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Abstract

In this paper we investigate the relevance of bargaining institutions in the decline in labor share. Several explanations for the decline exist, which consider the relevance of technology, globalization and markups. Surprisingly neglected so far, however, is the influence of bargaining institutions, in particular with a focus on changes in the outside option. We provide evidence of this issue, using the Hartz IV labor market reform in Germany as an exogenous shock in the wage bargaining of employees, and investigate its impact on the labor share. We begin by developing a theoretical model in which we outline the effect of a decrease in the outside option within a wage bargaining framework. Thereafter, the approach is twofold. Combining the EU KLEMS and Penn World Table databases, we first endogenously identify the Hartz IV reform as a significant structural break in the German labor share. Second, we estimate the effect of the Hartz IV legislation on the aggregated labor share using a synthetic control approach in which we construct a counterfactual Germany doppelganger. Finally, we use rich firm-level panel data compiled by Bureau van Dijk to support our results on the aggregated labor share. We find that the reform decreases the labor share by 1.6 – 2.7 percentage points depending on method and aggregation level. The synthetic control approach furthermore provides evidence that this effect is persistent over time since the reform.

Keywords: Labor share, Hartz reform, change-point tests, inequality, synthetic control method, GMM

JEL Codes: D04, E25, J51, L21, O43

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1 Introduction

There is intense debate on how economic outputs are divided between capital and labor (Rodriguez & Jayadev 2013). This division is usually measured using the concept of the labor share, i.e. the ratio of labor compensation to economic output. In macroeconomic models, the stability of the labor share is often referred to as a stylized fact of growth (e.g. Kaldor 1957). This stability, however, is challenged because of a decline in the labor share in many countries over several decades (e.g. Barkai 2020; Cantore et al. 2020; Karabarbounis & Neiman 2014).[1] In Germany for example, the labor share declined by roughly five percentage points from 70 % in the 1970s to 65 % in 2015 which also raises distributional questions regarding inequality (e.g. Iñaki 2020; Card et al. 2020; Piketty & Zucman 2014).

There is a wealth of theoretical and empirical literature on potential determinants on the decline of labor share. One explanation named in this context is technological progress such as the use of robots and algorithms as well as a decreasing price of capital in relation to labor.[2] Another line of research emphasized the role of so-called 'superstar firms'. These firms are based on capital-intensive production and exponential growth.[3] Globalization combined with outsourcing of labor-intensive tasks is another explanation.[4]

In this paper we consider the decline of bargaining power as an so far overlooked reason for the observed decrease in labor share, in particular with a focus on changes in the outside option. We therefore utilize the unique exogenous reform shock of the Hartz IV legislation, leading to a decrease in the threat point of unions within a bargaining framework. For the investigation, our approach is twofold. We first show that the Hartz legislation and, in particular, the Hartz IV reform in Germany contribute to a significant

[1] Figure A.1 in the Appendix provides an overview of labor share developments for different countries.

[2] See for example the literature by Acemoglu et al. (2020); Eden & Gaggl (2018); Acemoglu & Restrepo (2018); Acemoglu (2003); Bentolila & Saint-Paul (2003). Results from these studies using firm-level data from France suggests that the labor share declines by 4 to 6.3 percentage points for firms that adopt robots (Acemoglu et al. 2020).

[3] This strand of the literature is in particular driven by work from Autor et al. (2020); De Loecker et al. (2020); Kehrig & Vincent (2021).

[4] See for example Elsby et al. (2013) in the context of offshoring and Stockhammer (2017) for the impact of financial globalization.

structural break in the time series of the aggregated labor share. We therefore apply several endogenous tests drawn from the change point literature (e.g. Antoch et al. 2019; Andrews 2003; Bai & Perron 2003) in which we identify the Hartz IV reform as a significant structural break. In a second step, we estimate the reform effect on the labor share using (i) data on the aggregated labor share and (ii) firm-level data (i.e. the 'dafne' dataset) compiled by Bureau van Dijk. We apply ordinary least squares as well as a synthetic control approach (e.g. Abadie et al. 2010, 2015; Abadie 2020) in which we construct a Germany doppelganger as a counterfactual for what would have happened with the German labor share in the absence of the Hartz IV reform. For this analysis we use the EU KLEMS data combined with the Penn World Table database to investigate the German labor share for the period 1970 to 2015. Regarding the firm-level data, we apply fixed effects as well as System GMM estimation techniques. We provide evidence that the exogenous shock of the Hartz IV reform reduces the German labor share by around 2 percentage points. The synthetic approach additionally suggests that this decline is lasting, at least up to ten years after the reform was implemented.

Related literature also exists which examines the relationship between bargaining power and the labor share, however with a different focus. For the aggregate labor share, Young & Zuleta (2018); Blanchard & Giavazzi (2003) consider the direct bargaining power of unions. In a similar vein, Fichtenbaum (2011) finds that the decline in union density explains roughly one third of the decline in the share of labor. Bental & Demougin (2010) develop a theoretical model which explain movements in the labor share which depend on labor market institutions, and Brock & Dobbelaere (2006) develop a bargaining framework for the effects of globalization on the labor share. More closely related are, for example, Bazillier & Najman (2017), who investigate how crisis events affect the threat points of workers and result in a decrease in the labor share. More recently, Stansbury & Summers (2020) investigate the relevance of bargaining institutions for workers in the United States and **?** consider the impact of job protection deregulation. These authors in particular find that the decline in workers' bargaining power might be the main reason for changes in the labor share. On the firm level, there are numerous studies examining the role of firm-specific factors such as workforce or firm characteristics for the labor share (Harju et al. 2021; Siegenthaler & Stucki 2015). Although these studies focus on similar aspects of the decline of labor share, no study focuses on changes in *indirect* measures for bargaining power, such as the outside option.

The remainder of this paper proceeds as follows. In Section 2 we provide the institutional framework and background of the Hartz legislation in Germany. Moreover, we provide a simple bargaining model in which we derive implications for the connection between changes in the outside option in wage bargaining and the labor share. Section 3 then provides empirical evidence on the Hartz IV reform and identifies the reform as a structural break in the German labor share. We apply several endogenous and exogenous change point tests. Section 4 provides estimates of the magnitude of the reform on the aggregated and firm level. Section 6 concludes and provides policy implications.

2 Institutional framework in Germany

2.1 The Hartz legislation

A persistent and high unemployment rate in Germany in the early years of the 21st century led to the implementation of the so-called Hartz reforms, named after the chairman of the commission, Peter Hartz.[5] The reform consisted of four packages (Hartz I–Hartz IV), implemented successively during the years 2003–2005 and were designed to increase the flexibility of the labor market. Their main purpose was to reduce long-term unemployment.

The reform package started with Hartz I and II, introduced on January 1st, 2003. Both of these reforms led to increased labor market flexibility by deregulating temporary work, dismissals and fixed-term contracts. Empirical evidence on these two reforms is provided, for example, by Bradley & Kügler (2019) who find an increase in mini-job usage. The Hartz III reform was aimed at increasing matching efficiency on the labor market by

[5] The unemployment rate in Germany was persistently high at roughly 10 percent and a peak was reached at 11.1 percent in the year 2005 (Dustmann et al. 2014).

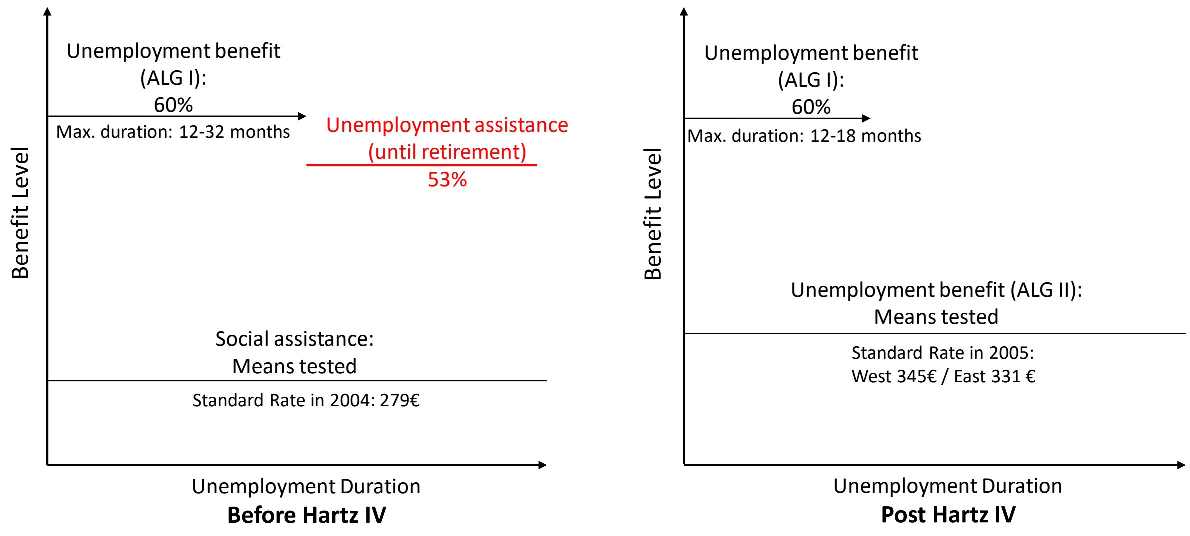
restructuring the Federal Employment Agency. It became effective on January 1st, 2004. For empirical evidence from a macroeconomic point of view on effects of the reform on matching efficiency see, for example, Launov & Wälde (2016) and Klinger & Weber (2016).

Finally, the Fourth Act for Modern Labour Market Services (commonly known as Hartz IV) focused on the abolition of long-term wage-dependent support payments and a transition to fixed benefit levels equivalent to the socio-cultural subsistence level. This final (and centerpiece) part of the reform became effective on January 1st, 2005. Before this reform, there had been a three-tier system consisting of short-term unemployment benefits (*Arbeitslosengeld ALG I*), unemployment assistance (*Arbeitslosenhilfe*) and social assistance (*Sozialhilfe*). The short-term unemployment benefits amounted to roughly 60-67 % of previous earnings and were usually paid for 12 months.

The Hartz IV reform transformed this system into a two-tier system, as depicted in Figure 1. In particular, the reform comprised the following elements: merging of unemployment assistance (*Arbeitslosenhilfe*) and social assistance (*Sozialhilfe*) into unemployment benefit II (*ALG II*); reduction of the period of entitlement to unemployment benefit (ALG I) from a maximum of 32 to a maximum of 18 months; reduction of support for children and young people, extended means testing (crediting of own fortune and income of partners against transfer payments) and new and stricter sanctions for unfulfilled conditions in the search for employment. The reform therefore led to a dramatic cut in received benefits for the long-term unemployed, since they were no longer eligible for long-term unemployment assistance (which was wage-dependent). As a result of the reform (i) the probability of unemployment increased and (ii) the consequences of unemployment in terms of wage cuts were more severe. Workers who rely on short-term unemployment benefits, now lose their eligibility much sooner and thus experience a much sharper reduction in benefits than before the reform.

In a similar vein, Hartung et al. (2018) also highlight, particularly for long-term employed workers with previously high wage payments, that the Hartz IV reform represents a drastic reduction in benefits. This is also reported by Bradley & Kügler (2019), who find

Figure 1: Hartz IV reform: reduction in the outside option



Notes: This figures shows the affects of the Hartz IV reform for a single household. The reform transformed the three-tier system of unemployment benefits ('Arbeitslosengeld'), unemployment assistance ('Arbeitslosenhilfe') as well as social assistance ('Sozialhilfe') into a two-tier system of only unemployment benefits and social assistance ('ALG II'). Slightly deviating illustration from Hochmuth et al. (2019).

that benefit payments were significantly reduced, especially for unskilled workers. This, however, was intended and the reform was designed to shift the focus from unemployment benefits as a form of insurance to incentives to take up work in such situations.

2.2 A simple bargaining model

In this section, we theoretically relate the exogenous reform shock to labor market institutions such as unions. Drawing from the rent-sharing literature, we show a model of union bargaining in which the threat point of unions is lowered because of the exogenous shock on alternative income stemming from the Hartz IV legislation. In this literature, there are direct and indirect factors affecting bargaining outcomes for workers in the labor market. Whereas direct factors increase the power of workers in negotiations (e.g. Blanchard & Giavazzi 2003), indirect factors change the threat point (or outside option) should the negotiations break down. Our focus is on the latter, and there are in fact a few studies in this context which investigate indirect effects stemming from welfare services in several countries (e.g. Stockhammer 2017; Onaran 2009; Jayadev 2007).[6]

Explanations of the labor share based on bargaining power have to assume a rent-sharing framework in which economic rents at either the organizational or the country level have to be shared between capital and labor. Thus, a firm is not a price-taker and possesses market power (De Loecker et al. 2020). In our model, however, the markup does not arise because of markups stemming from product markets. Our markups arise from the power of unions to shift the wage above its marginal product of labor. For a theoretical foundation, we derive a simple model in which we assume a market with two duopolists (firm 1 and firm 2) and a union which are involved in bargaining. The union's utility function is based on risk-neutral agents and is specified for the maximization of the rent of its members. The rent that employee's realize is the difference between the wage w and an alternative wage w_a. The monetary value of the alternative wage is determined either by unemployment benefits alone, or by a weighted average of (i) the wage when employed in another company and (ii) the unemployment benefit. The weights are the results of the employees' assessment of the probability of the two alternatives occurring. The value of w_a determines the lower limit of the negotiated wage w or the threat point during wage negotiations in case negotiations fail. We focus in this paper on the relative change in workers' bargaining power. The introduction of the Hartz IV reform as outlined in Section 2.1, has led to a deterioration in financial support for large parts of the workforce. We therefore assume that with the implementation of Hartz IV, w_a has decreased for parts of the workforce or at least is a very credible threat for lower wages when bargaining fails.

In the bargaining model, the rent per employee is multiplied by the number of employees who are members of the union. The aim of the union is to maximize the difference between the wage w and the alternative wage w_a which is simultaneously the threat point of the union. The term $\bar{N}$ is considered as union membership in which not all employees from the pool of employment N have to be union members $(0 < N \leq \bar{N})$. We consider the

[6] Although direct effects of bargaining power are not specifically considered in this paper, we include union density as a measurement of direct bargaining power in our regressions to adjust for this channel.

following union's objective function of a utilitarian form:

$$U(w) = N(w - w_a) \tag{1}$$

The function in Equation (1) is the well-known Stone-Geary utility function with risk-neutral workers which, for example, is applied in other bargaining models (e.g. Blanchflower et al. 1996; Dobbelaere 2004). We also assume that, in an event of bargaining delay, the firm earns zero profit because of the lack of workers, and employees receive the alternative wage w_a since they are unemployed for the time-being. Because of the dual structure of the industrial relations systems in Germany, unions at the industry-level usually bargain with employers' associations and determine wages but not employment. Thus, the bargaining framework in this paper considers wage bargaining, since the determination of employment levels is outside the scope of unions.[7]

Firm's utility is symmetric for firm i, where $i = 1, 2$ in this model and equals its profits π_i which is the output q_i times the price p. Output is produced using a Cobb-Douglas production technology in which we assume no fixed costs F and labor as the only variable input factor. Thus, the simple production function is $q_i = N$ in which the firm only has to pay the input costs w. The profit function then reads as follows:

$$\pi_i(w, N) = pq_i - wq_i \tag{2}$$

For pricing, the following linear inverse demand function is assumed:

$$p = d - b(q_1 + q_2) \tag{3}$$

As usual and shown in Equation (2), firms maximize the difference between sales and

[7] On the firm-level, however, wages are outside the field of application since they are determined on the industry-level by unions. In this level, firm owners or managers bargaining with co-determination institutions such as works council to determine employment. For a bargaining model on the company-level see for example Kraft (1998). For the empirical wage determination depending on different contracts between German unions and employer associations, see for example Fitzenberger et al. (2013).

costs which leads to the following profit function for firm 1:

$$\pi_1 = (d - b(q_1 + q_2))q_1 - wq_1 \qquad (4)$$
$$= (d - b(q_1 + q_2) - w)q_1$$

We consider the more realistic case of asymmetric generalized bargaining power (e.g. Dobbelaere 2004; Blanchflower et al. 1996) in which the bargaining power of two players is denoted by ϕ for the firm and $1 - \phi$ for the union. The aims of the two parties are combined by the well-known Nash bargaining solution with Equation (1) and (4):

$$\Phi = ((d - b(q_1 + q_2) - w)N)^{\phi}(N(w - w_a))^{1-\phi} \qquad (5)$$

For pure wage bargaining (and not efficient bargaining), N must be replaced by a function of w, respectively $N(w)$, before maximizing this Nash bargaining function. For this purpose, the profit function in Equation (4) is differentiated with respect to q_i and solved for output. Under the assumption of symmetric duopolists (with $q_1 = q_2$), this leads to:

$$q_1 = \frac{d - w}{3b} \qquad (6)$$

This function is inserted into the bargaining Equation (5) and after taking the logarithm, this function reads:

$$ln\Phi = \phi \ln\left(\frac{(d - w)^2}{9b}\right) + (1 - \phi) \ln\left(\frac{(w - w_a)(d - w)}{3b}\right) \qquad (7)$$

From differentiation Equation (7) with respect to w (i.e. $\frac{\partial ln\Phi}{\partial w}$) follows:

$$w = \frac{1}{2}\left(\phi(w_a - d) + w_a + d\right) \qquad (8)$$

Unsurprisingly the negotiated wage w increases with w_a. Inserting Equation (8) for w

into the expression for q_1 which is Equation (6) gives the output and labor demand:

$$N = q_1 = \frac{(1+\phi)(d-w_a)}{9b} \tag{9}$$

Output and thus also the demand for labor decrease with higher w_a. Then, in this Cournot model profits are given by:

$$\pi_1 = \frac{q_1^2}{b} = \frac{(1+\phi)^2(d-w_a)^2}{36b} \tag{10}$$

Therefore as shown in Equation (10), profits also fall with w_a. We conclude from this simple model that in the case of a lowered outside option resulting from the Hartz IV legislation, wages will decrease, labor demand will increase and profits will rise. These results are consistent with existing empirical research in which Grüner (2019) provides an overview.

The less obvious question, however, is what happens with the labor share if w_a falls. The labor share here is defined as $ls = wN/pq$, and since in this simple model $q = n$, the expression reduces to $ls = w/p$. By use of Equations (3) and (9) the following expression for p can be derived:

$$p = d - \frac{1}{3}(1+\phi)(d-w_a) \tag{11}$$

Then, the labor share ls is now:

$$ls = \frac{\frac{1}{2}(\phi(w_a - d) + w_a + d)}{d - \frac{1}{3}(1+\phi)(d-w_a)} \tag{12}$$

As a final step, to show the effect of changes in the alternative wage w_a, we take the derivative with respect to this coefficient:

$$\frac{\partial ls}{\partial w_a} = \frac{3(1+\phi)d}{2((2-\phi)d + (1+\phi)w_a)^2} > 0 \tag{13}$$

As evident from Equation (13) and outlined in the theoretical Section 2.1 in this paper, the labor share ls falls with decreasing w_a.

3 The Hartz reforms as a structural break in the labor share

3.1 Data sources and measurement

We want to begin by identifying the Hartz IV reform, which was implemented on January 1st, 2005, as a significant break point in the time series of the German labor share. Tests for structural breaks in an economic context actually have a long history, starting with the early work Chow (1960) and Quandt (1960). More recent theoretical contributions include Bai & Perron (1998); Han & Park (1989) as well as Hansen (2001), and nowadays there are many applications of change point tests in different fields (e.g. Lunsford 2020; Antoch et al. 2019; Link & van Hasselt 2019; Wiese 2014; Jayachandran et al. 2010). The general idea is to check whether an economic reform or an intervention constitutes a fundamental change in the data generating process and thus can be interpreted as a change point. We apply different exogenous and endogenous tests to check whether the introduction of Hartz IV in Germany in the year 2005 constitutes a significant impact on the labor share. Whereas in exogenous tests we must explicitly define the year of the break point, endogenous tests detect the break point year from within the data.

We use the data from the EU KLEMS[8], revision 2019 dataset, which we combine with data from the Penn World Tables and the OECD STAN database. Then, we calculate the labor share for Germany for the years 1970 to 2015. The labor share LS_t is defined as

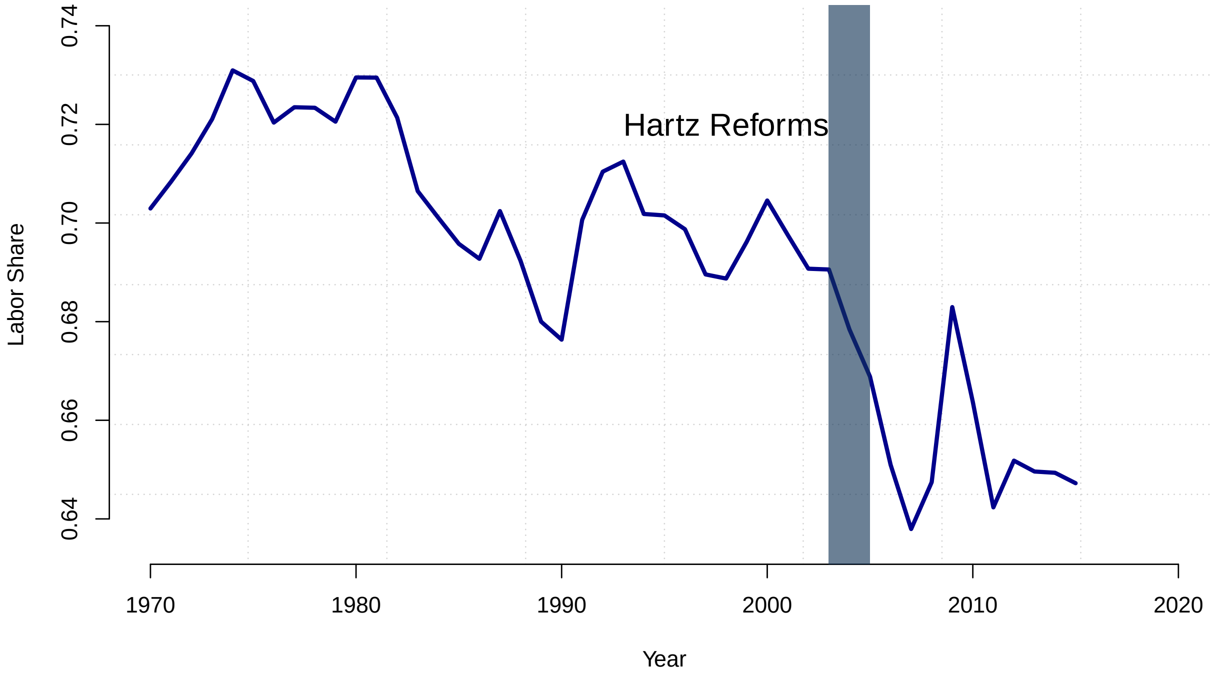
$$LS_t = \frac{W_t L_t}{Y_t} \tag{14}$$

where the expression $W_t L_t$ denotes labor compensation and Y_t gross value added at year t. One additional advantage of the EU KLEMS dataset is the consideration of self-employed workers who are often neglected when calculating the labor share (e.g. Cette et al. 2020). In using this data, we therefore assume that the self-employed receive the same hourly wage as employees in every industry and year and thus prevent measurement errors in

[8] For a comprehensive discussion of the dataset and methodology, see Stehrer et al. (2019).

the labor share calculation (Stehrer et al. 2019).

Figure 2: Trend in the German labor share



Notes: This figure shows the trend in the German labor share LS_t over the years 1970 to 2015. The German labor share is calculated as the ratio of labor compensation to gross value added for all industries in year t as described in Equation (14). The data for the EU KLEMS release 2019 can be obtained on https://euklems.eu/. For an overview of variable construction and methodology see Stehrer et al. 2019. The blue shaded area indicates the implementation of the Hartz legislation in which Hartz I and II are implemented in 2003, Hartz III in 2004 and finally Hartz IV in 2005.

As shown in Figure 2, the aggregated labor share for Germany is in line with several other studies (e.g. Karabarbounis & Neiman 2014).) There are three main events in recent decades which contribute to a change in the labor share in Germany. First, changes in the 70s can be attributed to the two oil price shocks in which the labor share sharply increases (Berthold et al. 2002). Second, the German reunification in 1990 also constitutes a sharp increase in the labor share because of large monetary transfers from western to eastern Germany in which the currency was not devalued.[9] And, finally, the Hartz reforms contribute to a significant decline in the labor share in which the share stays rather constant hereafter. The only exception and sharp increase is due to the financial crisis in the year 2009, which can be explained by sticky wages and labor hoarding, which primarily affects capital incomes (Bazillier & Najman 2017). The literature suggests

[9]For an synthetic control analysis of the effects of the German reunification on GDP, see for example Abadie et al. (2015).

that many firms use working-time arrangements such as 'time accounts' or other work-sharing schemes (Teague & Roche 2014). Empirical studies indeed find that the labor share increases in times of economic downturn, as for example the great financial crisis in Germany of 2008–2009 (e.g. Bazillier & Najman 2017). Whether these changes, however, are significant in a statistical manner is the question which obviously presents itself. In the following we therefore test these hypotheses using structural break tests.

3.2 Supremum of a sequence of Wald tests

As it is apparent from Figure 2, there is a notable decline in the labor share around the Hartz legislation between the years 2003 and 2005. Around this period, Figure 2 suggests a change point in the mean of the labor share. Of course, we could apply a simple t-test for pre- and post-reform mean differences using time dummy variables. However that would require that the break occurs at a known point in time. This is easy in principle, since we know the exact time of the implementation of the Hartz reforms and the potential break points[10] Choosing a fixed break date, however, might nevertheless be arbitrary since we do not know whether there are any delay or anticipation effects of the reform (e.g. Wiese 2014; Piehl et al. 2003).

To solve this problem we apply endogenous tests for structural breaks in the mean for unknown break dates (e.g. Lunsford 2020; Wiese 2014; Jayachandran et al. 2010; Hansen 2001). The endogenous approach is much more reliable than the one with, for example, exogenously determined breakpoints because the endogenous test checks all possible alternatives. As a first test, we therefore calculate Wald test statistics to determine whether there is indeed a structural break for a variety of break dates and take the maximum as the test statistic (Chow 1960; Quandt 1960). We test for a break in the mean of the labor share (LS_t) in year τ between $t = 1, \ldots, T$ where $t = 1970$ and $T = 2015$ estimating the

[10] In such cases, the Chow test might be a feasible alternative (Chow 1960).

following model several times[11] for every possible break point,

$$LS_t = \alpha + \delta_t D_t(\tau) + \gamma trend + \varepsilon_t \tag{15}$$

where $D_t(\tau)$ describes an indicator variable with $D_t(\tau) = 1$ if $t > \tau$ and $D_t(\tau) = 0$ otherwise. Thus, we test for all possible breaks in the mean for each year in the interval 1975 to 2009.[12] Given our stationary time series, which we confirm using a Dickey-Fuller test, we include a trend variable (e.g. Rodriguez & Jayadev 2013) and define the following Wald test statistic in which there is no change before and after the Hartz IV reform in the null hypothesis:

$$\begin{aligned} &H_0 : \delta_t = \delta_0 \; \forall \; t, \\ &H_1(\pi) : \delta_t = \begin{cases} \delta_1, & t = 1, \ldots, T\pi \\ \delta_2, & t = T\pi + 1, \ldots, T, \end{cases} \end{aligned} \tag{16}$$

where the parameter $\pi \epsilon (0, 1)$ is the sample fraction before and after the break point and $T\pi$ corresponds to the year of the change point. Then, we test the null hypothesis that there is no break point which is $\delta_t = 0$.

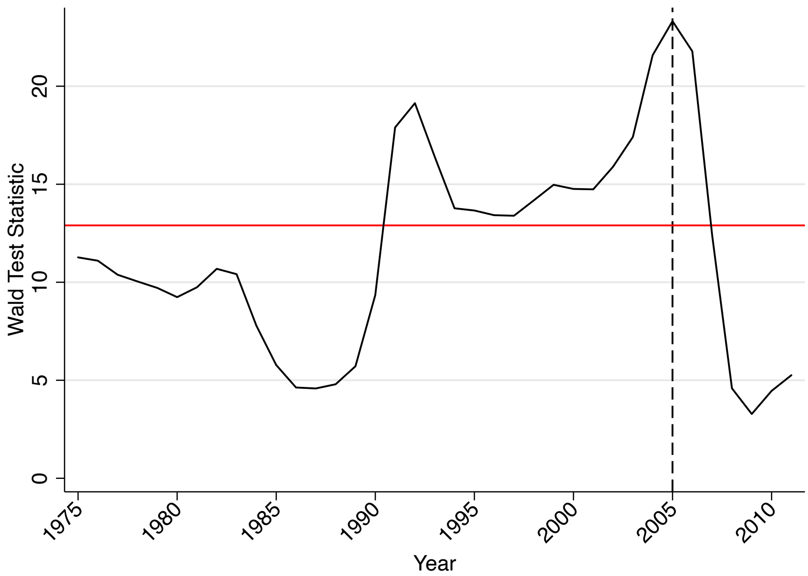
The maximum value of the Wald statistic (sup Wald) over all possible breaks is used to verify the break point and the significance of the break. Figure 3 shows the values for every possible Wald test statistic for each year. The red line indicates the critical value provided by Andrews (1993, 2003) for the assessment of significance.

As shown in Figure 3, the test statistic exceeds the critical value in the year of German reunification in 1990. Hereafter, the test stays significant, indicating that German reunification constitutes a rather lasting impact on the share of labor. The second break is indicated in the year 2005, which is also the maximum of the Wald test statistic (sup

[11] We also estimated the model with successively added control variables in which we include the number of strike days, the unemployment rate as well as the growth rate of GDP. Results can be found in Table A.4 and Table A.5 of the Appendix.

[12] The test uses a slightly smaller sample size to ensure that the test has enough power. A common approach therefore is to trim 15 percent from both ends of the sample (e.g. Jayachandran et al. 2010).

Figure 3: Wald test statistic for structural break



Notes: The figure shows values of Wald test statistics as outlined in Equations (15) and (16). Test for a change point in the mean of the labor share (LS_t) in year τ between $t = 1, \dots T$ where $t = 1975$ and $T = 2009$. The labor share is calculated as outlined in Equation (14). The blue line shows the values of the test statistics. The maximum value (sup Wald) of the Wald test statistic is 23.32, which occurred in 2005, which is exactly in the middle of the Hartz legislation. The red line indicates the critical value of the test statistics as provided by Andrews (1993, 2003). Values of the test statistics are provided in Table 1. We trim 15 percent from both ends of the sample to ensure that the test has sufficient power.

Wald). It seems, therefore, that the Hartz IV reform is a profound structural break in the mean of the German labor share. Table 1 presents results for the applied single structural break tests. The p-values are calculated by the method provided by Hansen (1997) and the test statistic are derived and tabulated by Andrews (1993, 2003). In addition to the supremum Wald test we also apply an average Wald and exponential Wald test. These tests tend to have more power compared to the supremum test (Andrews & Ploberger 1994). Our results, however, do not change.

3.3 Bai and Perron test for multiple breaks

The sequence of Wald tests are frequently applied in the empirical literature (e.g. Lunsford 2020; Link & van Hasselt 2019; Jayachandran et al. 2010; Piehl et al. 2003; Hansen 2001), however these tests are limited to the occurrence of only one break point. A look at the labor share time series in Figure 2 reveals, however, that there might in fact be more break points. We therefore expand the analysis and additionally allow for unknown timings and

Table 1: Values for Wald test statistics

Test	Value of test statistic (1)	Break year (2)	p-value (3)
Supremum Wald	23.32	2005***	.0002
Average Wald	12.10		.0005
Exponential Wald	8.99		.0003

Notes: This table reports values of the Wald test statistics as outlined in Equations (15) and (16). Test for a change point in the mean of the labor share (LS_t) in year τ between $t = 1, \ldots T$ where $t = 1975$ and $T = 2009$. The labor share is calculated as outlined in Equation (14). Critical Values were obtained from Andrews (1993, 2003).

different numbers of change points in the labor share time series using the Bai & Perron (2003, 1998) test for multiple break points.[13]

The idea of the test is to create a step-by-step route through the adjusted labor share time series LS_t and create an optimal model with m breaks in $m+1$ regimes. Drawing on a linear regression model (e.g. Casini & Perron 2019), we consider a model of the following form. In addition to a common method in which only a constant term is included (Wiese 2014), we also include the trend in the following regression model.

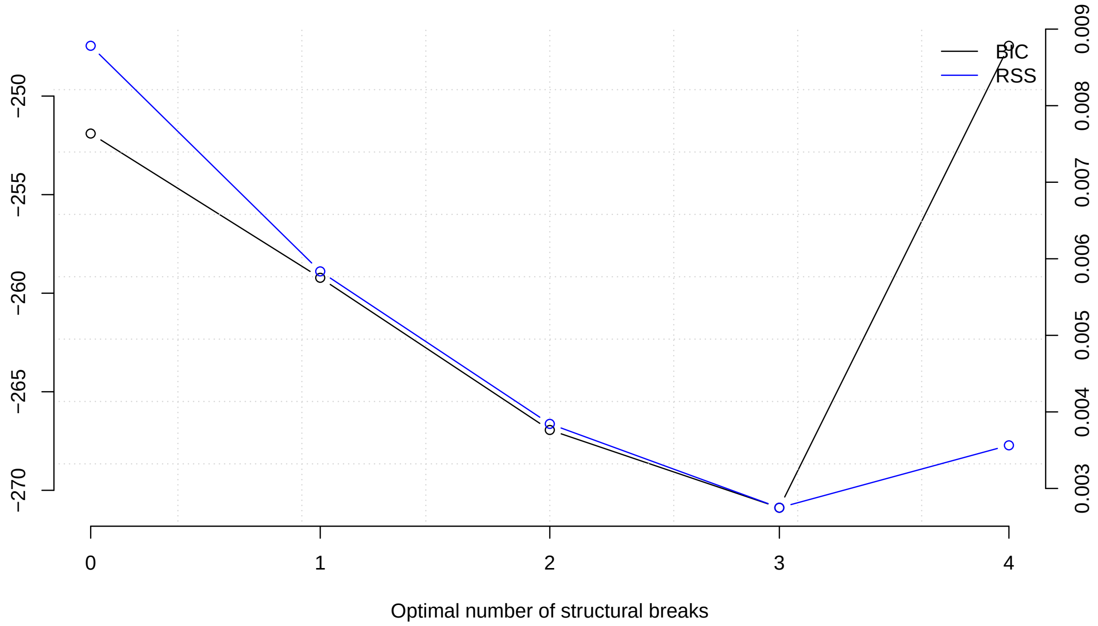
$$\begin{aligned} LS_t &= \delta_1 + \beta_1 x + u_t, \quad t = 1, 2, \ldots T_1 \\ LS_t &= \delta_2 + \beta_2 x + u_t, \quad t = T_1 + 1, \ldots T_2 \\ &\vdots \\ LS_t &= \delta_m + \beta_m x + u_t, \quad t = T_m + 1, \ldots T \end{aligned} \tag{17}$$

in which the dependent variable is the labor share LS_t and δ_m being a vector of estimated constants of $m+1$ possible regimes. Thus, it is the mean of the different segments which are divided into m breaks. The test then checks whether the change points are statistically significant. The number of break points is selected according to the lowest overall residual sum of square (RSS) for a given number of breaks and the Bayesian information criterion (BIC) which are shown in Figure 4. Both criteria refer to the optimal number of $m = 3$ breakpoints, dividing the labor share time series in Figure 2 into $m + 1 = 4$ regimes with

[13] See for example Wiese (2014); Benati (2007) for a similar application of the Bai & Perron test as well as Casini & Perron (2019) for a general assessment of structural break tests in time series.

different intercepts.

Figure 4: Optimal number of break points

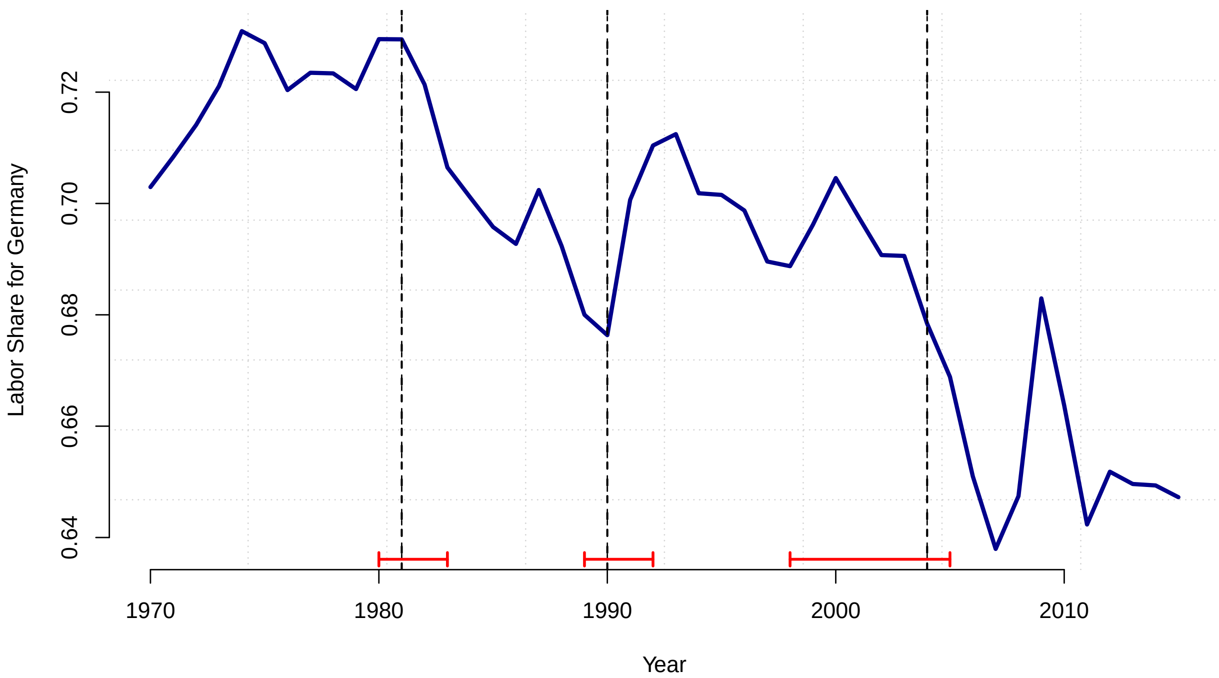


Notes: This figures shows the values of the selection criteria of the optimal number of unknown break points m in the (Bai & Perron 1998, 2003) test. According to the lowest residual sum of square (RSS) and Bayesian information criterion (BIC), the labor share times series in Figure 2 is divided into $m + 1 = 4$ regimes as shown in Figure 5.

The Bai & Perron (1998, 2003) test has different sequential stages, which will be briefly outlined. First, a supF type test is carried out to determine whether there is no structural break ($m = 0$) at all or a fixed number of breaks ($m = k$). In the next step, the null hypothesis that no structural break is present is tested versus the alternative hypothesis of an unknown number of structural breaks, with an upper limit being set. This test is implemented with double maximum tests. The first of these tests is based on equal weighting, while the second uses weights for the individual tests, which are calculated in a way that the marginal p-values are equal across values of m. The weighting is implemented because with an equal weighting the power of the test decreases when the number of structural breaks increases.

The next step is to identify the optimal number of structural breaks. Bai & Perron (1998, 2003) propose a test for a particular number of structural breaks l versus $l + 1$. The corresponding test $supF_t$ $(l + 1|l)$ then gives the maximum of the F-statistic, which tests the null hypothesis that no additional structural break exists versus the existence of an additional structural break. This test is performed sequentially for all possible points in time. The optimal number of structural breaks is then identified using residual sum of square (RSS) and the Bayesian information criterion (BIC). The approach allows for non-symmetric confidence intervals since the variance before and after a break does not have to be constant. Furthermore, the variance covariance matrix is robust to serial correlation and heteroscedasticity (Andrews 1991). The results of the described sequential testing procedure are summarized in Figure 4. The number of breaks is plotted on the horizontal axis, while the two vertical axes show the values of the BIC statistics and the residual sum of squares. The BIC has its minimum at three breaks.

Figure 5: German labor share with identified break points



Notes: Own calculations using the EU KLEMS 2019 release. The German labor share over the year 1970–2015 is calculated as the ratio of labor compensation to gross value added for all industries as shown in Equation (14). Dotted lines show endogenously identified change points using the Bai & Perron (1998, 2003) test explained above. Red bars at the bottom indicate 95 % confidence intervals around the estimated break point. The break points occur after the oil crisis in 1981, in 1990 during the period of East and West German reunification as well as in the year 2004 during the implementation of the Hartz reforms.

Figure 5 shows the exact times identified by the Bai & Perron (1998, 2003) test which coincides exactly with the change points we earlier identified in our optical inspection of the time series. Even more interesting, the first break occurs right after the second oil price crisis in the year 1981 in which the oil prices rapidly fell (Autor et al. 2020).

Thus, the severe drop in oil prices might spur capital intensive production thus leading to a decline in the labor share. The second break occurs shortly after East and West German reunification in 1990 and the third break occurs at the time of the introduction of the Hartz reforms in the year 2004. 95 % confidence intervals are shown in Figure 5 around the break points. Because of our rather short time series, since we use yearly data compared to daily or monthly data, for example, the confidence intervals are quite broad. Nevertheless, the breakpoints are consistent with the previous analysis of Wald statistics, which is summarized in Table 1. Important to note in our analysis, however, is the fact that these change points are endogenously identified within the labor share time series and interestingly they also highlight the Hartz reforms as having a significant impact.

To summarize, we use an endogenous Wald test for a single break point as well as the BP test for the identification of multiple endogenous break points. We can indeed verify that the Hartz reforms in Germany constitute a significant shift in the mean of the labor share. This result can be explained by the fact that the introduction of the Hartz IV reform has reduced the outside option in our bargaining framework for employees and therefore had a negative impact on the outcome in wage negotiations. The macroeconomic analysis has the advantage that tests on structural breaks can be carried out without predetermined break points and with several breaks. The disadvantages, however, are the small number of observations and the lack of a cross-sectional dimension. It is quite likely that industries and firms are affected differently, in particular when estimates are additionally adjusted by control variables. For example, the decline in the degree of trade union organization or the increasing decentralization of the negotiation process (e.g. Dustmann et al. 2014) may explain the low wage increases, and in fact the often discussed real wage reductions in the 2000s. Since variables vary between sectors and firms, we carry out additional research using different control variables to adjust for these channels in the following section. The estimates are further supported by a synthetic control method on the aggregated labor share as well as system GMM estimation for firm-level evidence.

4 Impact of the Hartz IV reform

4.1 First results using aggregated data

The structural break tests indeed indicate a significant break right before the Hartz IV legislation in Germany became effective in the year 2005. In this section we therefore inspect the effect of this exogenous shock of the Hartz IV reform on the aggregated labor share. As outlined in Section 2.2, Equation (13),), we expect that the exogenous negative shock on the outside option in the bargaining equation subsequently results in lower wages and, therefore, in a decrease in the labor share. To examine our hypothesis, we first apply ordinary least squares (OLS) regressions of the following form[14]:

$$\begin{aligned} LS_t = \alpha + \beta_1 HartzIV_t + \beta_2 Unemp + \beta_3 Strike \\ + \beta_4 Union + \beta_5 ExImRatio + \beta_6 trend + \varepsilon_t \end{aligned} \tag{18}$$

Where LS_t is the labor share in Germany ranging from $t = 1970$ to $T = 2013$. As control variables we include the trade union density (*Union*), which is a measure for the bargaining power of employees[15]. In fact, there is much literature about the impact of labor unions on the distribution of incomes and factor shares by different channels. First, there are direct positive effects stemming from bargaining in which labor unions reduce within-group as well as between-group wage inequality (e.g. Kristal & Cohen 2017). Furthermore, and more in line with our research, a strand of literature suggests that labor unions affect the compensation of the management and also returns to capital (e.g. Lee & Mas 2012). Second, a more recent paper suggests that labor unions do not affect the wages of employees directly, but rather that positive distributional effects arise from more generous fringe benefits (e.g. Knepper 2020). In this context, Card et al. (2020) provide a very recent overview on labor unions and inequality.

In addition, we also include the unemployment rate of Germany (*Unemp*). A higher

[14] Results from a regressing the labor share on year dummies is provided in Figure A.6.

[15] Trade union density is measured as the members in the German federation of trade unions in the corresponding year (which can be found here: https://www.dgb.de/uber-uns/dgb-heute/mitgliederzahlen) over the total employment as reported in the EU KLEMS dataset.

un- employment rate constitutes a higher risk for employees to go looking for a new job and hence there is less bargaining power for employees. Unemployment in this view constitutes a higher threat which restricts the demands and thus the power of employees and unions within a bargaining framework. We also include lost workdays due to strike in 1,000 employees, *strike* as an additional measure for workers' bargaining power. Finally, the export-import ratio (*ExImRatio*) is included, which is a measure for trade openness and globalization (e.g. Elsby et al. 2013). We expect this variable to carry a negative sign since there is much evidence that the relationship between globalization and the labor share is negative (Elsby et al. 2013).

Table 2 shows the descriptive statistics for the EU KLEMS data which is used for estimating Equation (18).

Table 2: Descriptive statistics for German EU KLEMS sample (1970–2013)

Variables	Mean (1)	Std. dev. (2)	Min (3)	Max (4)
Labor share	0.69	0.03	0.64	0.73
Unemployment rate	7.09	3.12	0.58	11.72
Trade union density	0.32	0.04	0.24	0.41
Export-import ratio	1.00	0.11	0.80	1.19
Lost workdays	24.05	60.01	0.40	278.60
Year			1970	2013
Observations	44			

Notes: The table shows the descriptive statistics for the German labor share sample ranging from 1970 to 2013. Data from the EU KLEMS release 2019 dataset and trade union information from the German federation of trade unions. Lost workdays due to strike from the Hans Böckler Foundation, per 1,000 employees. The labor share is calculated as $LS_t = \frac{W_t L_t}{Y_t}$ as explained in Section 3. For an overview of variable construction and methodology see Stehrer et al. (2019).

First results from estimating Equation (18) using OLS are presented in Table 3 with additionally adding control variables in column (2). As expected and derived in the theoretical model, the Hartz IV reform has a significantly negative impact on the labor share in the magnitude of -2.7 percentage points when adjusting for control variables. Regarding the control variable as shown in column (2) of Table 3, the unemployment rate also carries a negative sign as described above. The results are also similar when we use

Table 3: Results for OLS regression for the German labor share

	Labor Share	
	(OLS)	(OLS)
	(1)	(2)
Hartz IV	-.028***	-.016*
	(.006)	(.009)
Unemployment rate		-.001
		(.001)
Lost workdays		-.016
		(.018)
Trade union density		.191**
		(.090)
Export-import ratio		-.061
		(.037)
Linear trend	-.001***	-.001*
	(.000)	(.000)
Constant	.725***	.728***
	(.004)	(.043)
R^2	.817	.838
Observations	44	44

Notes: This table show results from estimating Equation (18). Data from the EU KLEMS release 2019 dataset and trade union information from the German DGB trade union association. The labor share is calculated as $LS_t = \frac{W_t L_t}{Y_t}$ as explained in Section 3. For an overview of variable construction and methodology see Stehrer et al. (2019). Results from regressing the labor share on year dummies is provided in Figure A.6. Robust standard errors in parentheses. *, **, and *** denote statistical significance at the .1, .05 and .01 level.

year dummy variables instead of a Hartz 4 indicator variable as shown in Figure A.6 in the Appendix. The coefficient on trade union density has an expected positive sign and measures the impact of an increase in bargaining power of employees on the labor share (e.g. Brock & Dobbelaere 2006). Finally, the measure of globalization (export-import ratio) also has a negative coefficient. As expected and shown in various studies, trade openness and globalization lead to more offshoring of labor-intensive work and thus a decrease in the labor share (e.g. Elsby et al. 2013).

4.2 Synthetic control method using a counterfactual Germany

By application of endogenous structural break models and simple OLS regressions as shown in Table 3, our results presented so far support the hypothesis that the Hartz reforms affected the labor share. In the next step we take possible selectivity effects into account.

Considering causal models, there is the well-known fundamental problem of causal inference which states that it is only possible to observe outcomes for entities (such as countries or firms) which are either treated or untreated (e.g. Rubin 1974; Imbens & Wooldridge 2009). A clearly defined control group with similar characteristics as the treatment group is therefore needed to draw causal conclusions. In our specific case, however, the Hartz reforms affected the whole economy in Germany and the labor share, and there is no natural control group. In the next step we therefore apply what we consider as a more advanced form of structural break analysis, which is known as the synthetic control method to tackle the fundamental problem of causal inference (e.g. Abadie et al. 2010, 2015; Abadie 2020). This method is not only more in line with recent developments in econometrics (e.g. Imbens & Wooldridge 2009) but also referred to as one of the most important innovation in the recent policy evaluation literature (Athey & Imbens 2017). In fact, there is an ongoing further development of this method regarding the implementation of covariates (e.g. Botosaru & Ferman 2019) as well as many empirical applications in different fields of economics (Chen 2020; Peri & Yasenov 2019)

Data and sample construction. For the application of the synthetic control method and the construction of a 'synthetic twin of Germany' the analysis requires additional data on other countries. These countries are referred to as the donor pool to construct the German doppelganger. We therefore need more information on industry particularities of other countries and thus we combine the EU KLEMS dataset with the Penn World Tables 9.0 database[16] for information regarding GDP spending and the OECD STAN

[16]The Penn World Table database 9.0 covers information on relative levels of income, output, input and productivity for 182 countries between 1950 and 2014. For an overview of the methodology as well as variables see for example Feenstra et al. (2015). Missing data on the unemployment rate for various countries were supplemented by World Bank data.

database for trade union density. Unfortunately, we do not have such rich information for other countries that allow us to create such a long time series as we have for Germany starting in the 1970s. Our analysis in this section therefore starts in the year 1995, for which we have all information on control variables. Descriptive statistics are provided in Table 4.

Table 4: Descriptive statistics for EU / World sample

Variables	Mean (1)	Std. dev. (2)	Min (3)	Max (4)
Labor share	0.62	0.06	0.49	0.86
Trade union density	32.35	21.20	5.50	95.80
Unemployment rate	8.27	4.05	2.25	27.48
Human capital index	3.21	0.27	2.55	3.73
Share of gross capital formation	0.25	0.05	0.10	0.47
Share of government consumption	0.19	0.05	0.09	0.42
Share of exports	0.48	0.27	0.08	1.39
Share of import	-0.51	0.28	-1.47	-0.11
Year			1995	2015
Observations	412			

Notes: The table shows the descriptive statistics for the shorter but more comprehensive country panel dataset. Data from the EU KLEMS release 2019, Penn World Table 9.0, OECD STAN as well as World Bank. The labor share is calculated as $LS_t = \frac{W_t L_t}{Y_t}$ as explained in Section 3 for each country. Figure A.1 on the Appendix provides the labor share trends for each country. Data sets are merged using country names and the corresponding year. For an overview of the EU KLEMS data see Stehrer et al. (2019) and for Penn World tables see Feenstra et al. (2015). More information regarding the human capital index is provided in Table A.1. The sample comprises the countries: Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Greece, Hungary, Ireland, Italy, Japan, Latvia, Lithuania, Luxembourg, Netherlands, Poland, Slovenia, Spain, Sweden, United Kingdom and the United States.

Methodology. Following the notation of Abadie et al. (2010), we apply the synthetic control method for the case that a single unit (Germany) is exposed to some treatment (the Hartz IV legislation) and there is no natural control group. The other $(J+1)$ countries remain unexposed to the reform and are referred to as the donor pool. This pool is then used to construct the Germany doppelganger as a counterfactual Germany without the Hartz legislation. Basically, the idea of this approach is to build a counterfactual Germany without the Hartz IV reform from the donor pool of the other $N = 22$ countries[17].

[17] The countries that comprise the donor pool are in alphabetical order: Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Latvia,

We observe the labor share for T periods in which the intervention starts in some period $T_0 + 1$ which is in our case the year 2005. Furthermore, we define the outcomes Y_jt which are the observed outcomes for the treated as well as the control countries. The fundamental problem in such a causal analysis is that we do not observe the labor share Y_1t for a counterfactual Germany, without the Hartz IV reform, after period T_0. Fortunately, the synthetic control method offers a solution for the estimation of Y_1t, by creating a 'synthetic control Germany' as a weighted combination of other countries (w_jY_jt) which best approximate relevant pre-intervention variables. The weighting vector is defined as $W = (w_2, \dots, w_{(J+1)})$ in which w_j is the contribution of each of the $N = 22$ donor pool countries.[18] The counterfactual Germany is constructed as a convex combination of the observed outcomes of the other countries and there should be no difference in the real and the synthetic Germany prior to the intervention:

$$Y_{1t} = \sum_{j=2}^{J+1} w_j Y_{jt}, t = 1, \dots, T_0 \quad (19)$$

The effect of the intervention for the aggregated time period after T_0 is then obtained by the difference of Equation (19) for the time period after the intervention compared to prior to the intervention which is $\delta_{jt} = Y_{1t} - \sum_{j=2}^{J+1} w_j Y_j t$. This can be estimated using a difference-in-differences (DiD) framework in which we regress the difference between the real and the synthetic Germany on a Hartz IV variable which takes unit value for all years after 2004 and zero otherwise. This synthetic control method derives the well-known average treatment effect on the treated (ATT) (Abadie 2020).

Country Weights and Counterfactual Germany. As shown in Table 5 there are four states which in particularly resemble the German trend in the labor share quite well. These countries receive the corresponding weight which is shown in Table 5 for the construction of the counterfactual Germany as shown in Equation (19). Thus, using

Lithuania, Luxembourg, Netherlands, Poland, Slovenia, Spain, Sweden, United Kingdom and the United States.

[18] Since Germany is the treatment state it is not part of the weighting vector. Moreover, the weights are constrained in that $w_j \geq 0$ and they sum up to one ($w_2 + \dots + w_{(J+1)} = 1$).

the synthetic control method with covariates (e.g. Botosaru & Ferman 2019) as provided in Table 4 for the construction of the Germany doppelganger, the Netherlands, Spain, Slovenia as well as the United Kingdom in particular are used as weighted aggregated comparisons.

Table 5: Country weights from donor pool

Country	Weight	Country	Weight
Austria	< 0.01	Japan	< 0.01
Belgium	< 0.01	Latvia	< 0.01
Czech Republic	< 0.01	Lithuania	< 0.01
Denmark	< 0.01	Luxembourg	< 0.01
Estonia	< 0.01	Netherlands	0.276
Finland	< 0.01	Poland	< 0.01
France	< 0.01	Spain	0.273
Greece	< 0.01	Slovenia	0.226
Hungary	< 0.01	Sweden	< 0.01
Ireland	< 0.01	United Kingdom	0.225
Italy	< 0.01	United States	< 0.01

Notes: This table shows how the weighting vector in Equation (19) is resembled and which weights (i.e. $W = (w_2, \ldots, w_{(J+1)})$) each donor pool country receives for the construction of the counterfactual Germany. Within the synthetic control method, variables are averaged for the pre-intervention period 1995 – 2004 (the share of capital formation, government spending, export as well as imports are averaged 1995 – 1999). Own calculations using the parametric synthetic control approach (e.g. Abadie et al. 2010, 2015; Abadie 2020).

Balancing of covariates. Similar to other matching algorithms that depend for example on the propensity score (e.g. Caliendo & Kopeinig 2008), the credibility of the synthetic control method also relies on the balancing of covariates. The balancing of the pre-intervention variable means should be checked, which is done in Table 6 by comparing the means between the weighted control group and treated Germany. In our case, we construct the synthetic Germany as a convex combination of the 22 donor pool states that resemble Germany as closely as possible in terms of pre-intervention variables. According to the literature, we use quite common variables to construct the Germany doppelganger.

First, trade union density and the unemployment rate are included as a measure of bargaining power (Blanchard & Giavazzi 2003; Bental & Demougin 2010). Also, the share of capital formation (as % of GDP) is included as a measure of capital accumulation in the economy, which is relevant to account for production capacities (Piketty & Zucman 2014). The share of government consumption is also included as a proxy for the welfare state (i.e. a proxy for social protection) which is, for example, also applied by Bazillier & Najman (2017). As a measure for globalization, we include the share of exports and imports (as % of GDP) (Elsby et al. 2013). And, finally, we account for the stock and quality of human capital in the economy by using the 'human capital index' provided by the Penn World Tables dataset. For example, firms need human capital to innovate and improve existing technologies which, in turn, affects capital and the production process. Thus, recent lines of research suggest accounting for this measurement in labor share regressions (e.g. Arif 2021).

Table 6: Labor share predictor means before intervention

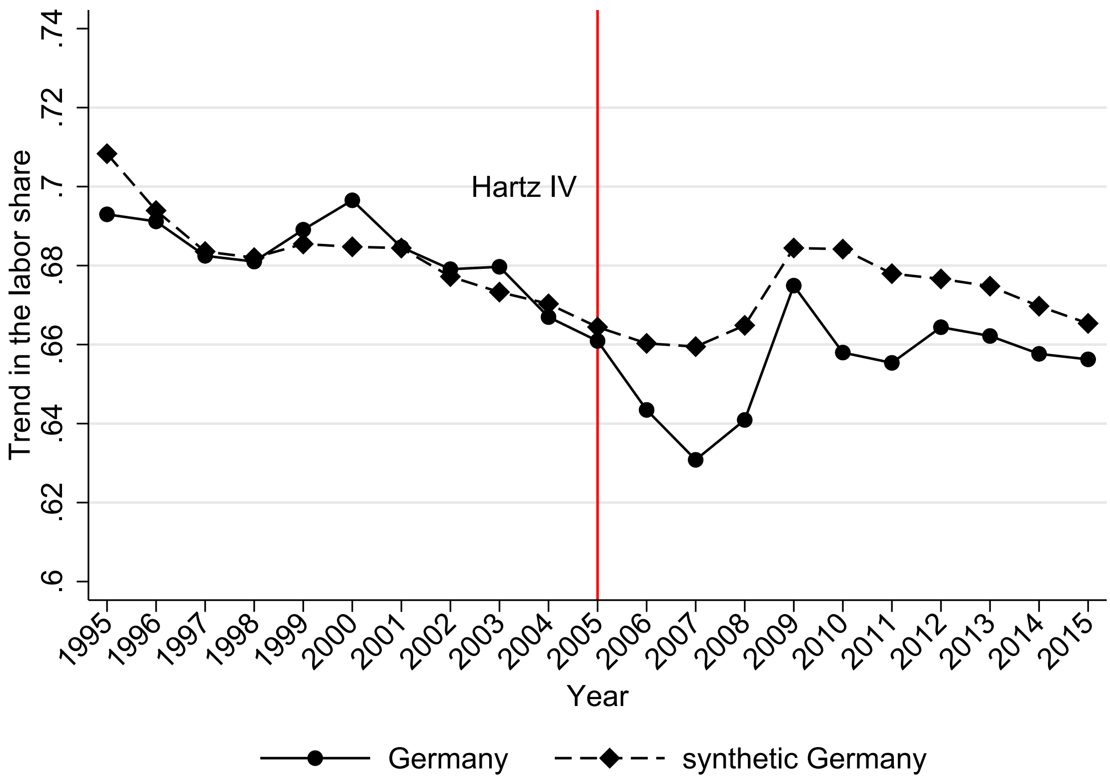
	Germany	
	Real	Synthetic
Covariates	(1)	(2)
Labor share	.684	.684
Trade union density	25.22	28.06
Unemployment rate	8.81	8.44
Human capital index	3.55	3.10
Share of capital formation	.251	.252
Share of government consumption	.137	.160
Share of exports	.356	.356
Share of imports	-.355	-.390

Notes: This table shows the mean comparisons of used covariates for the calculation of the counterfactual labor share which is shown in Figure 6 and the real German labor share. Means for the synthetic Germany are calculated using the weights provided in Table 5. For the construction of the weights, all variables are averaged for the pre-intervention period 1995–2004 (the share of capital formation, government spending, export as well as imports are averaged 1995–1999).

Results of the synthetic control method. Results from the synthetic control approach in addition to the trends among the synthetic and real Germany, are presented in Figure 6. Depicted in Table 6, the pre-intervention differences are balanced and trends between both labor shares are quite similar prior to the Hartz IV treatment. The Hartz

IV reform was enacted at the beginning of the year 2005 in which we see a sharp decline in the German labor share; however, not in the counterfactual trend. Interestingly, both trends capture the effects of the financial crisis in the year 2009 very well, however the real German increase is much more pronounced. What is additionally important besides the strong decline in the real Germany, is the fact that the differences among the labor share are persistent after the Hartz IV legislation.

Figure 6: Trends in labor shares: real vs. synthetic Germany



Notes: The figure shows the trends in the real and the synthetic labor share of Germany. The labor share is calculated as outlined in Equation (14). Trends for the synthetic Germany are calculated using the Netherlands, Spain, Slovenia and the United Kingdom with the corresponding weights as shown in Table 5, calculation according to Equation (19). All variables are averaged for the pre-intervention period 1995–2004 period (the share of capital formation, government spending, export as well as imports are averaged 1995–1999). Data from the EU KLEMS, Penn World Tables, OECD STAN as well as World bank.

Using the synthetic control approach, we are able to compare the real Germany where the Hartz IV legislation was enacted, with our synthetic control Germany doppelganger which never experienced the Hartz IV reform. Our graphical results in Figure 6 show the significant negative impact of the Hartz IV reforms for the aggregated real labor share in Germany compared to the synthetic labor share. Regression results using a Hartz IV dummy variable which takes unit value after the year 2005 and zero otherwise, yield similar results as before. The negative reform effect is significant and in the magnitude of 2.7 percentage points.

Compared to the estimates using the longer time series for Germany only, as presented in Table 3, the effect of the synthetic method is slightly smaller, but also highly significant. The decline in the labor share is roughly 1.6 percentage points after the Hartz IV reform was implemented at the beginning of 2005. The comparison of Germany with the synthetic control group shows that both follow the same downward trend in labor share over some time, but in contrast to the control observation this trend became stronger for Germany after the Hartz reforms. Moreover, the impact of the reform is strongest in the early years before the great financial crisis (2009), although the difference remains, albeit slightly smaller in terms of magnitude.

5 Robustness using firm-level evidence

5.1 Benchmark results

In this section we provide evidence on labor share changes stemming from the firm level (e.g. Harju et al. 2021). The use of firm-level data has two main advantages. First, we are able to take changing sector and industry composition into account that may affect the labor share (Siegenthaler & Stucki 2015). Second, as mentioned by Gollin (2002); Karabarbounis & Neiman (2014), aggregate labor share measures may be confounded by capital incomes earned by entrepreneurs and sole proprietors. We use firm-level data stemming from the 'dafne' dataset compiled by Bureau van Dijk which allows us to measure the impact of a change in the outside option more precisely. We use information for the years 2000–2011.

Dependent variable For the dependent variable, we use the same variables as explained earlier in Equation (14). Thus, we measure the labor share as the share of labor compensation to value added of the firm. We measure value added as the gross output minus intermediate inputs, depreciation as well as interest expenses. See Figure A.7 for a histogram of the labor share and Figure A.8 for the development of the labor share. Comparing the firm-level labor share with the aggregated German labor share, we see a quite similar development; a sharp decline around the Hartz legislation as well as a spike during the financial crisis.

Control variables With respect to control variables, we implement variables which are common in the literature as determinants of the labor share. First, in neoclassical growth models, the labor share is a function of the capital-output ratio (Bentolila & Saint-Paul 2003; Siegenthaler & Stucki 2015). Thus, we implement the logarithm of the capital-to-output ratio as an explanatory variable. The sign of the capital-to-output ratio depends on the elasticity of substitutions between capital and labor (Siegenthaler & Stucki 2015). In the case where labor and capital are complements, the capital-output-ratio increases the labor share. In the case of a substitutive relationship between capital and labor, the capital-output ratio decreases the labor share. The empirical literature usually finds controversial signs in different studies.

To account for unobserved demand shocks within the regression framework, we also add the logarithm of the ratio of intermediate inputs to firms' value added and its square to the regression equation. The idea is to take changes in the input factors into account when firms are hit by various demand shocks (e.g. Levinsohn & Petrin 2003; Siegenthaler & Stucki 2015). The labor share also depends on the degree of organization of the workforce or unions. In line with the literature, we expect a negative sign of this variable. However, the relevance of collective bargaining agreements as well as the trend of declining unionization (Oberfichtner & Schnabel 2019) we therefore expect lower wages (e.g. Akyol et al. 2013).

In the case of a rather inelastic demand curve this also implies a reduction of the labor share. With respect to the sign of the coefficient, we therefore expect a positive sign of our union measure. With respect to the union measure we calculated a unique measure for union density on the industry level. See Section A.3 in the Appendix for the construction of the index. We also include detailed NACE (rev. 2.0) two-digit industry-fixed effects as well as year-fixed effects in the regression model. Finally, we include further control variables subsumed in X_{it}. The vector includes an indicator variable whether the firm is a stock company or a Societas Europaea (SE) and whether the firm is located in Western Germany. Descriptive statistics are provided in Table 7.

Table 7: Descriptive statistics for firm-level data

Variables	Mean (1)	Std. dev. (2)	Min (3)	Max (4)
Laborshare	.456	.173	.001	.998
ln (Capital-output ratio)	.139	.271	-5.22	4.17
ln (Intermediate inputs)	.689	.546	-.559	6.95
ln (Intermediate inputs squared)	.769	1.55	.001	48.42
Trade union density	.194	.095	.008	.960
No stock company	.736	.440	0	1
Stock company	.261	.439	0	1
Societas Europaea (SE)	.002	.048	0	1
Western Germany	.762	.425	0	1
Year			2000	2011
Observations	38,808			

Notes: The data is based on the "dafne" dataset compiled by Bureau van Dijk; years 2000 – 2011. The labor share is calculated as $LS_t = \frac{W_t L_t}{Y_t}$ as explained in Section 3. Trade union density is measured at the industry level as outlined in Section A.3.

Regression framework We apply a quite common regression framework for labor share regressions by using the logarithm of the defined labor share as the dependent variable $ln(LS_{it})$ for firm i in year t as follows:

$$ln(LS_{it}) = \beta_0 + \beta_1 ln(k_{it}) + \beta_2 HartzIV + \beta_3 Org_{it} + \beta_4 \mathbf{Z}_{it} + \beta_5 \mathbf{X}_{it} + \mu_i + \theta_t + \varepsilon_{it} \quad (20)$$

In this specification the labor share depends on the capital-output ratio (k_{it}), a set of firm specific control variables ($\mathbf{X}_{it}$) such as being located in Western Germany or being a limited liability company. We estimate this specification using ordinary least squares (OLS), random effects (RE) as well as fixed effects (FE) models shown in Table 8.

As a final robustness check and to take potential endogeneity into account, we estimate System-GMM models (Blundell & Bond 1998). Therefore, we estimate dynamic models of the labor share with lagged levels of the labor share in the dynamic setting.[19] Generated instruments are stacked into one vector to limit the number of instruments and prevent weak instruments. Tests support our choice of instruments. To test the validity of our instrumental variables, we apply the standard Hansen test to check over-identifying restrictions (Hansen 1982). In addition, the system GMM estimator requires that there is no significant second-order auto-correlation in the residuals series. We therefore also test for first AR(1) and second-order AR(2) auto-correlation (Arellano & Bond 1991). With respect to standard errors, we use the quite standard two-step clustering approach and apply the Windmeijer (2005) finite sample correction.

Results Similar to our initial results for Germany, as well as the more sophisticated synthetic control approach, we also find a reduction of the labor share on the firm level stemming from the Hartz IV legislation. The size of reduction is very similar to the magnitude found in the regressions on the aggregated labor share series earlier. These firm-level results are consistent among pooled OLS, random and fixed effects as well as system GMM estimation.[20] With respect to the latter estimation results, the test statistics also support our results. After adjusting for time specific shocks in the labor share series using year-fixed effects, the Hartz IV dummy variable points to a significant negative relationship in the magnitude of around two percentage points. The point estimates are consistent among specifications and similar to the findings on the aggregated labor share. In line with the literature (e.g. Arif 2021; Siegenthaler & Stucki 2015), we also find that labor and capital in our data are complements (measured by the positive impact of capital-output ratio). With respect to our measure of trade union density, we find a positive association between bargaining power and the labor share as, for example, also found in Stansbury & Summers (2020). Regarding the measurement of intermediate inputs, our results are also in line with the findings by (Siegenthaler & Stucki 2015) in

[19] For a similar approach, see Böckerman & Maliranta (2012); Yang & Tsou (2021).

[20] We also applied different specifications in which the results are very consistent among specifications.

Table 8: Results for firm-level regressions

	Labor Share			
	OLS	Random effects	Fixed effects	System-GMM
Variables	(1)	(2)	(3)	(4)
Lag labor share				0.789***
				(0.101)
Hartz IV	-0.016*	-0.018***	-0.020***	-0.028**
	(0.009)	(0.006)	(0.006)	(0.012)
Capital-output ratio	0.040***	0.065***	0.075***	0.061
	(0.006)	(0.007)	(0.009)	(0.132)
Trade union density	0.010**	0.008**	0.007**	0.039
	(0.005)	(0.003)	(0.003)	(0.095)
Intermediate inputs	0.009	0.072***	0.106***	0.526***
	(0.006)	(0.009)	(0.011)	(0.155)
Intermediate inputs squared	-0.010***	-0.008**	-0.007*	-0.192***
	(0.002)	(0.003)	(0.004)	(0.056)
Western Germany	0.016***	0.016***		-0.011*
	(0.003)	(0.003)		(0.006)
Constant	0.352***	0.269***	0.319***	-0.183
	(0.016)	(0.013)	(0.012)	(0.267)
Industry fixed effects	✓	✓	✓	✓
Time fixed effects	✓	✓	✓	✓
Limited liability controls	✓	✓	✓	✓
R2	.159	.128	.136	
No. of instruments				105
AR1 (p-value)				.000
AR2 (p-value)				.602
Hansen-J (p-value)				.422
Observations.	38,808	38,808	38,808	29,501

Notes: This table shows results from estimating Equation (20). The data is based on the "dafne" dataset compiled by Bureau van Dijk; years 2000 – 2011. The labor share is calculated as $LS_t = \frac{W_t L_t}{Y_t}$ as explained in Section 3. (Hansen 1982) test is applied to check for over-identifying restrictions, and tests for first AR(1) and second-order AR(2) auto-correlation are provided (Arellano & Bond 1991). Firm-level clustered standard errors in combination with Windmeijer (2005) finite sample correction in parentheses. *, **, and *** denote statistical significance at the .1, .05 and .01 level respectively.

which we also see an inverted u-shaped relationship.

Summarizing, our robustness test by application of microeconomic data and quite different econometric methods supports our earlier results based on macroeconomic data. Our results are well in line with the empirical literature as, for example, Karabarbounis & Neiman (2014) found very similar estimates for the firm level labor share.

5.2 Testing the 'superstar' hypothesis

The narrative of the applied literature on the labor share is that the decline is primarily driven by large so-called 'superstar' firms (e.g. Autor et al. 2020; Kehrig & Vincent 2021). This interpretation is also consistent with the findings by De Loecker et al. (2020) in which large firms tend to have more power due to less competition and rising markups. We test this hypothesis by choosing a value of 2,000 employees as cutoff point, which marks the change from one-third to quasi-parity employee representation in corporate boards (e.g. Jäger et al. 2019; Gorton & Schmid 2004). Thus, we perform a sample split and estimate the specification for large firms (above $2,000$ employees) and small firms (below or equal $2,000$ employees) according to our definition. Results for large firms are presented in the following Table 9 and for small firms in Table 10.

Table 9: Results for 'large firms' $> 2,000$ employees

	Labor share			
	OLS	Random effects	Fixed effects	System-GMM
Variables	(1)	(2)	(3)	(4)
Lag labor share				.423*
				(.230)
Hartz IV	-.025**	-.023***	-.026***	-.053**
	(.013)	(.009)	(.009)	(.024)
Industry fixed effects	✓	✓	✓	✓
Time fixed effects	✓	✓	✓	✓
R^2	.173	.148	.111	
No. of instruments				107
AR1 (p-value)				.006
AR2 (p-value)				.304
Hansen-J (p-value)				.154
Observations	11,940	11,940	11,940	5,709

Notes: This table shows results from estimating Equation (20) for 'large firms' $> 2,000$ employees. The data is based on the "dafne" dataset compiled by Bureau van Dijk; years 2000 − 2011. The labor share is calculated as $LS_t = \frac{W_t L_t}{Y_t}$ as explained in Section 3. (Hansen 1982) test is applied to check for over-identifying restrictions, and tests for first AR(1) and second-order AR(2) auto-correlation are provided (Arellano & Bond 1991). Firm-level clustered standard errors in combination with Windmeijer (2005) finite sample correction in parentheses. *, **, and *** denote statistical significance at the .1, .05 and .01 level respectively.

As shown in both tables, there is indeed evidence according to the 'superstar' hypothesis

Table 10: Results for 'small firms' $\leq 2,000$ employees

	Labor share			
	OLS	Random effects	Fixed effects	System-GMM
Variables	(1)	(2)	(3)	(4)
Lag labor share				.573*
				(.332)
Hartz IV	.004	-.002	-.005	-.023
	(.013)	(.009)	(.009)	(.016)
Industry fixed effects	✓	✓	✓	✓
Time fixed effects	✓	✓	✓	✓
R^2	.163	.148	.099	
No. of instruments				103
AR1 (p-value)				.019
AR2 (p-value)				.973
Hansen-J (p-value)				.443
Observations	26,868	26,868	26,868	18,564

Notes: This table shows results from estimating Equation (20) for 'small firms' $\leq 2,000$ employees. The data is based on the "dafne" dataset compiled by Bureau van Dijk; years 2000 – 2011. The labor share is calculated as $LS_t = \frac{W_t L_t}{Y_t}$ as explained in Section 3. (Hansen 1982) test is applied to check for over-identifying restrictions, and tests for first AR(1) and second-order AR(2) auto-correlation are provided (Arellano & Bond 1991). Firm-level clustered standard errors in combination with Windmeijer (2005) finite sample correction in parentheses. *, **, and *** denote statistical significance at the .1, .05 and .01 level respectively.

as outlined in De Loecker et al. (2020); Autor et al. (2020), that the decline in the labor share is mostly driven by large firms. We find more pronounced effects in Table 9 for large firms compared to the point estimates in Table 8. Moreover, our results show that the decline in the labor share is indeed not driven by small firms since there is no effect discernible. Point estimates within each table, however, are quite consistent among the estimated OLS, fixed effects as well as System GMM specifications.

6 Conclusion

In this paper we investigate the relevance of bargaining institutions for the decline in the German labor share. The Hartz IV reform, enacted in Germany in the year 2005 provides a unique exogenous reform shock which allows us to estimate the impact of a reduction in the outside option in wage bargaining. Since the reform reduces long-term unemployment benefits for all workers in Germany, the threat point in bargaining between unions and employers is reduced and the threat of unemployment is more severe. We first present a simple bargaining model in which we analyze the relevance of the reduction in the outside option for the decline of the labor share. The model implies that rents are generated within a firm duopoly in which a union is the bargaining partner. Furthermore, the model connects the wage which is bargained for and the alternative wage which is exogenously reduced because of the Hartz IV reform.

The empirical part consists of three parts. We first combine the EU KLEMS, Penn World Tables and OECD STAN databases to identify the Hartz reforms as a significant structural break in the time series of the labor share. We therefore apply a variety of endogenous change point tests for single as well as multiple breakpoints, in which the tests reveal the Hartz reforms as a significant structural break in the labor share. They additionally point to the fact that, besides the Hartz IV reform, the reunification of East and West German is also an interesting factor worth considering with respect to the labor share. Second, estimates on the aggregated labor share imply that the Hartz IV reform shock reduces the labor share by around two percentage points, in particular after the first five years after the reform was implemented. Using a synthetic control approach to construct a counterfactual Germany doppelganger for drawing causal conclusions, we provide evidence that the effect is persistent. In a final robustness section, we additionally use rich firm-level panel data compiled by Bureau van Dijk in combination with fixed effects and System GMM estimation techniques to support the previous findings on the aggregated labor share. We therefore contribute to the burgeoning literature regarding the labor share in the context of technological progress, globalization and mark-ups stemming from increasing market concentration. In this context, using a unique exogenous reform shock we therefore provide novel evidence of the effects of a reduction in bargaining power and the share of labor.

Besides the endogenously identified Hartz reforms in the labor share series and the application of recent econometric methods in the area of program evaluation, our study is not without limitations. First, there is a debate regarding the measurement of the labor share in which the income of self-employed and real estate income is often neglected (e.g. Cette et al. 2020). With respect to the database, our data includes income of the self-employed but does not take revenues from real estate into account. Second, because of data limitations, our time series for the construction of the synthetic Germany is slightly shorter compared to the time series which only considers Germany.

With respect to policy implications, we provide a missing link for the effects on the labor share. Whereas studies as, for example, De Loecker et al. (2020) investigate the relevance of decreasing competition and thus an increase in power and mark-ups for the decrease in labor share, we provide evidence from a different direction. Our results show that also the decrease in unionization and thus bargaining power to increase the wage over its marginal product is reduced. Further studies in this context (e.g. Stansbury & Summers 2020) even argue that the decline in worker power is the major aspect of structural changes in the labor share. For Germany, the decline in unionization and representation of workers by co-determination rights on the establishment level, as mentioned, for example, by Addison et al. (2017), should therefore be in the focus of research on developments of the labor share. In summary, our study adds knowledge to the burgeoning literature on determinants of the labor share. Besides technological progress, globalization and mark-ups, we show within a bargaining framework the relevance of changes in the threat point or outside option, which has been neglected so far.

To this end, additional research might be helpful to investigate the reform effect on different kinds of employment such as temporary or marginal employment. Furthermore, future work should address the question of how to estimate the labor share more precisely and consistently within and between countries. Since the relevance and interest in technological progress and union power seems likely to increase in the future, more studies are to be expected on this topic.

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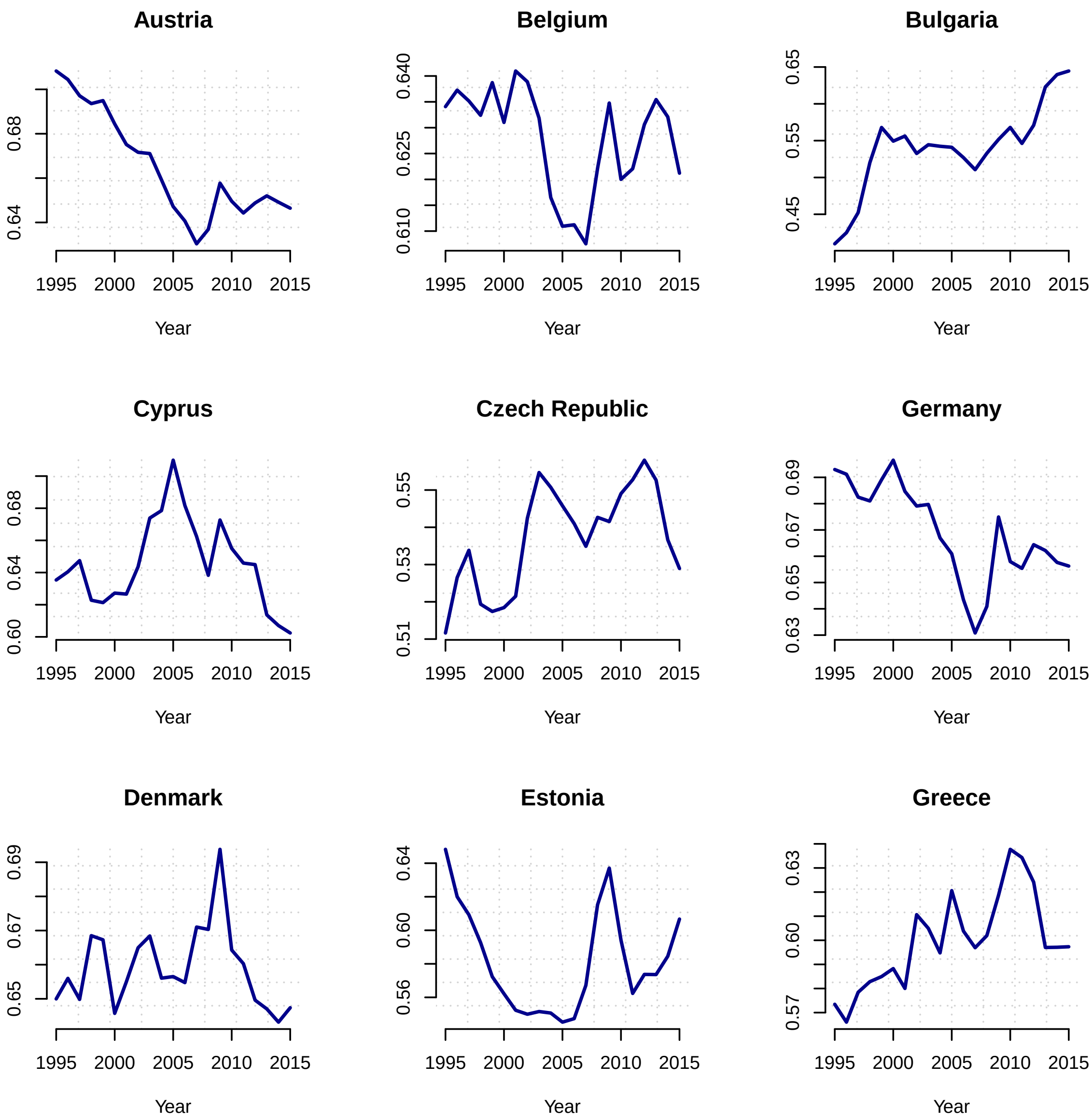
A Appendix

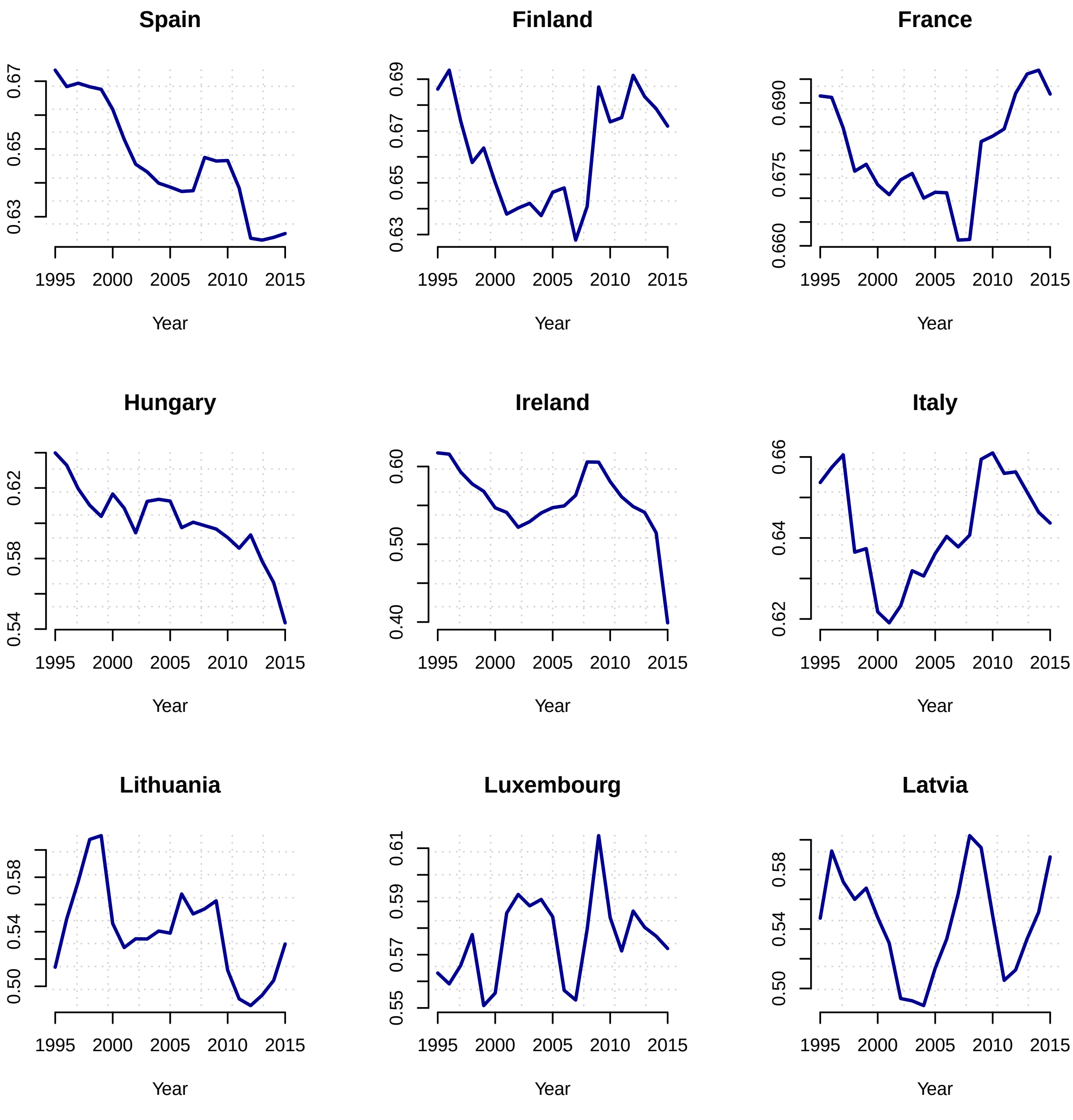
A.1 Figures

Figure A.1: Labor share for different countries



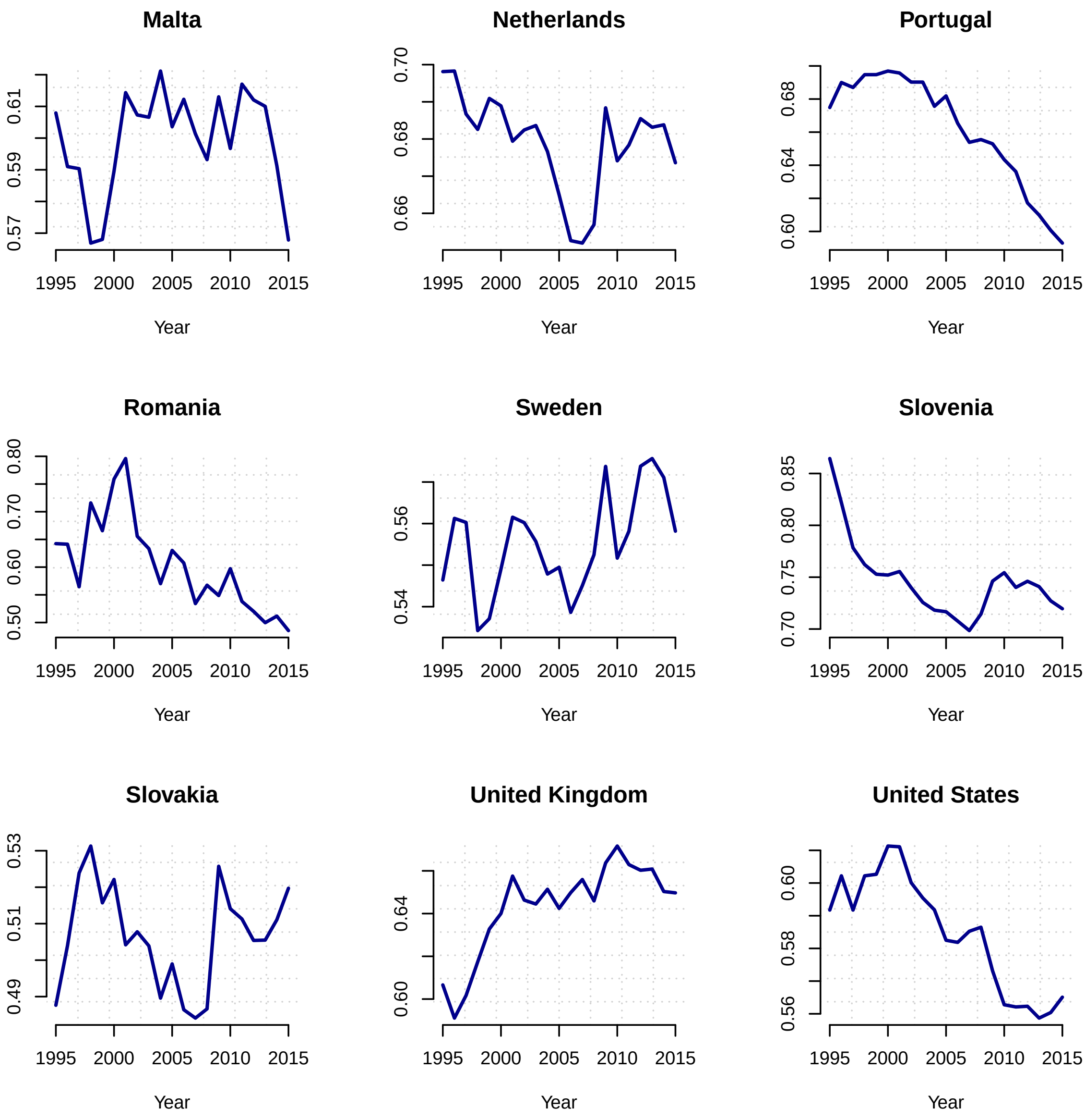
Notes: The figure plots the labor share for different countries between 1995 and 2015. The labor share is calculated as $LS_t = \frac{W_t L_t}{Y_t}$ which is the total compensation of employees in the economy in relation to gross valued added. Data from the EU KLEMS release 2019. For an overview of variable construction and methodology see Stehrer et al. (2019).

Figure A.2: Labor share for different countries: *continued*



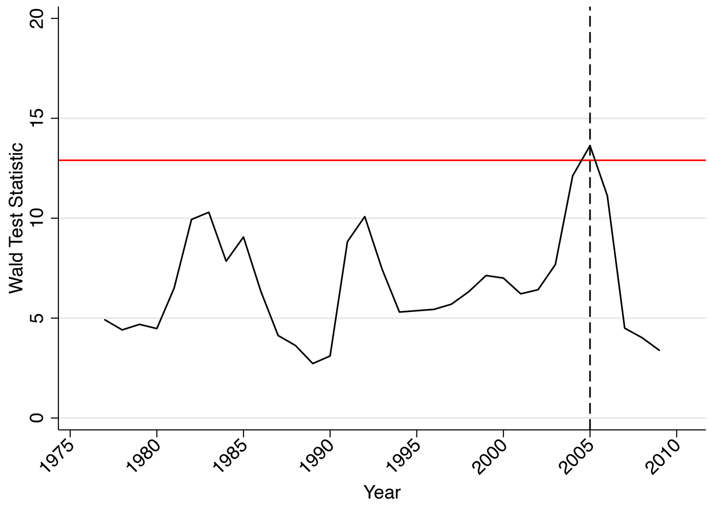
Notes: The figure plots the labor share for different countries between 1995 and 2015. The labor share is calculated as $LS_t = \frac{W_t L_t}{Y_t}$ which is the total compensation of employees in the economy in relation to gross valued added. Data from the EU KLEMS release 2019. For an overview of variable construction and methodology see Stehrer et al. (2019).

Figure A.3: Labor share for different countries: *continued*



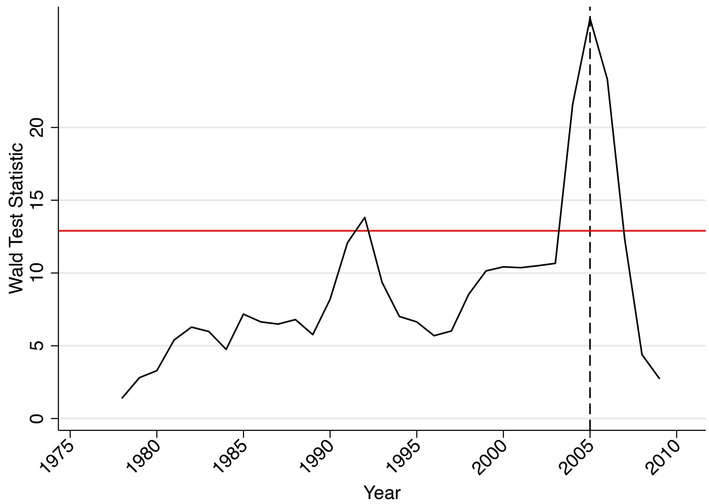
Notes: The figure plots the labor share for different countries between 1995 and 2015. The labor share is calculated as $LS_t = \frac{W_t L_t}{Y_t}$ which is the total compensation of employees in the economy in relation to gross valued added. Data from the EU KLEMS release 2019. For an overview of variable construction and methodology see Stehrer et al. (2019).

Figure A.4: Wald test robustness I



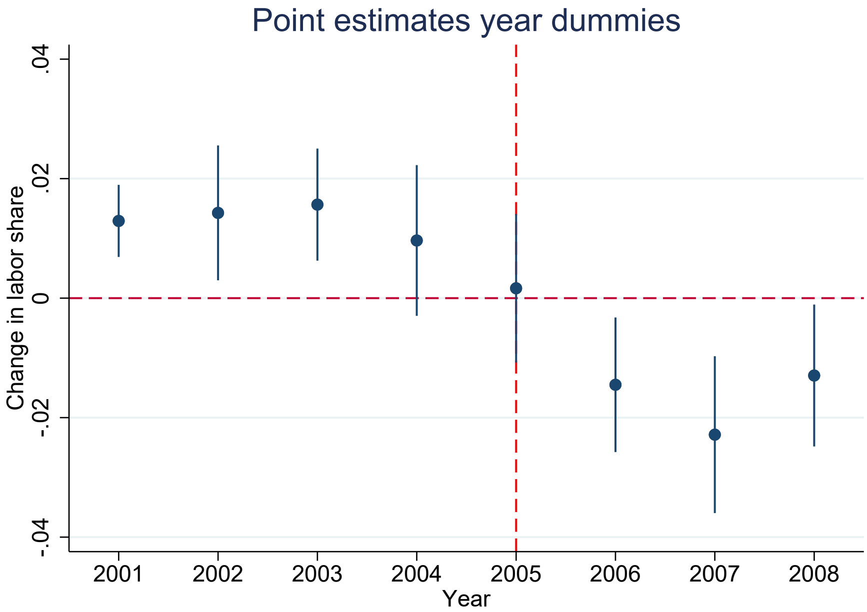
Notes: The figure shows values of the Wald test statistics as outlined in Equations (15) and (16). Regression includes the number of strike days as well as the unemployment rate as additional control variables. Test for a change point in the mean of the labor share (LS_t) in year τ between $t = 1, \ldots T$ where $t = 1977$ and $T = 2009$. The labor share is calculated as outlined in Equation (14). The blue line shows the values of the test statistics. The maximum value (sup Wald) of the Wald test statistic is 13.63 which occurred in 2005, which is exactly the mid-point of the Hartz legislation. The red line indicates the critical value of the test statistics as provided by Andrews (1993, 2003). Values of the test statistics are provided in Table 1. We trim 15 percent from both ends of the sample to ensure that the test has sufficient power.

Figure A.5: Wald test robustness II



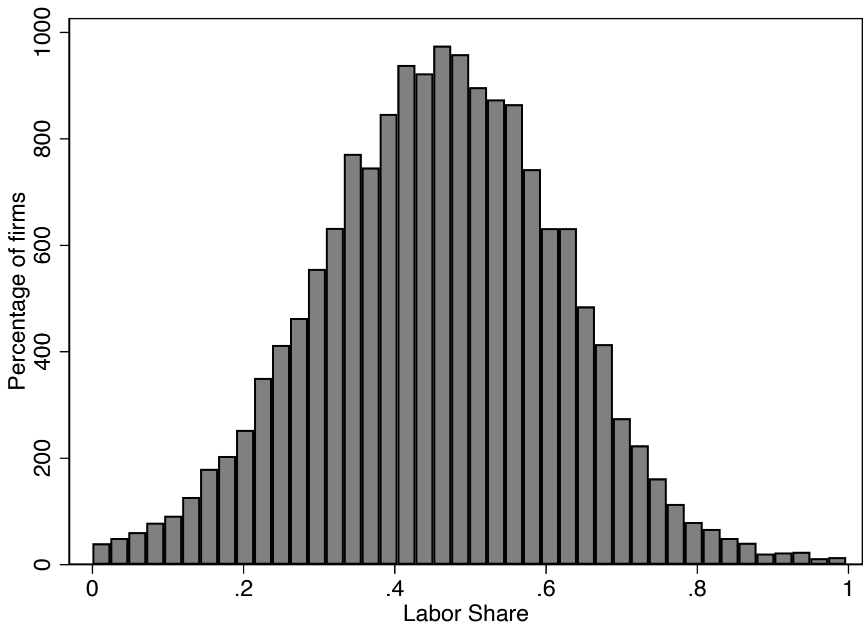
Notes: The figure shows values of the Wald test statistics as outlined in Equations (15) and (16). Regression includes the number of strike days, unemployment rate as well as GDP growth as additional control variables. Test for a change point in the mean of the labor share (LS_t) in year τ between $t = 1, \ldots T$ where $t = 1977$ and $T = 2009$. The labor share is calculated as outlined in Equation (14). The blue line shows the values of the test statistics. The maximum value (sup Wald) of the Wald test statistic is 27.48 which occurred in 2004, which is exactly the mid-point of the Hartz legislation. The red line indicates the critical value of the test statistics as provided by Andrews (1993, 2003). Values of the test statistics are provided in Table 1. We trim 15 percent from both ends of the sample to ensure that the test has sufficient power.

Figure A.6: Hartz IV Dummy variable point estimates



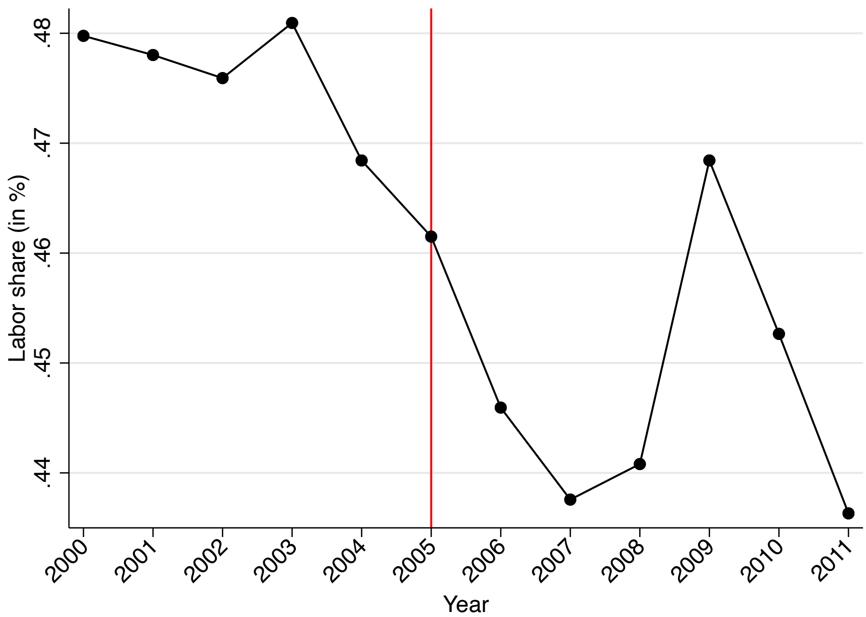
Notes: The figure plots the point estimates from regressing the labor share on all control variables and year dummies as outlined in Equation (18).

Figure A.7: Distribution of the firm-level labor share



Notes: The figure plots the firm-level labor share. The data is based on the "dafne" dataset compiled by Bureau van Dijk; years 2000 – 2011.

Figure A.8: Development of the firm-level labor share



Notes: The figure plots the development of the firm level labor share. The data is based on the "dafne" dataset compiled by Bureau van Dijk; years 2000 – 2011.

A.2 Tables

Table A.1: Description, Explanation and Source of Variables

Variable	Description and Explanation
Dependent Variable	
Labor share	*Source: EU KLEMS; Bureau van Dijk* $$LS_t = \frac{W_t L_t}{Y_t}$$ Which is labor compensation $W_t L_t$ in relation to gross value added Y_t at year t in the corresponding country.
Control Variables	
Share of gross capital formation	*Source: Penn World Tables 9.0.* The share in relation to GDP measures the stock in real capital within a country.
Share of government consumption	*Source: Penn World Tables 9.0.* The share in relation to GDP measures the government consumption within a country.
Share of exports	*Source: Penn World Tables 9.0.* The share in relation to GDP measures the exports within a country.
Share of import	*Source: Penn World Tables 9.0.* The share in relation to GDP measures the imports within a country.
Human capital index	*Source: Penn World Tables 9.0.* The human capital index is based on average years of schooling as calculated in Barro & Lee (2013) in combination with an assumed rate of return to education stemming from a Mincer equation as defined in Psacharopoulos (1994). See also the more comprehensive and detailed definition In the PWT Definition File.
Unemployment rate	*Source: The World Bank.* Unemployment is the share of the labor force that is without work but available for work and seeking employment.
Trade union density	*Source: OECD STAN.* Members of trade unions compared to total employment within in defined industry.

Other variables are drawn from the 'dafne' dataset compiled by Bureau van Dijk. Description as outlined in Section 5. See Section A.3 for the construction of the union density.

A.3 Construction of the industry union density measure

Data For the construction of the union density measure on the industry level we use the number of trade union members as provided by the German trade union association as well as the EU KLEMS data set for information regarding the number of employees in every industry.

Calculation For the calculation we performed the following steps.

- Trade unions must be assigned to the sectors in order to obtain a specific degree of organization. The constitutions (*Satzungen*) of the DGB trade unions were reviewed and the organizational areas listed were assigned to the respective sectors.
- The degree of organization is recorded as a ratio. This involves dividing the number of union members in a specific union in a year by the number of employees in all industries in a year in which the union is active. A major problem here is that some industries have more than one union. In such cases, the employees in an industry are divided by the number of relevant unions.
- This calculation results in what is known as the gross degree of organization, since union members also include those who have left the labor force.
- The degree of organization calculated for a union as an average across all sectors (relevant for the respective union) is assigned to the sectors in the next step. For example, if the union *IG Metall* is relevant in some sectors for examples 1 and 2, the same degree of organization is found in both sectors. If several unions are represented in these industries, the unweighted average of the n unions is used.
- The gross degree of organization for industry j at time t and union i is then calculated as:

$$Org_{jt}^{gross} = \frac{M_{it}}{\left[\sum_{j=1}^{K} \left(\frac{1}{n} B_{jt}\right)\right]} \tag{21}$$

  where M is the number of union members in a given trade union, B the number of employees in an industry and K the number of industries which are represented by trade union i and finally n is the number of trade unions in a given industry j.