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WHY HAS INCOME INEQUALITY IN GERMANY INCREASED FROM 2002 TO 2011? A BEHAVIORAL MICROSIMULATION DECOMPOSITION

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This paper proposes a method to decompose changes in income inequality into the contributions of policy changes, wage rate changes, and population changes while considering labor supply reactions. Using data from the Socio-Economic Panel (SOEP), this method is applied to decompose the increase in income inequality in Germany from 2002 to 2011, a period that saw tax reductions and a controversial overhaul of the transfer system. The simulations show that tax and transfer reforms have had an inequality-reducing effect as measured by the mean log deviation and the Gini coefficient. For the Gini, these effects are offset by labor supply reactions. In contrast, policy changes explain part of the increase in the ratio between the 90th and the 50th income percentiles. Changes in wage rates have led to a decrease in income inequality. Thus, the increase in inequality was due to changes in the population.

JEL Codes: D31, I38, J31

Keywords: inequality, decomposition, labor supply, microsimulation, policy reform

1. INTRODUCTION

Income inequality increased considerably in Germany from 2002 to 2011. The Gini coefficient of equivalized net household income increased from 28.5 to 29.5 (own calculation). From a policy perspective, it is important to learn about the determinants of increasing income inequality, in order to take appropriate countermeasures; for example, if policy reforms have had an inadvertent inequality-increasing effect. The time span from 2002 to 2011 is particularly interesting regarding the interaction of inequality and tax and transfer policy, as it witnessed a strong increase in inequality as well as major reforms to the tax and transfer system: the controversial Hartz IV reforms of the transfer system, as well as part of the phasing in of major tax reforms, started in 2001. Increasing wage dispersion is another potential explanation for the increase in income inequality. These potential factors in increasing inequality are described in detail in Section 3.

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The aim of this study is to quantify the impact of policy reforms, changes in conditional wage rates, and remaining changes of the population on income inequality. To allow for the joint analysis of these factors, the decomposition framework by Bargain (2012a, b) is extended to explicitly account for the effect of changes in conditional wage rates in the spirit of Bourguignon *et al*. (2008). The decomposition method combines microsimulation, a structural labor supply model, and the construction of counterfactual wage rates using Mincer-style wage regressions. The decomposition is done in an entirely disaggregated way that is not limited to a specific class of inequality indices. It allows for the graphical representation of counterfactual distributions. Marginal effects of particular factors on inequality are calculated by comparing actual and counterfactual distributions and thus can be interpreted as *ceteris paribus* changes unconfounded by demographic or business cycle changes. The decomposition method is explained in Section 3.

This study contributes to the literature on the decomposition of differences between two income distributions and in particular to the literature using microsimulation techniques. Bargain and Callan (2010), Bargain (2012b), Liégeois and Dekkers (2014), and Bargain *et al*. (2017) simulate counterfactual net incomes by applying the tax and transfer system of a given period to the population of another period using a detailed tax and transfer calculator to obtain intermediate distributions. Creedy and Herault (2011) and Bargain (2012a) expand the microsimulation approach by simulating counterfactual labor supply decisions. Bargain *et al*. (2015) simulate responses of taxable income. Herault and Azpitarte (2016) allow for the simulation of a wide range of additional determinants. The study at hand combines the simulation of counterfactual labor supply with the prediction of counterfactual wages following Bourguignon *et al*. (2008), akin to the decomposition method introduced by Blinder (1973) and Oaxaca (1973). As pointed out by Bourguignon *et al*. (2008), the combination of strictly parametric techniques offers the advantage of a straightforward economic interpretation (see also Brewer and Wren-Lewis 2015; Herault and Azpitarte 2016).

Apart from the method, the analysis conducted in this study adds to a developing literature on the causes of increases in income inequality in Germany in recent years (Arntz *et al*. 2007; Biewen and Juhasz 2012; Peichl *et al*. 2012; Biewen *et al*. 2016; Bargain *et al*. 2017). These studies are summarized in the next section.

The results are presented in Section 5. The decomposition shows that changes of the tax and transfer system have slightly alleviated inequality as measured through the Gini index and the mean log deviation (MLD). The negative effect of policy changes on the Gini is offset by labour supply reactions. In contrast, policy changes have led to an increase in the ratio between the 90th and the 50th income percentiles (Q90/50). The overall effect of changes in wage rates on inequality is found to be negative. Thus, the overall increase in income inequality was caused by changes in characteristics of the population that are not explicitly modeled; for example, in the household structure.

2. Previous Studies on Germany

A few papers decompose the overall change in income inequality in Germany between two periods into different factors. Table 1 summarizes the methods

TABLE 1
OVERVIEW OF PREVIOUS STUDIES ON GERMANY

	Biewen and Juhasz (2012)	Biewen *et al.* (2016)	Peichl *et al.* (2012)	Bargain *et al.* (2017)	Arntz *et al.* (2007)
Periods	1999/2000–2005/2006	2005/2006–2010/2011	1991–2007	2008–2013	2003–2005[a]
Policy changes	0 (transfer); + (tax)[b]	– (transfer); 0 (tax)		0	0 (total population); – (transfer recipients)
Method	Taxes: estimation of tax schedule with polynomial; transfers: microsimulation			Microsimulation	Microsimulation with labor supply simulation
Household structure	+	0	+ (MLD)		
Method	Reweighting of households with types distinguished by number of adults and children and whether adults are pensioners		Subgroup decomposition by number of adults and children[c]		
Household characteristics	0	+			
Method	Reweighting along household members' characteristics				
Labor supply	+	0	+ (MLD)		
Method	Reweighting along household members' employment outcomes conditional on household characteristics		Subgroups additionally defined by number of employed individuals[d]		
Labor market returns	+	– (Theil)			
Method	Linear prediction of log household labor income conditional on household characteristics and employment				

Notes:. Effect on the Gini coefficient, unless otherwise noted: +, inequality increase; –, inequality decrease; 0, very small or insignificant effect.
[a]*Ex ante* analysis of 2005 *transfer* reforms only.
[b]No significant effect of taxes conditional on all other effects.
[c]Reweighting along subgroups yields similar results.
[d]The employment effect is not disentangled from the effect of changes in the household structure.

and results of these studies. Biewen and Juhasz (2012) apply a reweighting technique (DiNardo *et al.* 1996) along with parametric techniques to study the rise of income inequality from 1999/2000 to 2005/2006. They find that changes in household characteristics as well as changes in the transfer system have had a minor effect. Changes in household structure, labor market returns, conditional employment outcomes, and changes in the tax system have led to an increase in income inequality. Their measure of conditional labor market returns is not limited to the effect of wage changes but, given their broad definition of employment outcomes, includes hours adjustments. Biewen *et al.* (2016) carry out a similar analysis for the periods 2005/2006 to 2010/2011. They find that income inequality did not increase in this period. While inequality in individual monthly labor incomes increased, changes in conditional annual labor market returns had no significant impact on the Gini, but led to a decrease in the Theil index. The impact of changes in capital returns is found to have had a negligible effect on income inequality.

Peichl *et al.* (2012) use subgroup decomposition and reweighting to quantify the impact of changes in household size and employment outcomes on the increase of income inequality from 1991 to 2007. They find that the decreasing average household size in Germany is associated with an increase in inequality. Bargain *et al.* (2017) focus on static policy effects for the period 2008 to 2013. Here, policy changes have had no effect on overall inequality and a positive effect on poverty measures. Arntz *et al.* (2007) conduct an *ex ante* study of the distributional effect of the 2005 Hartz IV reform of the transfer system described in Section 4. They find no direct effect of the reform on the Gini coefficient, while some other inequality measures decreased. For people directly affected by the reform, the changes in the transfer system have led to a substantial decrease in the Gini coefficient.

The present paper is the first to estimate the effect of tax and transfer reforms in Germany on inequality taking labor supply reactions into account. It is also the first to evaluate the impact of conditional hourly wage rates.

3. Factors in Increasing Inequality

3.1. *Policy Changes*

Figure 1 shows marginal income tax rates for a single household for the years 2002 and 2011 as well as 2004 and 2005. The figure was constructed using the STSM (Steuer-Transfer-Simulations-modell, see Steiner *et al.* 2012), a tax and transfer microsimulation model for Germany. Note that the aim of this paper is to estimate the effect of the overall change in the tax and transfer system. Therefore the "intermediate" tax schedules of 2004 and 2005 are displayed as additional information, but are not used for the construction of counterfactual distributions. For all levels of gross income, the marginal income tax rate for 2011 is lower than the one in 2002. The initial marginal tax rate was decreased gradually from 19.9 percent to 14 percent in 2009. The top marginal tax rate applicable for incomes exceeding €55,008 (year 2002) was decreased gradually from 49 percent to 42 percent in 2005 and the top marginal tax rate income threshold was decreased to €52,151 (2004). In 2007, the so-called rich people's tax of 45 percent

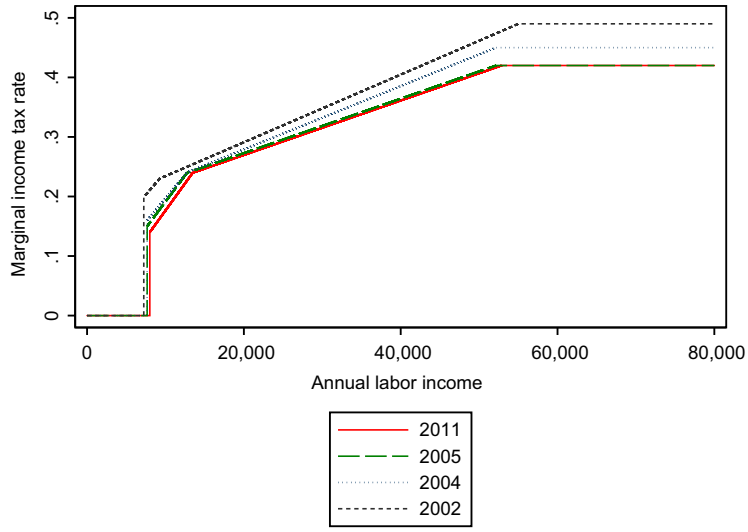

Figure 1. Marginal Income Tax Rates for a Single Household [Colour figure can be viewed at wileyonlinelibrary.com]

for gross incomes exceeding €250,000 per year came into force (not displayed in Figure 1). Additionally, the size of the tax brackets was regularly adjusted slightly to account for inflation. Previously, capital income was part of the income tax base: the year 2009 saw the introduction of a capital income tax of 25 percent, leading to a tax reduction for earners of capital income with a marginal income tax rate exceeding this figure.

The transfer system has been radically overhauled in the course of the Hartz IV reform. While the short-term unemployed are generally entitled to a transfer called Unemployment Benefit (colloquially referred to as "Unemployment Benefit I"),[1] two kinds of means-tested transfers existed for the long-term unemployed before the reform: Unemployment Assistance, which amounted to 53 percent of previous labor income (57 percent if a child lived in the household) and Social Assistance covering the social existence minimum. In 2005, these two transfers were replaced with the so-called Unemployment Benefit II, which only ensures the social subsistence minimum. Individuals deemed able to participate in the labor market were subject to these changes. Former recipients of Unemployment Assistance experienced a potentially severe reduction of income due to the introduction of Unemployment Benefit II. The aim of the reform in this regard was to improve incentives for the unemployed to accept job offers. However, the level of Unemployment Benefit II is slightly higher than Social Assistance, so that former

[1] The period of entitlement to this transfer was reduced from up to 36 months to 12 months and 18 months for individuals over 55 years of age. The entitlement period for the elderly was further increased in 2006 and in 2008. In 2011, the maximum entitlement period for individuals of at least 58 years of age was 24 months. Compared to the year 2002, this still means a reduction in the maximum entitlement period and could potentially have led to an increase in inequality.

recipients of the latter were better off. Overall, the Hartz IV reform has led to an increase in government spending (Biewen and Juhasz 2012) and an *ex post* evaluation has shown that the average equivalized net income of previous recipients of Unemployment Assistance was higher a year after the reform than before (Bruckmeier and Schnitzlein 2007). As this reform of the transfer system implied lower transfers for some and higher transfers for others, the distributional effect is *a priori* ambiguous.

In both years, marginal employment (so-called "mini jobs" for gross incomes of up to €325 per month in 2002 and €400 in 2011) was exempted from taxes and social security contributions. However, in 2002, when gross income exceeded the threshold for marginal employment, the average social security contribution rate paid by employees jumped from 0 to the full rate of regular jobs. This implied negative incentives for the marginally employed to work slightly more. Since 2003, average social security contributions paid by employees have been increasing slightly with increasing gross income until they reach 20 percent at a monthly gross income of €800 (year 2011). Jobs with gross incomes in this range are called "midi jobs."

Finally, the Citizen Relief Act (the *Bürgerentlastungsgesetz*)—in effect since July 2010—has brought about an increase in the possible tax allowances for insurance premia. Overall, tax reforms in the analyzed time span have produced lower marginal tax rates both at the upper and at the lower end of the income distribution, so the distributional effect is unclear *a priori*. If the substitution effect dominates the income effect, decreased marginal tax rates lead to increases in labor supply over the entire distribution. On the other hand, increased generosity of transfers for the long-term unemployed implies lower labor supply incentives for this group. This is expected to have an inequality-increasing effect.

Figure 2 shows the change in the budget constraint for a single household without children and without wealth.[2] For low values of labor income, the household is eligible for Social Assistance in 2002 and for Unemployment Benefit II in 2011. Only labor income is varied along the horizontal axis and the corresponding net income is displayed on the vertical axis. In contrast to Figure 1, which shows marginal income tax rates, Figure 2 additionally accounts for transfers and social security contributions. For low levels of gross labor income, the transfer received in the 2011 regime is far more generous. The lower marginal tax rates for 2011 translate into a steeper slope of the budget constraint starting at an annual gross income of about €20,000.

3.2. *Wage Dispersion*

Wages in Germany have dispersed considerably since the 1990s (see, e.g., Fuchs-Schuendeln *et al.* 2010). Several studies attest that this is partly due to polarization, which is consistent with skill-biased technological change (see, e.g., Dustmann *et al.* 2009). However, there is less evidence for this phenomenon in the time span beginning in 2002. Therefore, it is not to be expected that changes

[2] For the 2002 budget constraint, gross labor incomes have been deflated to 2002 levels and—along with simulated net incomes—inflated back to 2011 levels.

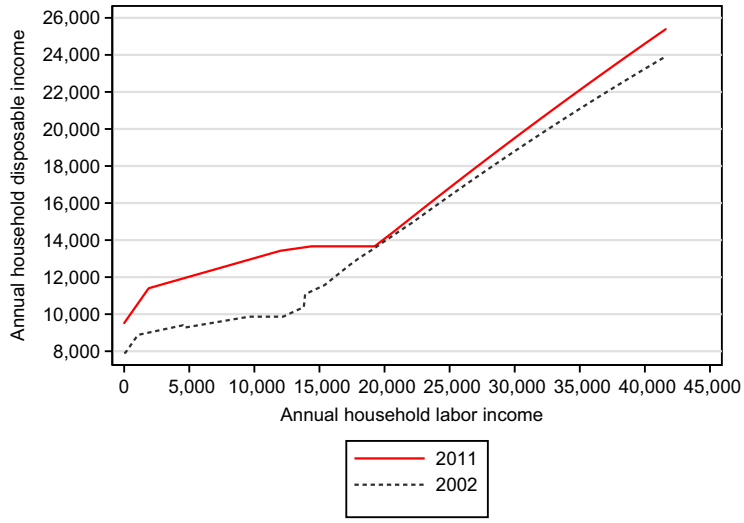

Figure 2. The Budget Constraint of a Single Household in 2011 Euro [Colour figure can be viewed at wileyonlinelibrary.com]

in conditional wage rates have led to an increase in income inequality. An alternative explanation for increasing wage dispersion is selection into employment. A recent employment boom in Germany (see, e.g., Biewen *et al.* 2016) is likely to have changed the composition of the workforce, possibly at roughly constant *conditional* wage rates.

Figure 3 depicts the estimated Epanechnikov kernel density of log hourly wage densities in the two years. Following Biewen and Juhasz (2012), a fixed bandwidth of 0.175 is used throughout the paper. It shows a marked increase in mass

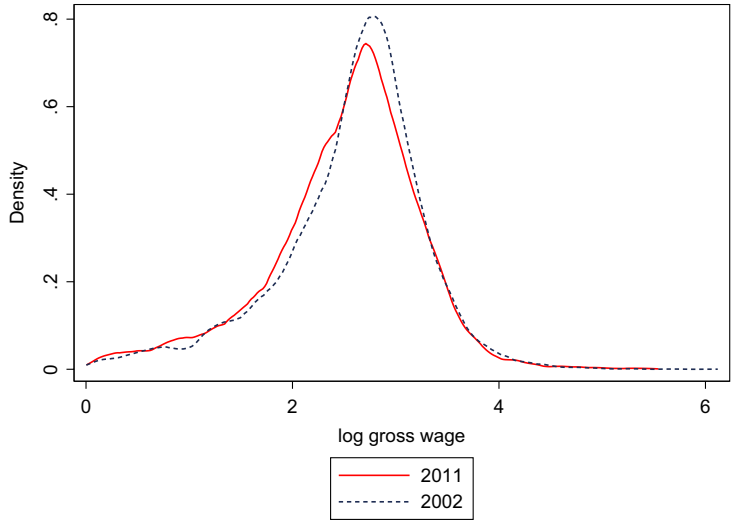

Figure 3. The Densities of the Log Hourly Wages in 2011 Euro [Colour figure can be viewed at wileyonlinelibrary.com]

at the left of the distribution from 2002 to 2011, implying a relative increase in the number of low-paying jobs. A likely explanation is the change in the composition of the workforce due to the decrease in unemployment.

4. Empirical Strategy: Decomposition

4.1. *Counterfactual Distributions and Decomposition*

The decomposition is restricted to parametric techniques that have a straightforward economic interpretation. Let y_{bd}^{ce} be a matrix that describes socio-demographic characteristics and market incomes of the people observed in period b who receive the conditional wage rates of period d with work hours given the incentives of the tax and transfer regulations of period c and the incentives given the conditional gross wages of period e. As described in Subsection 4.4, work hours are simulated conditional on the budget constraints of individuals, which in turn are determined by the tax and transfer system and the gross hourly wage. Let x_a be the tax and transfer function that translates the market income and socio-demographic characteristics into the net income of each household and denote by I an inequality index, so that $I\left(x_a\left(y_{bd}^{ce}\right)\right)$ denotes inequality in a given observed or counterfactual situation.

The decomposition relies on the construction of counterfactual net incomes for observed households. *Household* gross income is the sum of individual labor incomes L of all household members and other pre-government household income; for example, capital income.

Specifically, let $I\left(x_{2011}\left(y_{2011,2011}^{2011,2011}\right)\right)$ be an inequality index of the actually observed outcomes for 2011 and let $I\left(x_{2002}\left(y_{2002,2002}^{2002,2002}\right)\right)$ be the inequality of observed outcomes in 2002. Marginal effects are given by the change in income inequality obtained by changing one factor while keeping everything else equal.

4.1.1. The Policy Effect

The *static* marginal effect of policy changes on income inequality is

$$I\left(x_{\mathbf{2011}}\left(y_{2002,2002}^{2002,2002}\right)\right)-I\left(x_{2002}\left(y_{2002,2002}^{2002,2002}\right)\right). \tag{1}$$

The *total* policy effect is given by

$$I\left(x_{\mathbf{2011}}\left(y_{2002,2002}^{\mathbf{2011},2002}\right)\right)-I\left(x_{2002}\left(y_{2002,2002}^{2002,2002}\right)\right); \tag{2}$$

that is, the difference between actual inequality in 2002 and inequality of the counterfactual distribution, where net incomes are calculated using the 2011 tax transfer system and labor supply reactions are simulated conforming to incentives in 2011 for the 2002 sample.

To obtain this marginal effect, counterfactual gross incomes need to be calculated. For the total policy effect, the counterfactual individual labor income of a given household member is given by

$$\hat{L} = \left(\hat{h} | T_{2011}, w_{2002}, z_{2002}\right) \times w_{2002}, \tag{3}$$

where $\hat{h} | T_{2011}, w_{2002}, z_{2002}$ denotes the predicted annual hours of work given the tax and transfer system T of 2011, while the observed wage rates w and household characteristics z for the year 2002 are used. Net incomes x_{2011} are calculated applying microsimulation to gross incomes, taking into account relevant household characteristics and income sources.

4.1.2. The Wage Effect

Similarly, the *static* wage effect is given by

$$I\left(x_{2002}\left(y^{2002,2002}_{2002,\mathbf{2011}}\right)\right) - I\left(x_{2002}\left(y^{2002,2002}_{2002,2002}\right)\right). \tag{4}$$

The *total* wage effect is

$$I\left(x_{2002}\left(y^{2002,\mathbf{2011}}_{2002,\mathbf{2011}}\right)\right) - I\left(x_{2002}\left(y^{2002,2002}_{2002,2002}\right)\right), \tag{5}$$

which is the difference between the 2002 income inequality and inequality of the intermediate distribution, with wages as in 2011 predicted for all workers and labor supply adjusted according to these counterfactual wages.

Counterfactual individual labor incomes for this calculation are obtained from

$$\hat{L} = \left(\hat{h} | T_{2002}, \hat{w}_{2011}, z_{2002}\right) \times \hat{w}_{2011}. \tag{6}$$

Predicted hours of work are obtained by simulating labor supply given the counterfactual household budget constraint obtained when substituting actual hourly wages with their predicted counterparts. Counterfactual wages conditional on individual characteristics in 2002 are given by

$$\hat{w_{2011}} = c_{2002} \times \hat{\beta}_{2011} + \hat{\epsilon}_{2002}, \tag{7}$$

where the coefficients $\hat{\beta}_{2011}$ are obtained from a wage regression using the 2011 population and the c_{2002} are actual individual characteristics. $\hat{\epsilon}_{2002}$ is the readjusted residual of 2002 (for details of the entire procedure, see Subsection 4.2.).

4.1.3. The Combined Effect

The combined effect of changes in conditional wage rates and the tax and transfer system is

$$I\left(x_{\mathbf{2011}}\left(y^{2002,2002}_{2002,\mathbf{2011}}\right)\right) - I\left(x_{2002}\left(y^{2002,2002}_{2002,2002}\right)\right) \tag{8}$$

without labor supply reactions and

$$I\left(x_{\mathbf{2011}}\left(y^{\mathbf{2011},\mathbf{2011}}_{2002,\mathbf{2011}}\right)\right) - I\left(x_{2002}\left(y^{2002,2002}_{2002,2002}\right)\right) \tag{9}$$

with labor supply reactions. In this case, counterfactual labor incomes are given by

$$\hat{L} = \left(\hat{h} | T_{2011}, \hat{w}_{2011}, z_{2002} \right) \times \hat{w}_{2011}. \tag{10}$$

To give a concrete example for the procedure, the counterfactual distribution for the combined policy and wage effect including labor supply is obtained following four steps: (1) estimate the wage equation using the 2011 sample and predict counterfactual wages for the 2002 population; (2) use microsimulation to calculate the counterfactual budget constraint (i.e., net household incomes for different labor supply choices) for the 2002 population, given the 2011 tax and transfer system and 2011 wages; (3) estimate the structural labor supply model using the observed 2002 population, wages, and tax and transfer system; and (4) use these labor supply model estimates to predict labor supply choices, given the counterfactual budget constraint.

4.1.4. The Population Effect

The effect of changes in the population—that is, everything that is not explicitly modeled—is calculated by subtracting the 2002 status quo from a counterfactual distribution of the 2011 population with the counterfactual 2002 wages, tax and transfer system, and labor supply:

$$I\left(x_{2002}\left(y^{2002,2002}_{\mathbf{2011},2002} \right) \right) - I\left(x_{2002}\left(y^{2002,2002}_{2002,2002} \right) \right). \tag{11}$$

Counterfactual labor incomes for this step are given by

$$\hat{L} = \left(\hat{h} | T_{2002}, \hat{w}_{2002}, z_{2011} \right) \times \hat{w}_{2002}; \tag{12}$$

that is, the actual population of 2011, where 2002 wages are predicted and hours of work are simulated given the household budget constraint if the tax and transfer system and wages conform to 2002.

In Section 5, marginal effects of wage and policy changes are reported using the year 2002 as base, as in the above equations. As a robustness test, results using the year 2011 as base year are reported in the Appendix A (in the online Supporting Information).[3] While the interpretation of the effects of wage and policy changes is straightforward, the population effect represents a residual capturing all household characteristics that are not explicitly modeled; for example, demographic changes, changes in assortative matching, changes in the distribution of capital income, changes in education choices, and so on. Note that this effect will also

[3] Another possibility would be to calculate "intermediate contributions"; that is, to calculate the difference between two counterfactual distributions. For instance, one could first calculate the contribution of wage rate changes and in a second step calculate the contribution of tax and transfer changes *conditional on wage changes*. One could then calculate the average contribution of, for example, wage rate changes over all—essentially arbitrary—decomposition orders. Instead, this paper focuses on marginal effects, since they have a precise and intuitive economic interpretation.

capture all residual effects of potential misspecification of the different components used in the model.

4.2. *Changes in Wage Rates*

The effect of conditional wages is analyzed by running a regression of log hourly wages on years of education,[4] work experience, and experience squared, as well as years not worked in the past 10 years, to capture loss of human capital. Heckman's (1979) method is used to account for selection bias, with variables capturing the number of children, family status, and the income of other household members as exclusion restrictions. Separate regressions are run for women and men and the former East and West Germany.

The coefficients and the constant for the years 2002 and 2011 are used to predict counterfactual wages for the respective other years' populations.[5] The entire labor incomes of employees are replaced with the counterfactual predictions.

For instance, for the wage effect with base year 2002, equation (4), the hourly wages of the 2002 sample are replaced with predicted wages using coefficients of the 2011 wage regression. Following Bourguignon *et al*. (2008) and Bourguignon and Ferreira (2004), each individual's residual is multiplied by the ratio of standard deviations of residuals of the counterfactual and the observed period, and added to the deterministic (predicted) part of the counterfactual wage.[6] Gross labor incomes are calculated by multiplying the counterfactual hourly wage with actual hours of work. Counterfactual wages are only predicted for employees. For the self-employed, observed wages are used. For the status quo distribution, observed instead of predicted values are used in the analysis.

The results of the wage regressions are reported in Tables 2 and 3. The signs of the coefficients are as expected, implying positive returns to schooling, positive and decreasing returns to experience, a wage penalty to human capital loss and—if significant—a positive selection term. They offer no evidence for skill-biased technological change in the observed period; instead, the returns to schooling have decreased for all groups except East German women. However, it should be kept in mind that changes in conditional wage rates reflect changes in both labor demand—for example, because of skill-biased technological change—and labor supply. Moreover, the finding of decreasing education premia is not robust to the use of categorical education variables (see Tables A.2 and A.3), but this does not change the results regarding the impact of conditional wage changes on income inequality.

4.3. *The Tax and Transfer System: Simulated Net Incomes*

Counterfactual net incomes and budget constraints are calculated using the STSM microsimulation model: see Steiner *et al*. (2012) for additional

[4] An alternative estimation with categorical education variables is reported in Tables A.2 and A.3.

[5] 2002 wages are inflated to 2011 levels for the regressions. Counterfactual predicted wages for the 2002 sample are deflated to 2002 levels.

[6] The ratio of the standard deviations for 2002 and 2011 is 1.002, implying virtually no change in within-group wage inequality.

TABLE 2
Wage Regression, 2002

	Ln(hourly wage)			
	Men East	Women East	Men West	Women West
Years of schooling	0.066***	0.065***	0.065***	0.072***
	(0.005)	(0.007)	(0.002)	(0.004)
Years not worked	−0.150***	−0.112***	−0.095***	−0.037***
	(0.020)	(0.015)	(0.009)	(0.005)
Experience	0.054***	0.078***	0.068***	0.064***
	(0.007)	(0.008)	(0.003)	(0.004)
Experience^2/100	−0.104***	−0.164***	−0.123***	−0.128***
	(0.017)	(0.022)	(0.008)	(0.012)
Constant	1.183***	0.921***	1.444***	1.120***
	(0.101)	(0.148)	(0.045)	(0.078)
Mills	0.074	0.047	0.023	0.094*
lambda	(0.071)	(0.087)	(0.031)	(0.045)
N	2,616	2,899	7,586	8,253

Notes: Standard errors in parentheses: $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

information and Jessen *et al.* (2017) for a detailed depiction of budget constraints and marginal tax rates simulated with the STSM. The STSM covers the German tax and transfer system and accounts for deductions, allowances, social security payments, and child benefits as well as interactions of the components of the tax and transfer system. When simulating counterfactual net incomes, all monetary variables in the dataset are inflated or deflated with respect to the policy year. The simulated net incomes are then deflated or inflated back to the data year.

TABLE 3
Wage Regression, 2011

	Ln(hourly wage)			
	Men East	Women East	Men West	Women West
Years of schooling	0.055***	0.068***	0.055***	0.057***
	(0.005)	(0.006)	(0.003)	(0.003)
Years not worked	−0.137***	−0.113***	−0.146***	−0.049***
	(0.016)	(0.013)	(0.010)	(0.005)
Experience	0.071***	0.054***	0.068***	0.052***
	(0.007)	(0.007)	(0.004)	(0.004)
Experience^2/100	−0.156***	−0.106***	−0.131***	−0.095***
	(0.019)	(0.019)	(0.010)	(0.011)
Constant	1.235***	1.035***	1.486***	1.330***
	(0.090)	(0.125)	(0.047)	(0.074)
Mills	0.082	−0.001	0.097**	0.027
lambda	(0.072)	(0.072)	(0.037)	(0.046)
N	2,419	2,695	6,898	7,825

Notes: [a] Standard errors in parentheses: $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

4.4. *Behavioral Effects*

Labor supply reactions to policy and wage changes are simulated via a random utility discrete choice model, following van Soest (1995). For the estimation of the labor supply model, the sample is restricted to household heads and partners with flexible labor supply; that is, working-age individuals, excluding the self-employed, civil servants, the severely disabled, and people on parental leave. Households are assumed to jointly maximize utility, which depends on disposable household income and the leisure of the male and female partners.

The coefficients of the utility function, in turn, depend on household characteristics such as the household members' age and the number of children. Weekly labor supply is discretized into six categories for women, five for men, and thus 30 for couples, mimicking the observed distribution of labor supply. The net income for each labor supply category is calculated using the STSM. Gross labor income is given by the product of work hours and the (actual or counterfactual) hourly wage. The potential hourly wages of the unemployed are predicted using the selectivity-corrected wage regressions described above.[7] Let L_f denote the leisure of the female partner, L_m the leisure of the male partner, C consumption, and ε a random disturbance. Then, the utility of household i for choice alternative j is given by

$$V_{ij} = U(Lf_{ij}, Lm_{ij}, C_{ij}) + \varepsilon_{ij}. \tag{13}$$

The translog specification of the deterministic part of individual utility is used, allowing for interactions of the components of the utility function; that is,

$$\begin{aligned} U_{ij} = {} & \beta_1 ln(C_{ij}) + \beta_2 ln(C_{ij})^2 + \beta_3 ln(Lf_{ij}) + \beta_4 ln(Lf_{ij})^2 + \beta_5 ln(Lm_{ij}) \\ & + \beta_6 ln(Lm_{ij})^2 + \beta_7 ln(C_{ij}) ln(Lf_{ij}) + \beta_8 ln(C_{ij}) ln(Lm_{ij}) + \beta_9 ln(Lf_{ij}) ln(Lm_{ij}). \end{aligned} \tag{14}$$

Heterogeneity between households' utility functions is incorporated through taste shifters—observed household characteristics that affect some of the coefficients of the utility function:

$$\beta_1 = \alpha_0^C + X_1' \alpha_1^C,$$

$$\beta_2 = \alpha_0^{C^2} + X_2' \alpha_1^{C^2},$$

$$\beta_3 = \alpha_0^{Lf} + X_3' \alpha_1^{Lf},$$

$$\beta_5 = \alpha_0^{Lm} + X_4' \alpha_1^{Lm},$$

$$\beta_9 = \alpha_0^{LfxLm} + X_5' \alpha_1^{LfxLm}.$$

X_1, X_2, X_3, X_4, and X_5 contain individual and household characteristics such as age, disability indicators, whether the observed person is a German citizen, and the number and age of children in the household.

[7] For simulations with counterfactual wages, the wages of the employed are predicted as well: see Subsection 4.2.

The error terms ε_{ij} are assumed to be independently and identically distributed across hour categories and households according to the extreme value type I distribution. As shown in McFadden (1974), the probability that alternative k is chosen by household i is then given by

$$P_{ik} = \Pr(V_{ik} > V_{ij}, \forall j \in 1 \ldots J) = \frac{\exp(U_{ik})}{\sum_{j=1}^{J} \exp(U_{jk})}. \tag{15}$$

Alternative k is chosen if it implies a higher utility than any other alternative. Changes in net income associated with specific hours points lead to changes in the choice probabilities given by equation (15). These allow for the calculation of labor supply effects of the hypothetical tax and transfer systems or gross wages.

The estimation results and the resulting elasticities are reported in Appendix B, in Tables B.1 and B.2. The uncompensated labor supply elasticity for women in couples is particularly large and cross-wage elasticities are negligible, in line with common previous findings in the literature summarized, for example, in Blundell and Macurdy (1999).

Note that the model assumes constant wage rates. In practice, increases in labor supply lead to decreases in market wage rates, which, in turn, lead to decreases in labor supply. Neglecting this effect is likely to lead to an overestimation of labor supply effects. However, as will be seen, estimated labor supply reactions to policy and wage changes are small. Therefore, equilibrium effects are likely limited.

4.5. *Data*

This study is based on the Socio-Economic Panel (SOEP), a yearly representative survey of German households (for further information, see Wagner *et al.* 2007). The concept of income in this study is yearly equivalent post-government income. Like most surveys, the SOEP does not capture the very top of the income distribution. Bach *et al.* (2009) combine the SOEP with income tax return data to cover the entire distribution of market incomes until the year 2003. They find that the SOEP serves reasonably well to describe the evolution of income inequality as measured with the inequality indices used in this study, while it fails to describe the change of the top-focused entropy index GE(2). Table 4 shows descriptive statistics for the most important variables for the years 2002 and 2011. The means of net household income as well as personal net income equivalized according to the OECD modified equivalence scale[8] have increased from 2002 to 2011. The SOEP provides information for weekly work hours and for annual labor incomes. Annual work hours are given by 52 times weekly work hours and hourly wages are calculated by dividing annual labor income by annual work hours. Counterfactual labor incomes as predicted by the labor supply model are obtained by multiplying the hourly wage by the counterfactual weekly hours of work times 52. Average hourly wages and hours of work, as well as the numbers of adults and children per household, decreased slightly from 2002 to 2011.

[8] That is, net household incomes are divided by 1 plus 0.5 for each additional adult and 0.3 for each child under 14 years.

TABLE 4
Descriptive Statistics

	2002		2011	
	Mean	SD	Mean	SD
Net household income	36,856.27	24,821.02	37,405.98	31,402.50
Equivalent net income	20,933.44	12,617.48	21,712.71	16,864.70
Hourly gross wage	15.89	12.45	15.24	12.73
Weekly work hours	36.35	12.30	35.89	12.57
Years of education	11.04	3.64	11.44	3.85
Household members with age >13	2.18	0.93	2.14	0.95
Children in household	0.59	0.92	0.50	0.89
Observations	27,633		24,780	

Notes: [a] Monetary variables in 2011 real euro. Only positive wages and work hours.

5. Decomposition Results

This section shows marginal effects of wage rate and tax and transfer changes. They have been calculated as *ceteris paribus* effects of changes in labor market returns and the tax and transfer system; that is, everything is kept at the 2002 level and only one factor is changed. Following Biewen and Juhasz (2012), this comes closest to the "effect" of a particular factor. A second exercise, in which everything is kept at the 2011 level and only one factor is changed to the 2002 level, is briefly described in Subsection 5.4 and reported in Appendix A.1.

5.1. *The Policy Effect*

The solid line in Figure 4 shows the static policy effect. It is the difference between the actual estimated Epanechnikov kernel densities of log equivalized annual net income for the population of 2002 and the counterfactual distribution, where the tax and transfer system is that of 2011 but the work hours remain as in 2002. The dashed line shows the total policy effect; that is, the counterfactual distribution, where the tax and transfer system is as in 2011 and labor supply reactions to the tax and transfer changes are simulated. The 50th, 75th, and 90th percentiles of the income distribution in the status quo are labeled on the upper horizontal axis.

The static effect of policy reforms yields a decrease in density at the bottom of the distribution, which is in line with the findings of Biewen and Juhasz (2012). It can be explained by former recipients of Social Assistance receiving the more generous Unemployment Benefit II. Moreover, the density at the right of the distribution is increased due to the policy reforms—this is the effect of tax reductions. Compared to the static counterfactual, labor supply reactions to policy reforms seem to have partly offset the static effect. The density at the bottom of the distribution is closer to the status quo. In the lower half of the distribution, labor supply effects shift the distribution to the left, and between the 50th and the

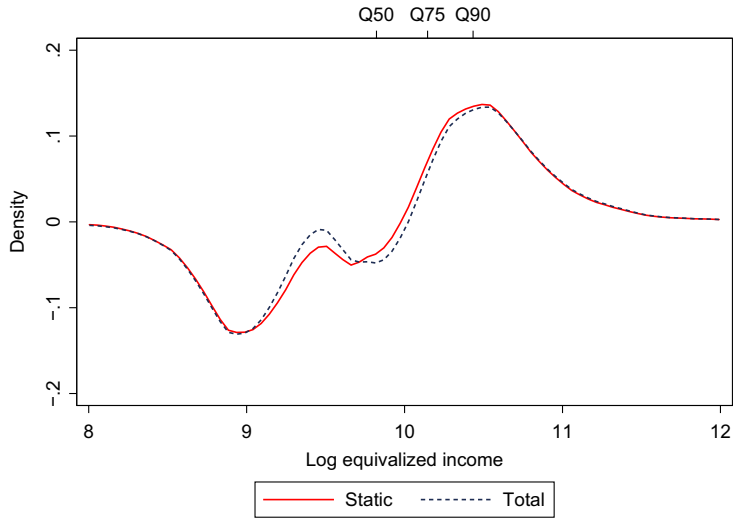

Figure 4. The Policy Effect—Base Year 2002 [Colour figure can be viewed at wileyonlinelibrary.com]

Notes: The difference between the actual distribution in 2002 and counterfactual distributions applying the 2011 tax and transfer system to the 2002 population (static; see equation (1)) and additionally simulating labor supply reactions (total; see equation (2)).

90th percentiles, labor supply leads to a shift to the right. This reflects the change in labor supply incentives: more generous transfers have decreased incentives for low-income households, while lower tax rates have increased incentives for higher-income households to work.

5.2. *The Wage Effect*

Figure 5 shows the difference between the actual log income distribution for 2002 along with counterfactual distributions applying 2011 wage rates with (dashed line) and without (solid line) labor supply reactions to wage changes. Application of the coefficients of the 2011 wage regression to the 2002 population leads to a slight shift of the distribution to the left, while the labor supply effect is negligible.

5.3. *A Summary of the Effects*

Table 5 shows the Gini along with two entropy measures, the Theil index (GE(1)) and the mean log deviation (MLD, GE(0)), as well as the ratio between the 90th and the 50th income percentiles (Q90/50) for the year 2002 (status quo) and the difference in inequality between the actual 2002 distribution and the counterfactual distributions depicted in Figures 4 and 5. Additionally, the joint effect of policy and wage changes as well as the effect of population changes are reported. Inequality indices for the status quo are calculated using actual observations, with net incomes calculated using microsimulation. Wage effects are based on wage regressions, policy effects on microsimulation, and labor supply effects on structural labor supply simulation.

The Gini index, which is sensitive to changes in the middle of the distribution, was 28.5 in 2002 and a *ceteris paribus* change to the tax and transfer system of 2011

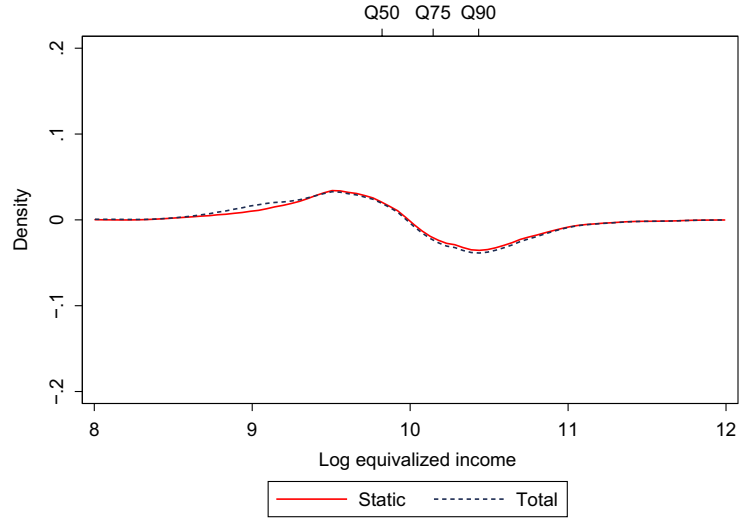

Figure 5. The Wage Effect—Base Year 2002 [Colour figure can be viewed at wileyonlinelibrary.com]

Notes: The difference between the actual distribution in 2002 and counterfactual distributions applying the 2011 conditional wage rates to the 2002 population (static; see equation (4)) and additionally simulating labor supply reactions (total; see equation (5)).

would have reduced it by 0.4. The effect on the MLD, which is more sensitive to changes at the lower end of the distribution, is also negative (−0.01). In contrast, the effect of policy reforms on the Q90/50 ratio is positive, so part of its increase can be explained by means of the policy reforms. These three effects are highly significant. In contrast, the Theil index remains unchanged.

The increased generosity of the transfer system has reduced inequality as measured by the MLD and the Gini, but this is offset by the inequality-increasing effect of tax reductions for high-income earners, when using the Theil index. Lower tax rates have led to an increase in the Q90/50 ratio. The total tax and transfer effect shows that labor supply reactions to policy changes have offset the inequality-reducing effect of policy changes as measured through the Gini. As the Gini index is sensitive to changes in the middle of the distribution, it has been substantially affected by the labor supply adjustments depicted above in Figure 4. In contrast, labor supply reactions have led to an additional increase in the Q90/50 ratio.

A change in wage rates to 2011 levels with and without behavioral adjustments would have led to slight decreases in all reported inequality indices. The inclusion of behavioral effects renders the wage effect on the MLD insignificant. The next two lines show how changes in wage rates and policy changes interact. These effects are negative as measured by the Gini, the MLD, and the Theil index. The point estimates of the total effects are closer to zero than the static effects. In contrast, the total effect of policy and wage effects on the Q90/50 ratio is positive (0.03) and statistically significant. Thus, part of the increase in this measure is explained through wage and policy changes.

Overall, the decomposition shows that the policy changes from 2002 to 2011 have reduced inequality (Gini index and MLD) and that this reduction was partly

TABLE 5
Decomposition with Base 2002

Marginal effect		Gini	Theil	MLD	Q90/50
$x_{2002}(y^{2002,2002}_{2002,2002})$	Status quo	28.5***	0.144***	0.143***	1.82***
		(0.323)	(0.005)	(0.004)	(0.020)
$x_{\mathbf{2011}}(y^{2002,2002}_{2002,2002})$ $-x_{2002}(y^{2002,2002}_{2002,2002})$	Static tax and transfer	−0.4*** (0.108)	0.00 (0.002)	−0.010*** (0.002)	0.026*** (0.009)
$x_{\mathbf{2011}}(y^{\mathbf{2011},2002}_{2002,2002})$ $-x_{2002}(y^{2002,2002}_{2002,2002})$	Total tax and transfer	0.0 (0.130)	0.002 (0.002)	−0.008*** (0.003)	0.044*** (0.010)
$x_{2002}(y^{2002,2002}_{2002,\mathbf{2011}})$ $-x_{2002}(y^{2002,2002}_{2002,2002})$	Static wage	−0.4*** (0.090)	−0.004*** (0.001)	−0.003** (0.001)	−0.021*** (0.001)
$x_{2002}(y^{2002,\mathbf{2011}}_{2002,\mathbf{2011}})$ $-x_{2002}(y^{2002,2002}_{2002,2002})$	Total wage	−0.3*** (0.113)	−0.003** (0.002)	−0.002 (0.002)	−0.024** (0.010)
$x_{\mathbf{2011}}(y^{2002,2002}_{2002,\mathbf{2011}})$ $-x_{2002}(y^{2002,2002}_{2002,2002})$	Static wage and tax transfer	−1.0*** (0.146)	−0.006*** (0.0022)	−0.016*** (0.002)	0.010 (0.012)
$x_{\mathbf{2011}}(y^{\mathbf{2011},\mathbf{2011}}_{2002,\mathbf{2011}})$ $-x_{2002}(y^{2002,2002}_{2002,2002})$	Total wage and tax transfer	−0.7*** (0.158)	−0.003 (0.002)	−0.013*** (0.002)	0.030** (0.013)
$x_{2002}(y^{2002,2002}_{\mathbf{2011},2002})$ $-x_{2002}(y^{2002,2002}_{2002,2002})$	Population	1.9*** (0.507)	0.028*** (0.010)	0.018*** (0.006)	0.141*** (0.027)

Notes: ${}^{a}x_a(y^{ce}_{bd})$, household net incomes according to the tax and transfer regulations of period a of gross incomes of the population of period b with wages according to labor market prices of period d with labor supply outcomes given the incentives of the tax and transfer regulations of period c and wages of period e. Bootstrapped standard errors in parentheses: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

offset by labor supply reactions. The Q90/50 ratio was increased through policy changes. The effect of wage rate changes on income inequality was negative. Thus, the increase in income inequality was mostly due to changes in the population. The last line in Table 5 confirms this. It shows that the difference in the Gini index of the actual 2002 population and the 2011 population with the tax and transfer system and conditional wages as in 2002 and labor supply simulated on this basis is 1.9.

5.4. *Robustness Tests*

Appendix A reports the results of two robustness tests. First, the order of the decomposition is changed; that is, marginal effects are reported relative to the year 2011. This exercise demonstrates what would have happened if wage rates or the tax and transfer system had not changed since 2002 apart from adjustment for inflation. The results are reported in Appendix A.1. While the sizes of the coefficients change, the main message remains the same: wage changes and

policy changes have both led to a decrease in the Gini and the MLD, and the increase in income inequality is due to population changes.

Second, wage effects are reestimated using categorical education variables instead of years of education for the wage regressions. The results are reported in Appendix A.2 and are very close to those obtained using a continuous variable.

6. Conclusion

This paper suggests a decomposition of changes in inequality into contributions from policy changes, changes in conditional wage rates, and population changes while considering both static and behavioral effects. In the application of the decomposition method to the increase in income inequality in Germany from 2002 to 2011, changes in the tax and transfer system are found to have had a small inequality-reducing effect, as measured by the Gini and the MLD, and a negligible effect on the Theil index. The reduction of the Gini was offset by labor supply reactions to the policy reforms. Tax reductions have increased the ratio between the 90th and the 50th income percentiles.

The effect of changes in wage rates on income inequality was also significantly negative. Behavioral reactions to wage changes are rather limited. Regarding both wage and tax and transfer effects, the impact of labor supply adjustments on the distribution is small.

This study confirms findings in Arntz *et al*. (2007) and Biewen and Juhasz (2012) regarding the distributional effects of the most important reforms of the German transfer system in recent years, which, contrary to popular belief, have had a slight inequality-reducing effect. The policy reforms undertaken in the analyzed time span, an increase of the generosity of the transfer system and tax reductions, have had a negative impact on the government budget. Future research should study the distributional effects of the funding of these policy measures.

The decomposition exercise shows that most of the change in inequality cannot be explained by means of the policy and wage rate changes, but is due to changes in the population. These include changes in household structure and the distribution of non-labor income (Biewen and Juhasz 2012; Peichl *et al*. 2012; Biewen *et al*. 2016) as well as changes in employment patterns unrelated to changes in wage rates and the tax and transfer system. Further research into the driving forces of the population changes is warranted.

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Supporting Information

Additional supporting information may be found in the online version of this article at the publisher's web site:

Appendix A: Robustness

A.1. Base Year 2011
Figure A.1: Policy Effect—Base Year 2011
Figure A.2: Wage Effect—Base Year 2002
Table A.1: Decomposition with Base 2011

A.2. Categorical Education Variable
Table A.2: Wage Regression 2002 with Categorical Education Variables
Table A.3: Wage Regression 2011 with Categorical Education Variables
Table A.4: Wage Effects with Base 2002 and Categorical Education Variables

Appendix B: Estimation Results for Labor Supply Model
Table B.1: Estimation Results for Labor Supply Model 2002
Table B.2: Estimation Results for Labor Supply Model 2011