Scenario in thousand euro, Baseline (blue circle), Phase-Out-2035-Weak (red square), Phase-Out-2040-Age (green diamond), Phase-Out-2040-Balanced (magenta triangle point-up) and Phase-Out-2035-Strong (cyan triangle point-down). Horizontal lines indicate the maximum and minimum value observed for 1200 simulations.

Figure 3: Simulation results for employment rates in lignite sector



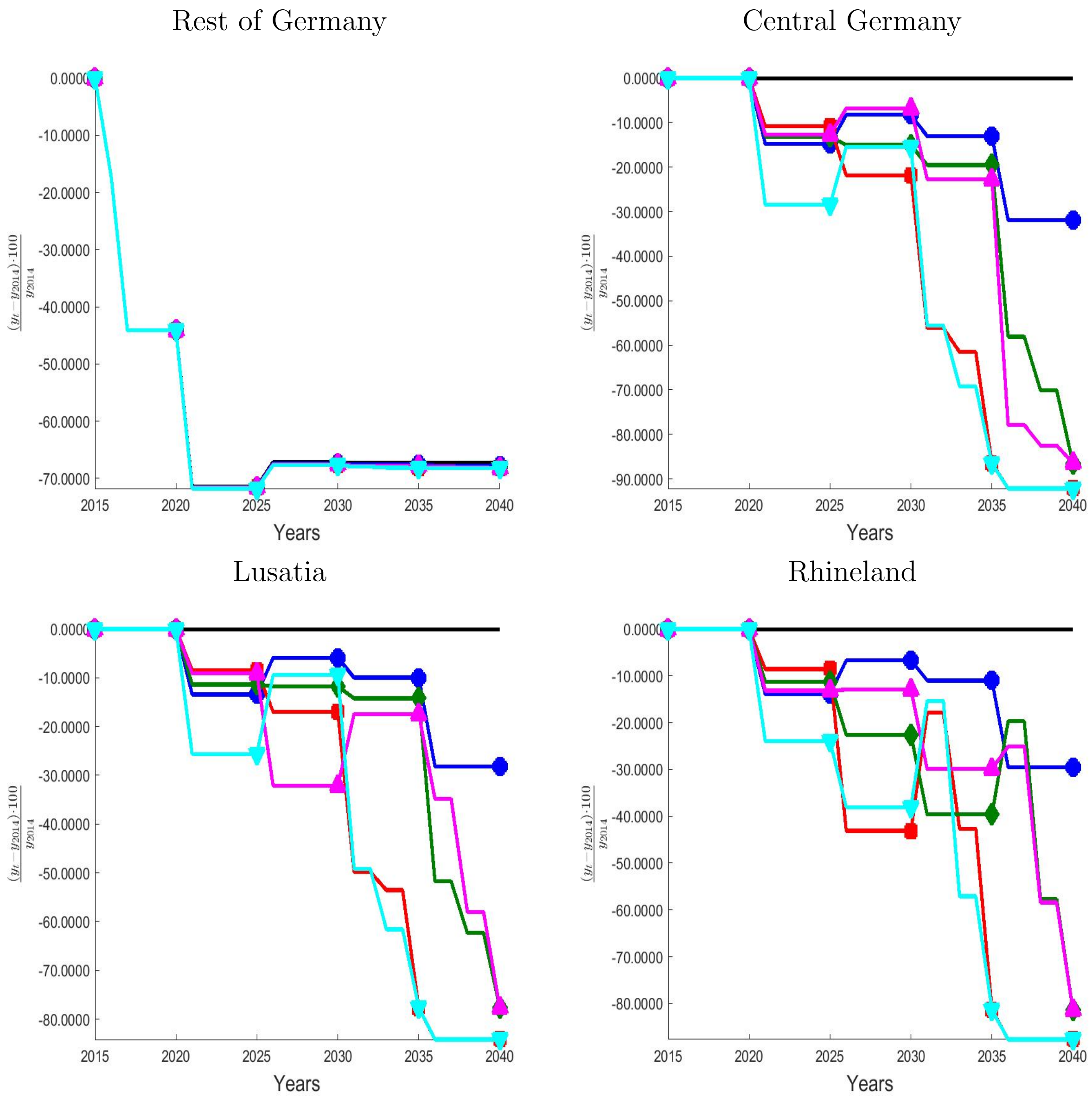
Note: The plots depict the simulation trajectories for the Null-Scenario (black solid line), Baseline (blue line with circle), Phase-Out-2035-Weak (red line with square), Phase-Out-2040-Age (green line with diamond), Phase-Out-2040-Balanced (magenta line with triangle pointing upward) and Phase-Out-2035-Strong (cyan line with triangle pointing downward).

Figure 4: Simulation results for unemployment rates



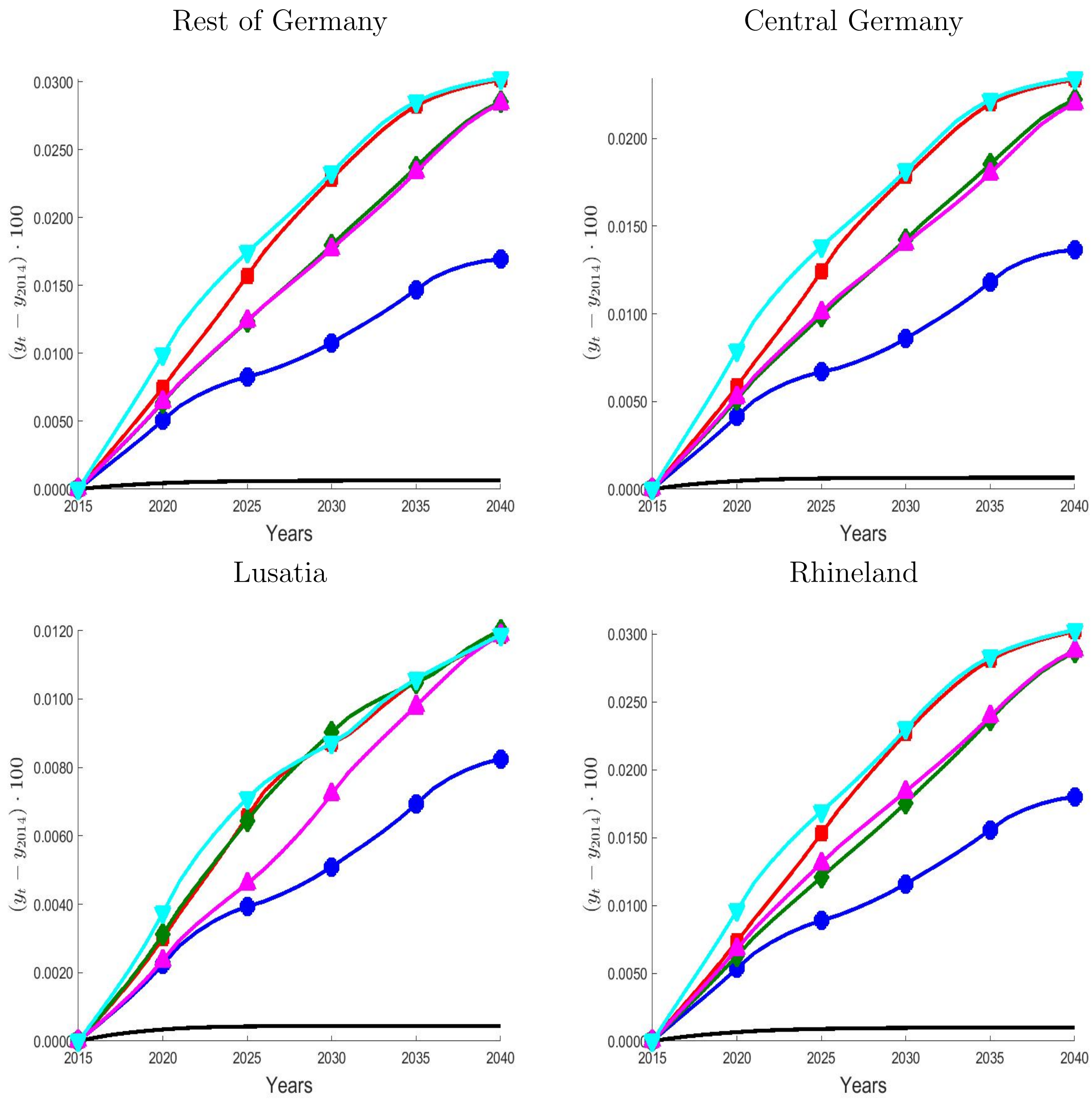
Note: The plots depict the simulation trajectories for the Null-Scenario (black solid line), Baseline (blue line with circle), Phase-Out-2035-Weak (red line with square), Phase-Out-2040-Age (green line with diamond), Phase-Out-2040-Balanced (magenta line with triangle pointing upward) and Phase-Out-2035-Strong (cyan line with triangle pointing downward).

Figure 5: Simulation trajectory for productivity shocks on lignite sectors



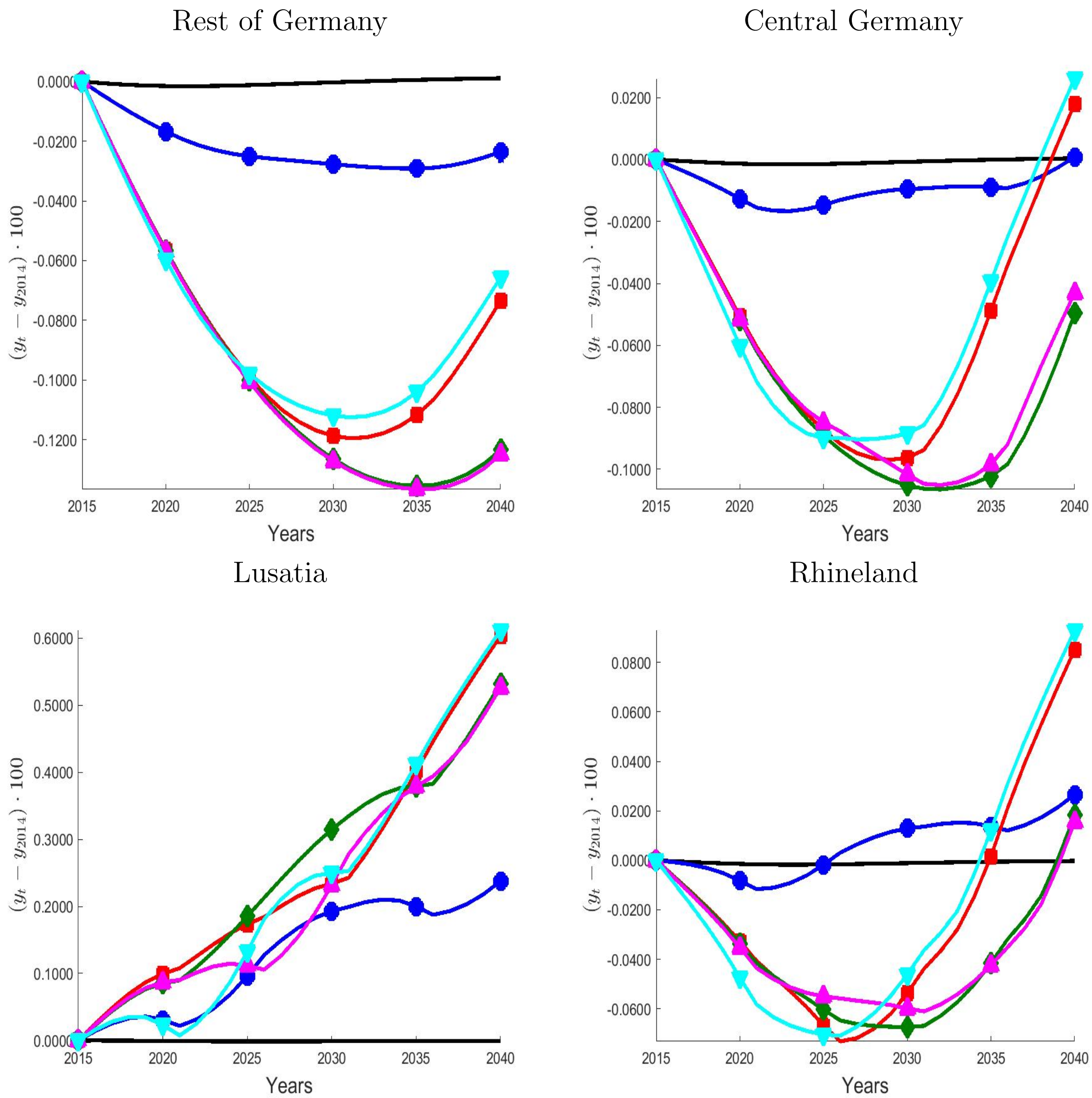
Note: The plots depict the simulation trajectories for the Null-Scenario (black solid line), Baseline (blue line with circle), Phase-Out-2035-Weak (red line with square), Phase-Out-2040-Age (green line with diamond), Phase-Out-2040-Balanced (magenta line with triangle pointing upward) and Phase-Out-2035-Strong (cyan line with triangle pointing downward).

Figure 6: Simulation trajectory for non-lignite employment rates



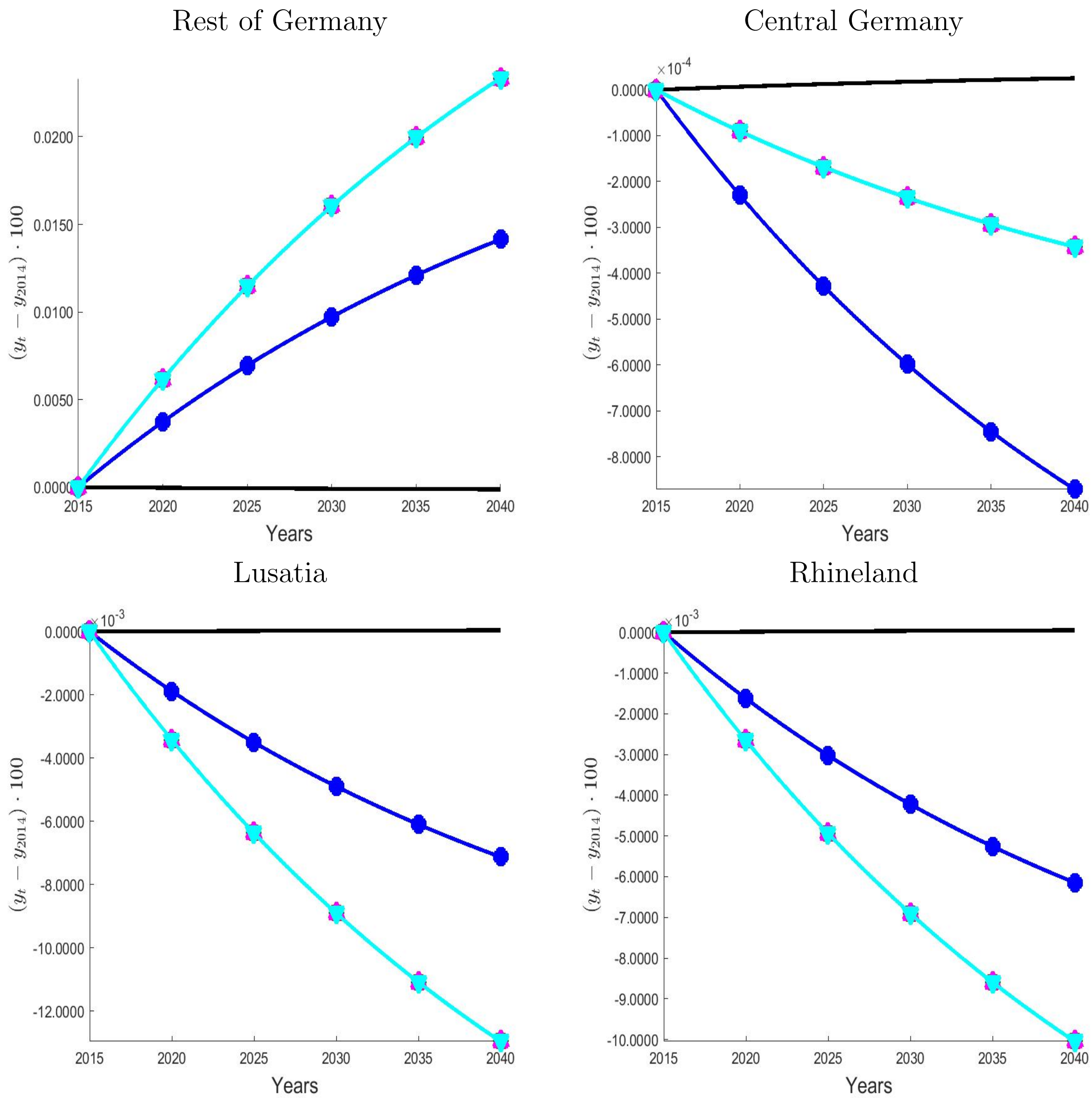
Note: The plots depict the simulation trajectories for the Null-Scenario (black solid line), Baseline (blue line with circle), Phase-Out-2035-Weak (red line with square), Phase-Out-2040-Age (green line with diamond), Phase-Out-2040-Balanced (magenta line with triangle pointing upward) and Phase-Out-2035-Strong (cyan line with triangle pointing downward).

Figure 7: Simulation trajectory for non-energy employment rates



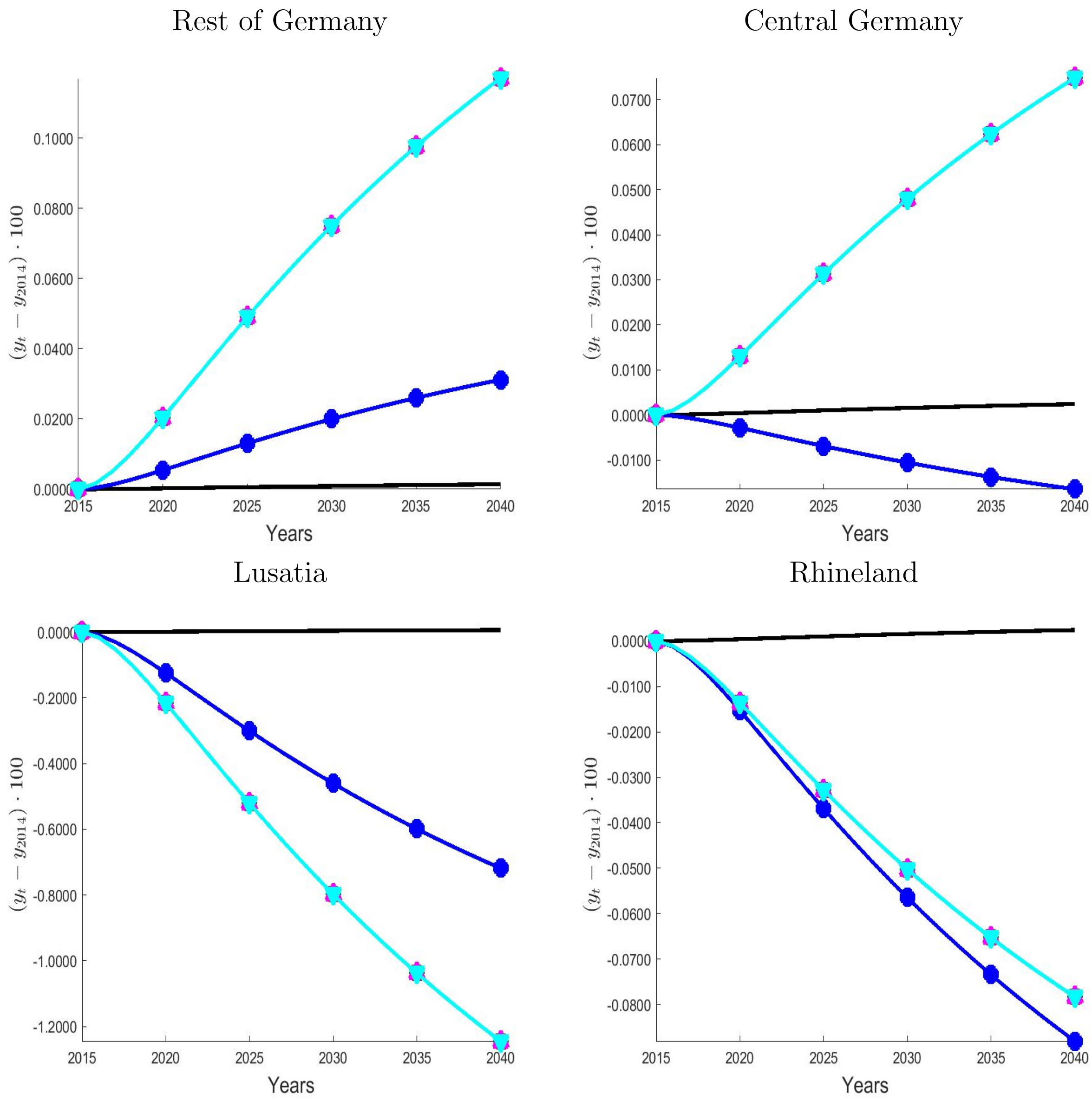
Note: The plots depict the simulation trajectories for the Null-Scenario (black solid line), Baseline (blue line with circle), Phase-Out-2035-Weak (red line with square), Phase-Out-2040-Age (green line with diamond), Phase-Out-2040-Balanced (magenta line with triangle pointing upward) and Phase-Out-2035-Strong (cyan line with triangle pointing downward).

Figure 8: Simulation trajectory for population shares



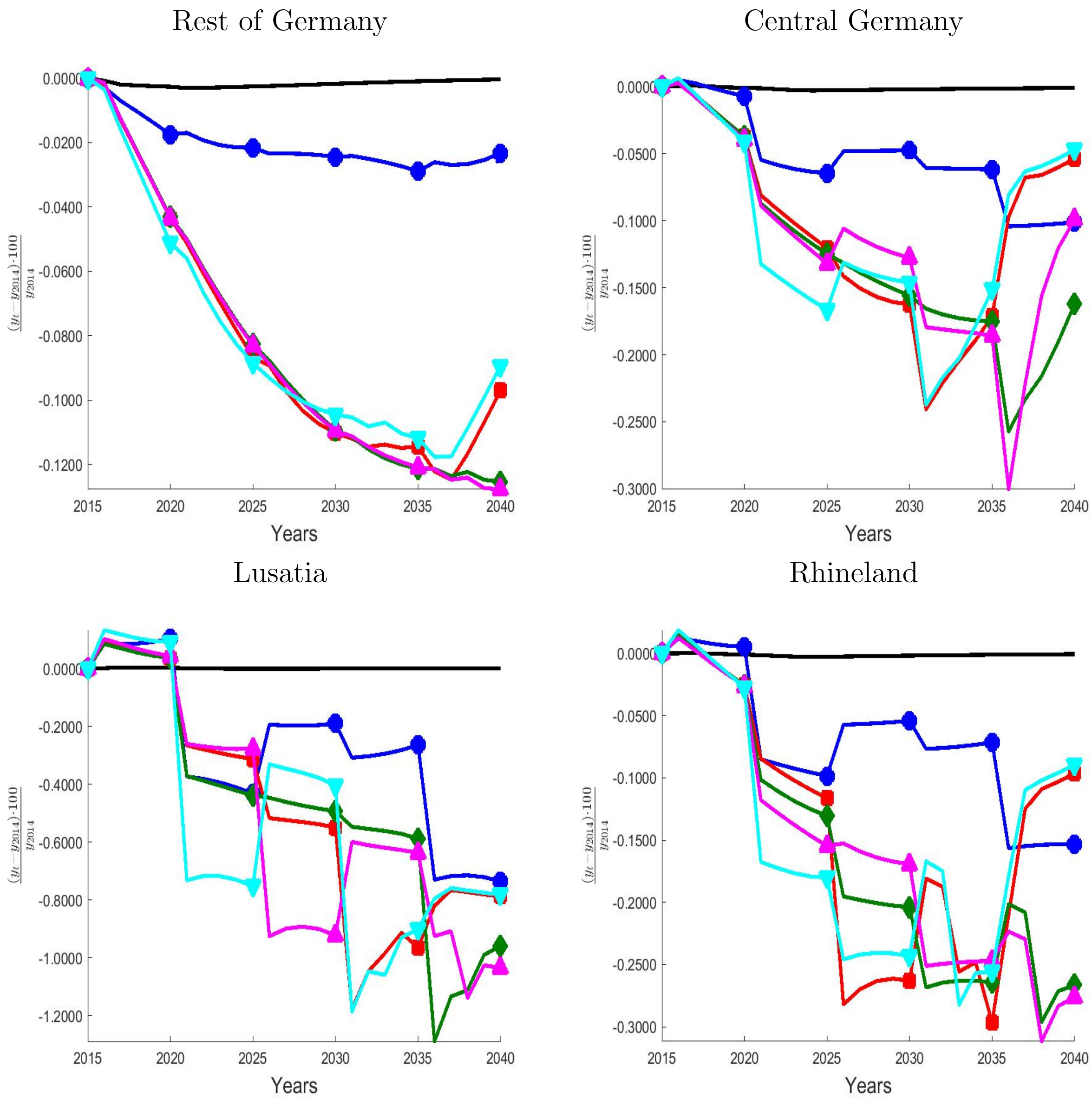
Note: The plots depict the simulation trajectories for the Null-Scenario (black solid line), Baseline (blue line with circle), Phase-Out-2035-Weak (red line with square), Phase-Out-2040-Age (green line with diamond), Phase-Out-2040-Balanced (magenta line with triangle pointing upward) and Phase-Out-2035-Strong (cyan line with triangle pointing downward).

Figure 9: Simulation trajectory for mark-ups



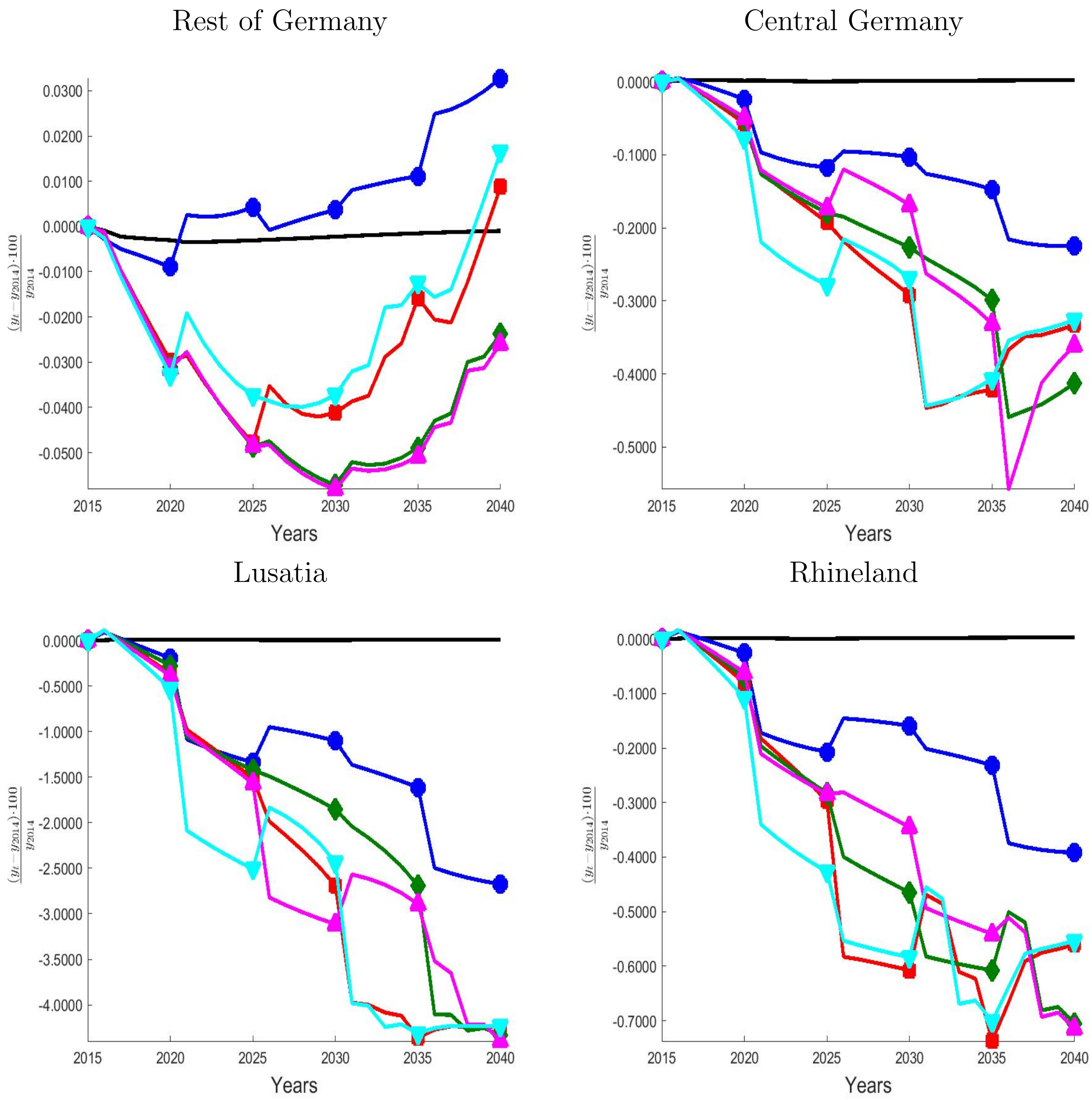
Note: The plots depict the simulation trajectories for the Null-Scenario (black solid line), Baseline (blue line with circle), Phase-Out-2035-Weak (red line with square), Phase-Out-2040-Age (green line with diamond), Phase-Out-2040-Balanced (magenta line with triangle pointing upward) and Phase-Out-2035-Strong (cyan line with triangle pointing downward).

Figure 10: Simulation trajectory for regional consumption



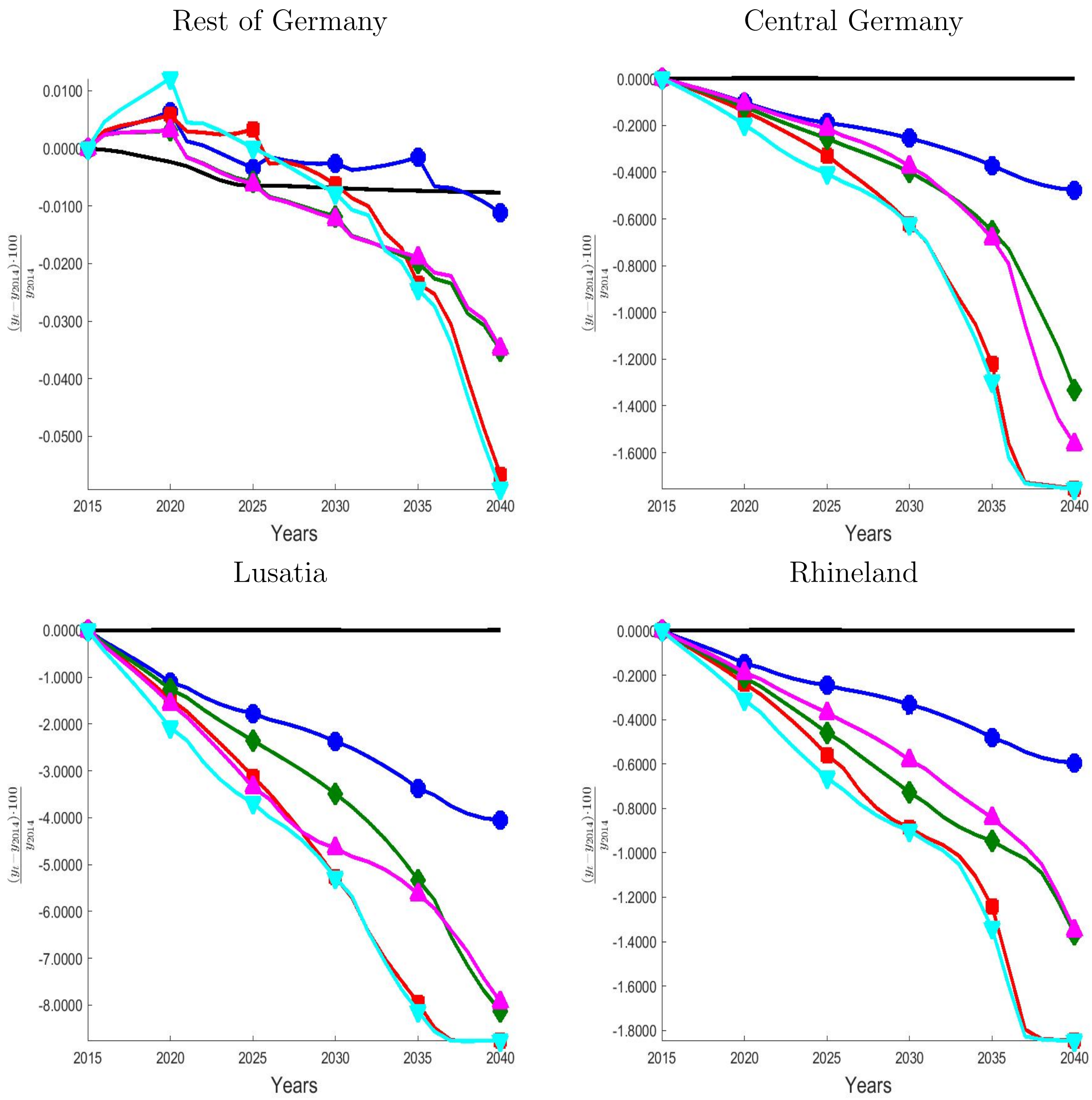
Note: The plots depict the simulation trajectories for the Null-Scenario (black solid line), Baseline (blue line with circle), Phase-Out-2035-Weak (red line with square), Phase-Out-2040-Age (green line with diamond), Phase-Out-2040-Balanced (magenta line with triangle pointing upward) and Phase-Out-2035-Strong (cyan line with triangle pointing downward).

Figure 11: Simulation trajectory for regional gross value-added



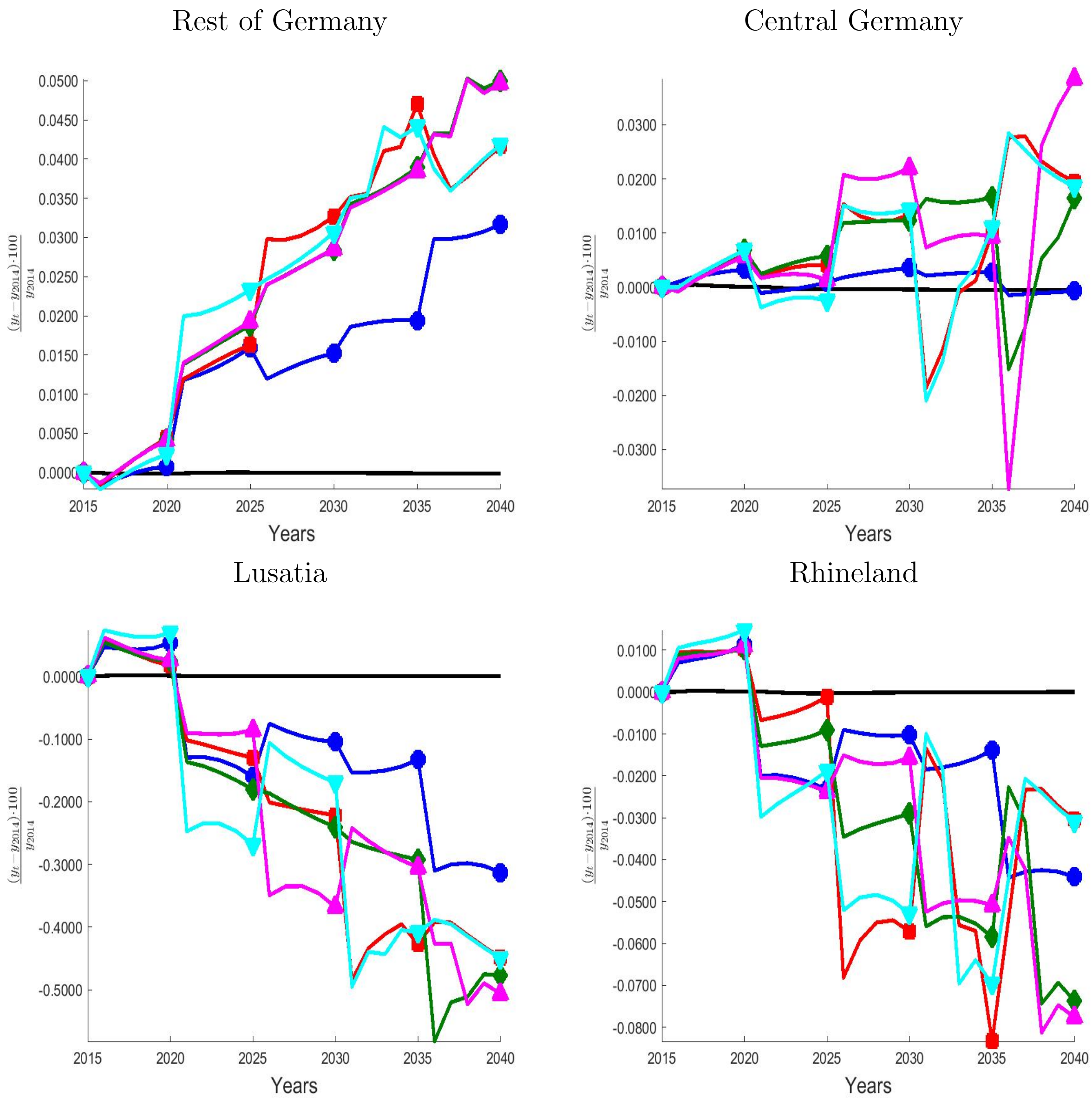
Note: The plots depict the simulation trajectories for the Null-Scenario (black solid line), Baseline (blue line with circle), Phase-Out-2035-Weak (red line with square), Phase-Out-2040-Age (green line with diamond), Phase-Out-2040-Balanced (magenta line with triangle pointing upward) and Phase-Out-2035-Strong (cyan line with triangle pointing downward).

Figure 12: Simulation trajectory for regional real wages



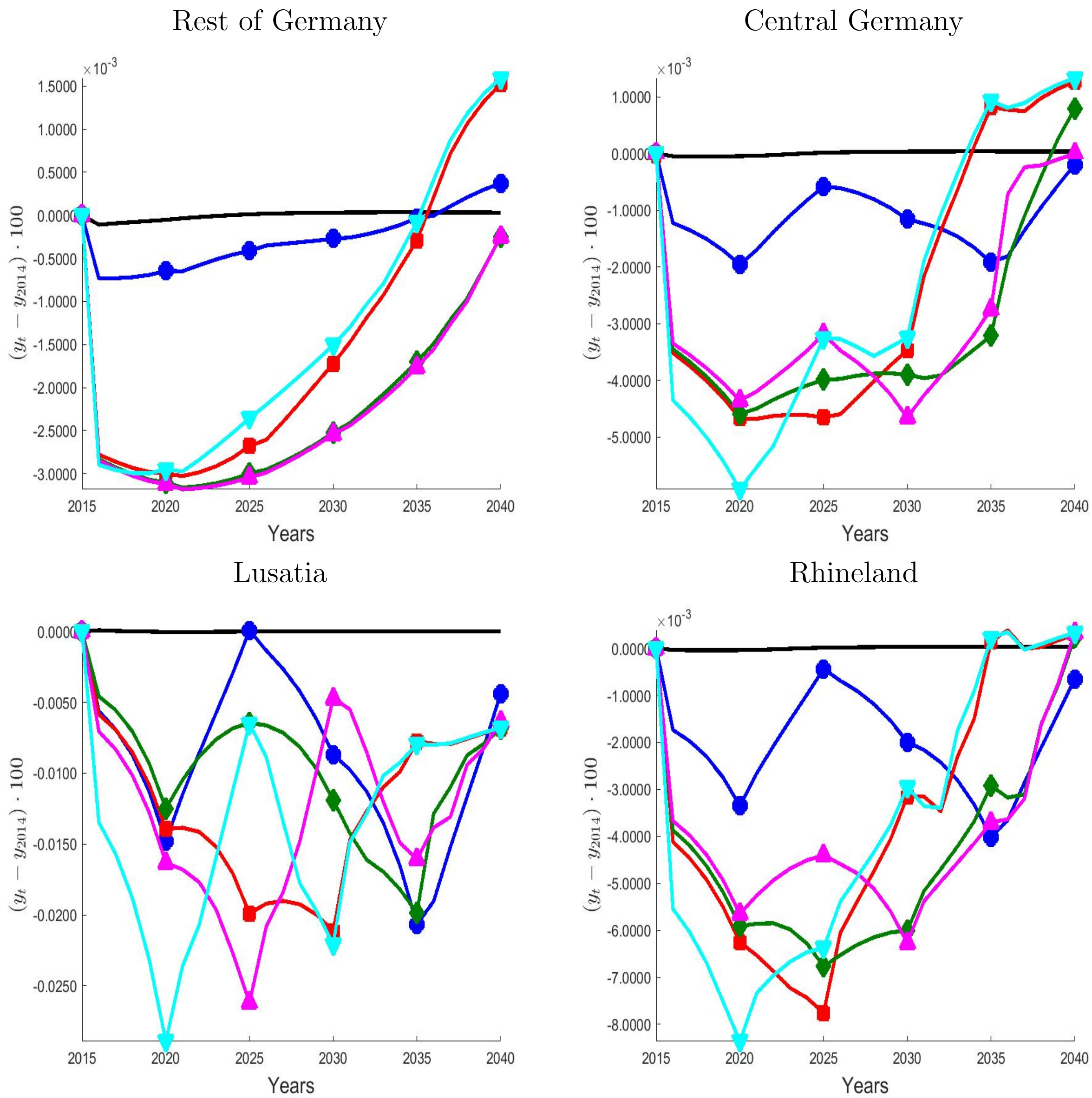
Note: The plots depict the simulation trajectories for the Null-Scenario (black solid line), Baseline (blue line with circle), Phase-Out-2035-Weak (red line with square), Phase-Out-2040-Age (green line with diamond), Phase-Out-2040-Balanced (magenta line with triangle pointing upward) and Phase-Out-2035-Strong (cyan line with triangle pointing downward).

Figure 13: Simulation trajectory for regional consumption price levels



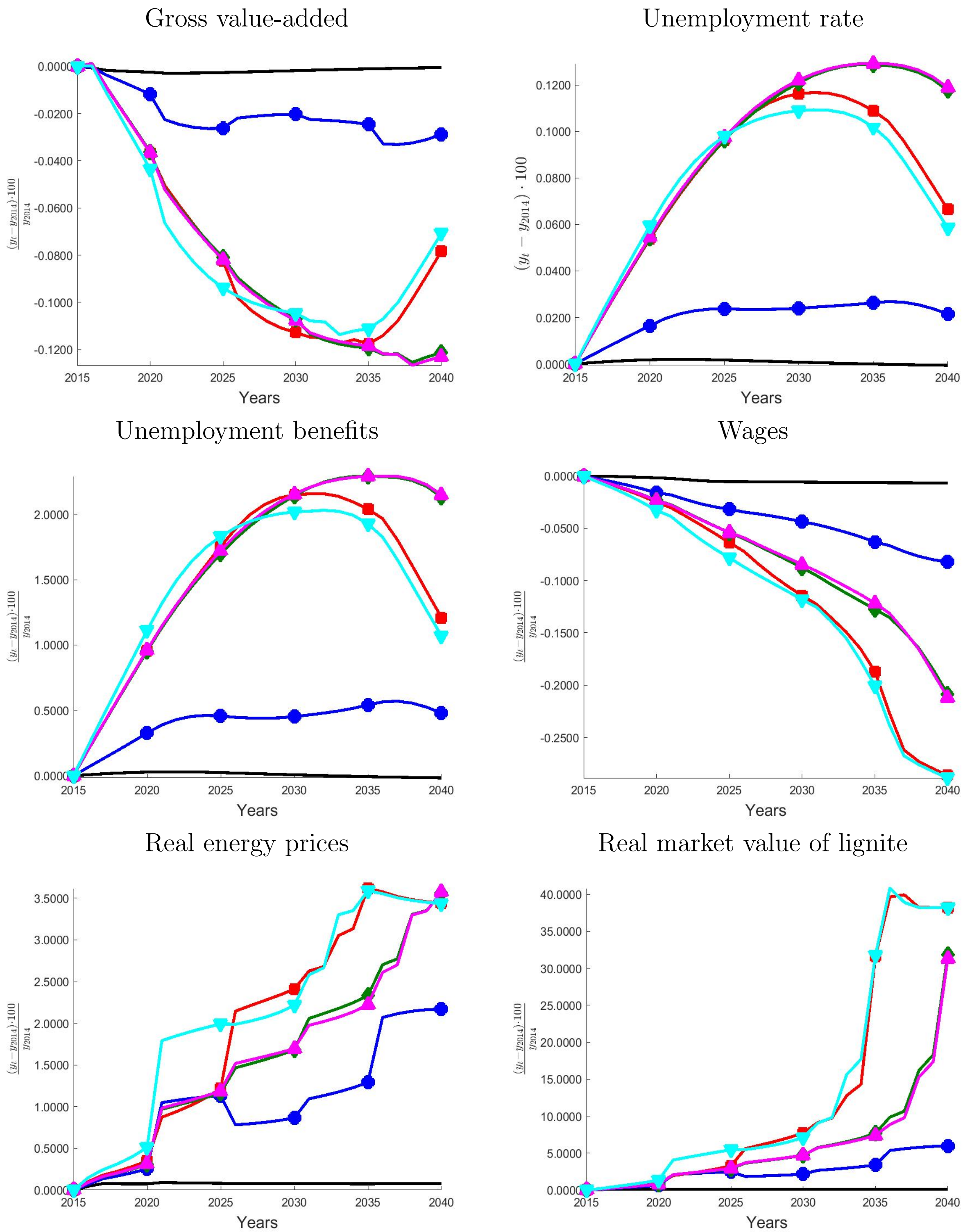
Note: The plots depict the simulation trajectories for the Null-Scenario (black solid line), Baseline (blue line with circle), Phase-Out-2035-Weak (red line with square), Phase-Out-2040-Age (green line with diamond), Phase-Out-2040-Balanced (magenta line with triangle pointing upward) and Phase-Out-2035-Strong (cyan line with triangle pointing downward).

Figure 14: Simulation trajectory for regional hiring rates



Note: The plots depict the simulation trajectories for the Null-Scenario (black solid line), Baseline (blue line with circle), Phase-Out-2035-Weak (red line with square), Phase-Out-2040-Age (green line with diamond), Phase-Out-2040-Balanced (magenta line with triangle pointing upward) and Phase-Out-2035-Strong (cyan line with triangle pointing downward).

Figure 15: Simulation trajectory for national aggregates



Note: The plots depict the simulation trajectories for the Null-Scenario (black solid line), Baseline (blue line with circle), Phase-Out-2035-Weak (red line with square), Phase-Out-2040-Age (green line with diamond), Phase-Out-2040-Balanced (magenta line with triangle pointing upward) and Phase-Out-2035-Strong (cyan line with triangle pointing downward).

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Blanchard, O. & Galí, J. (2010), 'Labor markets and monetary policy: A New Keynesian model with unemployment', *American Economic Journal: Macroeconomics* **2**(2), 1–30.

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