With or Without U?

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With or Without U? Testing the Hypothesis of an Inverted U-Shaped Union Membership-Age Relationship

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ABSTRACT In this note, we apply a new test by Lind and Mehlum (2010), casting doubt on the claim proposed by Blanchflower (2007) that the probability of unionisation follows an inverted U-shaped pattern in age with a maximum in the mid- to late 40s. With this new test for an inverted U-shaped pattern, which has not been applied to the age-membership nexus before, and by constructing exact confidence intervals for the maximum value, we demonstrate that – at least with respect to West Germany – Blanchflower's hypothesis does not hold. Our findings suggest that more definitive evidence is needed before the existence of international unionisation-age patterns can be taken for granted.

KEY WORDS: unionisation, age, inverted U-shape, Germany

JEL Classification: J51

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1. Motivation

Lind and Mehlum (2010) showed in a recent paper that statistically significant regression coefficients of a variable and its squared term that have opposite signs, plus a computed extreme value based on these estimated coefficients that lies inside the data range, are only necessary but not sufficient to proof the existence of a U-shaped (or inverted U-shaped) relationship. Specifically, Lind and Mehlum (2010, p. 110) argue "that this criterion is too weak. The problem arises when the true relationship is convex but monotone over relevant data values. A quadratic specification may then erroneously yield an extreme point and hence a U shape." They note that standard testing methodology is no longer suitable for the U-shape test of the *composite* null hypothesis that the relationship is decreasing at the left hand side of the interval *and/or* is increasing at the right hand side (resp. the opposite in case of an inverted U shape). Lind and Mehlum (2010) adopt a general framework developed by Sasabuchi (1980) to test for the presence of a U-shaped or inverted U-shaped pattern and propose the Fieller (1954) method to compute the confidence interval for the estimated extreme value.

The insights provided by Lind and Mehlum (2010) cast some doubt on a well-known finding by David Blanchflower, which is set to become a stylised fact in the empirical literature on union membership. Blanchflower (2007, p. 1) claims to have found "an empirical regularity not hitherto identified, namely, the probability of being unionized follows an inverted U-shaped pattern in age, maximizing in the mid- to late 40s in 34 of the 38 countries [studied]" (Blanchflower 2007, p. 1). To test for this pattern and compute the estimated maximum, Blanchflower estimates probit functions with a union membership dummy as the endogenous

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variable and age, age squared, and a set of control variables (e.g., gender, education, and year dummies, if appropriate) as the exogenous variables. He argues that statistically significant positive and negative coefficients of age and age squared, respectively, indicate an inverted U-shaped pattern and reports the maximum of this pattern by solving this quadratic equation (Blanchflower 2007, p. 15).

While this procedure is standard methodology in many fields of economics and the social sciences, it is not appropriate when considered against the insights provided by Lind and Mehlum (2010). Even if the estimated coefficients of age and age squared are positive and negative, respectively, in a union membership function the estimated coefficients are statistically significantly different from zero at a conventional error level, and the computed maximum of the probability of being a union member based on these estimates is neither smaller nor larger than the age of the youngest or oldest person in the sample, these conditions are insufficient to determine that union membership follows an inverted U-shaped pattern in age.

In this note, we compute Sasabuchi tests and Fieller confidence intervals to test the hypothesis proposed by Blanchflower (2007). We use data for West Germany, which is a case in point, according to the figures reported in Blanchflower's Table 7, with an age maximum in unionisation of 43 in West (and East) Germany. Section 2 describes the data and outlines our empirical strategy. Section 3 reports the results of our econometric investigation. Section 4 concludes.

2. Data and empirical strategy

We investigate the relationship between unionisation and age using data from various waves of the German general social survey ALLBUS. This survey has been conducted biennially since 1980. Note that the ALLBUS data sets are not part of a panel study; an independent random sample is drawn for each wave covering individuals age 18 years or older (for additional information on the ALLBUS, see Terwey 2000). We observe individuals between the ages of 18 and 64 working either full time or part time as blue-collar workers, white-collar workers (except top managers), or civil servants (*Beamte*). Foreigners are excluded because they were not included in the survey until 1991 and form a small, rather heterogeneous proportion of the samples. We focus on West Germany because of the special modalities of quasi-automatic union recruitment in East Germany before and after unification. This characteristic enables us to cover a longer period of observation. We conduct separate analyses for male and female employees to account for the different work histories of men and women and the lower labour force attachment of women which both can be expected to affect union membership differently.

Data are taken from the ALLBUS surveys conducted between 1980 (the starting year of this series of surveys) and 2006 (the most recent year for which data were available). Because information on an important variable, the political orientation of the individuals, is missing in 1984, the 1984 wave could not be included in the data. The data are pooled over all surveys in each decade, leading to three data sets covering the periods of 1980 to 1988, 1990 to 1998, and 2000 to 2006.

Table 1 reports descriptive statistics on the share of union members and non-members and the average age of both groups for West German men and women during the 1980s, 1990s, and 2000s. Union density is higher for men than for women, but this gender gap narrows over time as men contribute disproportionately to a substantial fall in union density over the years. The average age of both union members and non-members increases between the 1980s and 2000s, and union members tend to be slightly older than non-members.

To investigate the role of age as a determinant of union membership, we estimate membership functions separately for men and women using the probit method to analyse the pooled data. The endogenous variable is a dummy variable that equals one if a person is a union member and zero otherwise. To test for the presence of an inverted U-shaped pattern of union membership in age, four different (nested) empirical models are estimated. Model 1 includes only age and age squared (plus a constant). Model 2 augments model 1 with a set of dummy variables indicating whether a person was born within one of the following ten-year periods: 1916-1925, 1926-1935, 1936-1945, 1946-1955, 1956-1965, 1966-1975, and 1976-1985. Model 3 adds an additional set of dummy variables for the various years of the ALLBUS surveys from which the data are taken. Model 4 augments model 3 by including the following control variables: dummy variables for com-

Table 1. Descriptive statistics on union membership and age in West Germany, 1980 – 2006

Sample	1980 – 1988		1990 – 1998		2000 – 2006	
	Share (per cent)	Age (mean) (years)	Share (per cent)	Age (mean) (years)	Share (per cent)	Age (mean) (years)
Men						
Union members	38.0	40.7	34.2	40.8	26.6	42.9
Non-members	62.0	39.1	65.8	39.1	73.4	40.4
Women						
Union members	19.0	36.6	18.9	39.8	16.5	42.0
Non-members	81.0	36.7	81.1	37.9	83.5	40.5

Note: Computed from various waves of the ALLBUS survey; see text for details.

pleted apprenticeship or master craftsman, polytech or university degree, blue-collar worker, civil servant, public sector employee, and father being a blue collar worker as well as the value of an index measuring the political orientation of individuals from 1 = extreme left to 10 = extreme right. (See Schnabel & Wagner (2005; 2008) for a discussion of these control variables, which are standard in the unionisation literature.)

We test the Blanchflower (2007) hypothesis of an inverted U-shaped pattern of union membership in age with a maximum at the mid- to late 40s in three stages. First, we apply the standard significance tests to the estimated coefficients of the variables age and age squared (both separately and jointly). Second, we conduct a Sasabuchi (1980) test of an inverted U-shape in age (also known as an intersection-union test), which tests the composite null hypothesis that the relationship is increasing at low values of the age interval, decreasing at high values, or both. Third, for the estimated extreme point, we compute the Fieller (1954) confidence interval (for the ratio of the two normally distributed estimates for the age and age squared variables) and determine whether this confidence interval is contained within the data range. We also observe whether the estimated maximum lies in the age range found by Blanchflower – i.e., the mid- to late 40s (for details regarding the statistical theory underlying these methods, see Lind and Mehlum (2010). All computations use Stata 10.0 and the ado-file utest provided by Lind and Mehlum. To facilitate replication and extensions all do-files are available from the second author.

3. Empirical results

The results of our empirical investigation for men and women are reported in Tables 2.1 – 2.3 and Tables 3.1 – 3.3, respectively. Given our focus on testing the inverted U-shape hypothesis, we report only the estimated coefficients of the age and age squared variables – that is, we do not report the coefficients of the cohort dummy variables, the survey dummy variables, and the control variables measured at the individual level (while not reported here, detailed results for the individual-level control variables are available from the second author).

Our results concerning men clearly reject the hypothesis of an inverted U-shaped pattern of union membership in age with a maximum at the mid- to late 40s. While age (age squared) has a positive (negative) sign in all 12 empirical models, the estimated coefficients are only separately and jointly statistically significant at an error level of five per cent or less in model 1 for all three decades and model 4 for the pooled data from 1990 to 1998. This weak evidence, however, is contrasted by the Sasabuchi test, which rejects the hypothesis at the five per cent level for all of the models except model 4 in the 1990s. Even in this model, however, a closer look casts doubt on the second part of the hypothesis concerning the maximum. The Fieller confidence interval is rather broad, spanning an age period from the late 20s to the mid-50s. Thus, we find no stable evidence of a Blanchflower-type relationship between unionisation and age among West German men.

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Table 2-1. Test of an inverse U-shaped relationship between the probability of union membership and age for West German men. Part I: 1980 – 1988

		Model 1	Model 2	Model 3	Model 4
Age (years)	ß	0.04076	0.03092	0.02578	0.02205
	p	0.008	0.248	0.347	0.480
Age squared	ß	-0.00040	-0.00032	-0.00030	-0.00027
	p	0.032	0.323	0.348	0.459
Test of joint significance of age variables. prob-value		0.0001	0.431	0.635	0.760
Sasabuchi-test of inverse U-shape in age. prob-value		0.114	0.276	0.232	0.264
Estimated extreme point (years) (bounds of 95% Fieller interval)		50.5	48.8	42.8	40.3
		[44.3; 154.7]	[-inf.; +inf.]	[-inf.; +inf.]	[-inf.; +inf.]
Test of joint significance of cohort dummy variables. prob-value		[-]	0.004	0.0025	0.054
Test of joint significance of survey dummy variables. prob-value		[-]	[-]	0.145	0.338
Test of joint significance of control variables. prob-value		[-]	[-]	[-]	0.000
LR-test of entire regression prob-value		0.0001	0.0000	0.0000	0.0000
Number of observations		2943	2943	2943	2234

Notes: ß is the estimated regression coefficient from a probit model; p is the prob-value (based on robust standard errors). For an explanation of the Sasabuchi-test and the Fieller interval, see text.
Cohort dummy variables are included for birth years 1926-1935, 1936-1945, 1946-1955, 1956-1965, and 1966-1975, using 1916-1925 as the reference category. Survey dummy variables are included for the ALLBUS surveys 1982, 1986, and 1988, using 1980 as the reference category. The control variables include dummy variables for completed apprenticeship or master craftsman, polytech or university degree, blue-collar worker, civil servant, public sector employee, and father being a blue-collar worker, and the value of an index measuring political orientation (from 1 = extreme left to 10 = extreme right). Data from the ALLBUS survey for 1984 were excluded due to missing information on political orientation. [-] indicates that the group of variables is not included in the model.

Table 2-2. Test of an inverse U-shaped relationship between the probability of union membership and age for West German men. Part II: 1990 – 1998

		Model 1	Model 2	Model 3	Model 4
Age (years)	ß	0.04833	0.03262	0.03906	0.08597
	p	0.004	0.241	0.170	0.009
Age squared	ß	-0.00049	-0.00050	-0.00045	-0.00107
	p	0.015	0.140	0.185	0.008
Test of joint significance of age variables. prob-value		0.000	0.176	0.388	0.028
Sasabuchi-test of inverse U-shape in age. prob-value		0.067	0.183	0.164	0.011
Estimated extreme point (years) (bounds of 95% Fieller interval)		49.3	32.8	43.8	40.2
		[44.2; 86.5]	[-inf.; +inf.]	[-inf.; +inf.]	[27.5; 55.2]
Test of joint significance of cohort dummy variables. prob-value		[-]	0.133	0.965	0.670
Test of joint significance of survey dummy variables. prob-value		[-]	[-]	0.114	0.241
Test of joint significance of control variables. prob-value		[-]	[-]	[-]	0.0000
LR-test of entire regression prob-value		0.0000	0.0002	0.0002	0.0000
Number of observations		2907	2907	2907	2320

Notes: ß is the estimated regression coefficient from a probit model; p is the prob-value (based on robust standard errors). For an explanation of the Sasabuchi-test and the Fieller interval, see text.
Cohort dummy variables are included for birth years 1926-1935, 1936-1945, 1946-1955, 1956-1965, and 1966-1975, using 1916-1925 as the reference category. Survey dummy variables are included for the ALLBUS surveys 1992, 1994, 1996, and 1998, using 1990 as the reference category. The control variables include dummy variables for completed apprenticeship or master craftsman, polytech or university degree, blue-collar worker, civil servant, public sector employee, and father being a blue collar worker, and the value of an index measuring political orientation (from 1 = extreme left to 10 = extreme right). [-] indicates that the group of variables is not included in the model.

Table 2-3. Test of an inverse U-shaped relationship between the probability of union membership and age for West German men. Part III: 2000 – 2006

		Model 1	Model 2	Model 3	Model 4
Age (years)	ß	0.06930	0.00042	0.00996	0.01514
	p	0.003	0.993	0.831	0.779
Age squared	ß	-0.00067	-0.00012	-0.00008	-0.00010
	p	0.016	0.819	0.875	0.872
Test of joint significance of age variables. prob-value		0.000	0.580	0.962	0.786
Sasabuchi-test of inverse U-shape in age. prob-value		0.104	1.000	0.487	1.000
Estimated extreme point (years) (bounds of 95% Fieller interval)		52.0	1.7	58.7	75.6
		[46.1; 98.2]	[-inf.; +inf.]	[-inf.; +inf.]	[-inf.; +inf.]
Test of joint significance of cohort dummy variables. prob-value		[-]	0.0015	0.008	0.411
Test of joint significance of survey dummy variables. prob-value		[-]	[-]	0.243	0.397
Test of joint significance of control variables. prob-value		[-]	[-]	[-]	0.000
LR-test of entire regression prob-value		0.0000	0.0000	0.0000	0.0000
Number of observations		1708	1708	1708	1410

Notes: ß is the estimated regression coefficient from a probit model; p is the prob-value (based on robust standard errors). For an explanation of the Sasabuchi-test and the Fieller interval, see text.
Cohort dummy variables are included for birth years 1946-1955, 1956-1965, 1966-1975, and 1976-1985, using 1936-1945 as the reference category. Survey dummy variables are included for the ALLBUS surveys 2002 and 2004, using 2000 as the reference category. The control variables include dummy variables for completed apprenticeship or master craftsman, polytech or university degree, blue-collar worker, civil servant, public sector employee, and father being a blue collar worker, and the value of an index measuring political orientation (from 1 = extreme left to 10 = extreme right). [-] indicates that the group of variables is not included in the model.

Table 3-1. Test of an inverse U-shaped relationship between the probability of union membership and age for West German women. Part I: 1980 – 1988

		Model 1	Model 2	Model 3	Model 4
Age (years)	ß	-0.015	-0.0126	-0.0095	-0.0172
	p	0.478	0.737	0.807	0.709
Age squared	ß	0.00019	-0.00009	-0.00011	0.0002
	p	0.490	0.848	0.819	0.714
Test of joint significance of age variables. prob-value		0.7745	0.1126	0.3816	0.9316
Sasabuchi-test of inverse U-shape in age. prob-value		0.262	1.000	1.000	0.389
Estimated extreme point (years) (bounds of 95% Fieller interval)		40.0	-68.5	-43.2	41.2
		[-inf .; +inf.]	[-inf.; 35.2]	[-inf.; +inf.]	[-inf.; +inf.]
Test of joint significance of cohort dummy variables. prob-value		[-]	0.1300	0.3751	0.4519
Test of joint significance of survey dummy variables. prob-value		[-]	[-]	0.8258	0.6926
Test of joint significance of control variables. prob-value		[-]	[-]	[-]	0.0000
LR-test of entire regression prob-value		0.7745	0.2492	0.4466	0.0000
Number of observations		1767	1767	1767	1323

Notes: ß is the estimated regression coefficient from a probit model; p is the prob-value (based on robust standard errors). For an explanation of the Sasabuchi-test and the Fieller interval, see text.
Cohort dummy variables are included for birth years 1926-1935, 1936-1945, 1946-1955, 1956-1965, and 1966-1975, using 1916-1925 as the reference category. Survey dummy variables are included for the ALLBUS surveys 1982, 1986, and 1988, using 1980 as the reference category. The control variables include dummy variables for completed apprenticeship or master craftsman, polytech or university degree, blue-collar worker, civil servant, public sector employee, and father being a blue-collar worker, and the value of an index measuring the political orientation (from 1 = extreme left to 10 = extreme right). Data from the ALLBUS survey for 1984 were excluded due to missing information on political orientation. [-] indicates that the group of variables is not included in the model.

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Table 3-2. Test of an inverse U-shaped relationship between the probability of union membership and age for West German women. Part II: 1990 – 1998

		Model 1	Model 2	Model 3	Model 4
Age (years)	ß	0.0544	0.0494	0.0595	0.0649
	p	0.020	0.215	0.134	0.180
Age squared	ß	-0.0006	-0.00062	-0.00062	-0.00071
	p	0.049	0.197	0.198	0.236
Test of joint significance of age variables. prob-value		0.0028	0.4340	0.2947	0.3885
Sasabuchi-test of inverse U-shape in age. prob-value		0.0947	0.123	0.233	0.218
Estimated extreme point (years) (bounds of 95% Fieller interval)		47.6 [41.9; 1564.1]	39.6 [-inf.; +inf.]	48.4 [-inf.; +inf.]	45.4 [-inf.; +inf.]
Test of joint significance of cohort dummy variables. prob-value		[-]	0.2988	0.3681	0.7734
Test of joint significance of survey dummy variables. prob-value		[-]	[-]	0.2326	0.1833
Test of joint significance of control variables. prob-value		[-]	[-]	[-]	0.0000
LR-test of entire regression prob-value		0.0028	0.0106	0.0107	0.0000
Number of observations		1950	1950	1950	1492

Notes: ß is the estimated regression coefficient from a probit model; p is the prob-value (based on robust standard errors). For an explanation of the Sasabuchi-test and the Fieller interval, see text.
Cohort dummy variables are included for birth years 1926-1935, 1936-1945, 1946-1955, 1956-1965, and 1966-1975, using 1916-1925 as the reference category. Survey dummy variables are included for the ALLBUS surveys 1992, 1994, 1996, and 1998, using 1990 as the reference category. The control variables include dummy variables for completed apprenticeship or master craftsman, polytech or university degree, blue-collar worker, civil servant, public sector employee, and father being a blue collar worker, and the value of an index measuring political orientation (from 1 = extreme left to 10 = extreme right). [-] indicates that the group of variables is not included in the model.

Table 3-3. Test of an inverse U-shaped relationship between the probability of union membership and age for West German women. Part III: 2000 – 2006

		Model 1	Model 2	Model 3	Model 4
Age (years)	ß	0.0738	0.0224	0.0407	0.0920
	p	0.013	0.692	0.488	0.186
Age squared	ß	-0.00081	-0.00043	-0.000383	-0.00088
	p	0.024	0.523	0.577	0.288
Test of joint significance of age variables. prob-value		0.0179	0.4489	0.7183	0.2970
Sasabuchi-test of inverse U-shape in age. prob-value		0.039	0.417	0.405	0.312
Estimated extreme point (years) (bounds of 95% Fieller interval)		45.7 [40.7; 78.0]	26.1 [-inf.; +inf.]	53.1 [-inf.; +inf.]	52.0 [-inf.; +inf.]
Test of joint significance of cohort dummy variables. prob-value		[-]	0.0424	0.1143	0.1392
Test of joint significance of survey dummy variables. prob-value		[-]	[-]	0.0199	0.0802
Test of joint significance of control variables. prob-value		[-]	[-]	[-]	0.0000
LR-test of entire regression prob-value		0.0179	0.0044	0.0008	0.0000
Number of observations		1309	1309	1309	1058

Notes: ß is the estimated regression coefficient from a probit model; p is the prob-value (based on robust standard errors). For an explanation of the Sasabuchi-test and the Fieller interval, see text.
Cohort dummy variables are included for birth years 1946-1955, 1956-1965, 1966-1975, and 1976-1985, using 1936-1945 as the reference category. Survey dummy variables are included for the ALLBUS surveys 2002 and 2004, using 2000 as the reference category. The control variables include dummy variables for completed apprenticeship or master craftsman, polytech or university degree, blue-collar worker, civil servant, public sector employee, and father being a blue collar worker, and the value of an index measuring political orientation (from 1 = extreme left to 10 = extreme right). [-] indicates that the group of variables is not included in the model.

The results for West German women are even less consistent with Blanchflower's hypothesis. The estimated coefficients of the age and age squared variables are only individually and jointly statistically significantly different from zero at an error level of five per cent or better for model 1 in the 1990s and 2000s. Only the latter model also passes the Sasabuchi test with a prob-value of 0.039. While the point estimates of the maximum are consistent with Blanchflower's hypothesis in both cases (taking values of 47.6 and 45.7 years), the Fieller confidence intervals demonstrate that these estimates are too imprecise to establish that the maximum falls within the range of the mid- to late 40s.

4. Concluding remarks

The results presented in this note cast some doubt on the claim proposed by David Blanchflower (2007) that the probability of unionisation follows an inverted U-shaped pattern in age with a maximum in the mid-to late 40s. In contrast to the findings Blanchflower (2007) presents concerning Germany, we demonstrate that – at least with respect to West Germany – this is not the case. Because our findings are based on a different data set than Blanchflower's, distinguish between men and women, and, for the first time in this context, apply Lind and Mehlum's (2010) statistical method, which is best suited for testing U-shaped patterns, by Lind and Mehlum (2010) that has not been used before in this context, we would agree that the jury is still out on the relationship between union membership and age.

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