Cognitive Abilities and Labour Market Outcomes – First Evidence for Germany

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ABSTRACT

We contribute to the literature on the relationship between cognitive abilities and labour market outcomes providing first evidence for Germany. In particular, cross-sectional data from the German Socio-Economic Panel (SOEP) are used, which include two measures of cognitive ability, one test of fluid mechanics (speed test) and another test of crystallised pragmatics (word fluency test). We find a positive relationship between cognitive abilities and economic activity, as workers with high ability test scores are less likely to be unemployed. In addition, results from Mincer-type OLS and 2SLS regressions suggest that mechanics abilities are correlated with wages in a significantly positive way for West German workers, even when educational attainment is controlled for, whereas pragmatics of cognition do not affect earnings significantly. However, we also find that ability and education are inseparable determinants of earnings, which confirms findings of recent studies for other countries.

JEL: J24, J31, I21

Keywords: Cognitive ability, earnings regressions, returns to education, ability bias, unemployment probability

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INTRODUCTION

The research on cognitive abilities has received increasing attention in Economics in the discussion on the returns to education since the 1970s both in Europe and in the US. As school choice and returns to schooling may vary by ability, the estimated returns are biased if unobserved ability affects both education and the worker's productivity given a certain schooling level.[1] In addition to new estimation techniques, which have been implemented to capture spurious ability effects, this bias may also be eliminated by the inclusion of test score measures as proxy for omitted ability. However, the analysis of cognitive abilities is relevant not only for estimating unbiased returns to schooling, but also to improve the understanding of the overall wage structure and determinants of the employment status.

A number of studies have revealed substantial returns to cognitive abilities in the US and Great Britain. Among others, Bishop (1989), Neal and Johnson (1996), Cameron and Heckman (1993), Blackburn and Neumark (1993), and more recently, Bronars and Oettinger (2006), Green and Riddell (2003), and Gould (2005) provide evidence for a positive relationship between intelligence and earnings. In their heavily disputed study "The Bell Curve", Herrnstein and Murray (1994) even argue that intelligence is the most important determinant of social and economic success in the US. However, their findings have been strongly criticized on grounds of measurement error, omitted variables for family background and lack of control for education (e.g. Korenman and Winship, 1995). Moreover, Cohn and Kiker (1986), Bound, Griliches, and Hall (1986), Murnane, Willett, and Levy (1995) report that cognitive ability has barely any effect on earnings, as the coefficients are not statistically significant and do not explain much of the earnings variance. Cawley, Heckman, and Vytlacil (2001), and Zax and Rees (2002) conclude that cognitive ability is a poor predictor of earnings compared to a direct measure of education, family background, and environment.

Our contribution to the literature is to investigate the relationship between cognitive abilities and labour market outcomes in Germany for the first time. Data from the German Socio-Economic Panel (SOEP) study allow us to investigate the return to education by including ability measures and to analyse the direct effect of cognitive

[1] The relationship between ability and education has usually been shown to be positive, which implies that the schooling coefficient is overestimated in standard Mincer equations (Hause, 1971).

ability on earnings. Moreover, we are able to analyse whether cognitive abilities are related to unemployment. Whereas most existing studies use pre-market measures of cognitive abilities, i.e. intellectual capacity measured during adolescence, and relate these to subsequent earnings during early adulthood, the SOEP observes intelligence measures for all cohorts at the same time and belongs to the few datasets which observe labour market outcomes of the respondents beyond the mid-thirties.

COGNITIVE ABILITIES AS DETERMINANTS OF LABOUR MARKET SUCCESS

Intelligence is defined as the "ability to understand complex ideas, to adapt effectively to the environment, to learn from experience, to engage in various forms of reasoning, to overcome obstacles by taking thought" (American Psychological Association, 1995). More specific, Baltes, Staudinger, and Lindenberger (1999) distinguish between two components of intellectual functioning: the mechanics and the pragmatics of cognition. Mechanics abilities comprise general and largely innate abilities, such as reasoning and perceptual speed, and refer to the performance and speed of solving tasks that are related to new material. The pragmatics of cognition, such as verbal knowledge, concerns the fulfilment of more specific tasks which improve with accumulated knowledge and skills acquired in the past.[2]

DATA AND METHODOLOGY

Two cognitive ability tests were designed to be included in a large-scale longitudinal survey like the German Socio-Economic Panel Study (SOEP), and conducted in the 2005 SOEP cross-sectional study for the first time.[3] Since fully-fletched IQ tests were not feasible, two ultra-short tests were developed (Lang 2005) to construct indicators of cognitive ability: speed of cognition and word fluency. The former was developed after the symbol-digit-modalities-test (Smith, 1995). Respondents have 90 seconds to assign as many correct signs as possible with a keyboard to the

[2] This concept is closely related to the distinction of "fluid" (mechanics) and "crystallised" (pragmatics) abilities (Cattell, 1987).
[3] The SOEP is a representative micro-database that provides a wide range of longitudinal socio-economic information on private households in Germany (http://www.diw.de/soep). Moreover, cross-sectional interviews are realised, which contain new questions in addition to items included in the standard questionnaire.

consecutively displayed digits on a screen, while the appropriate assignment code is visible to them all the time. The latter test has been developed after the animal-naming-task (Lindenberger and Baltes, 1995). Respondents name as many different animals as possible within 90 seconds. Both tests were previously shown to produce outcomes which are sufficiently correlated with test scores of more comprehensive and well-established intelligence tests (Lang, 2005).

The 2005 SOEP study consists of about 1,000 randomly drawn persons in East and West Germany (Schupp and Wagner, 2006). We restrict our sample to West German respondents of age 20 to 60 to avoid estimation problems that could possibly arise from structural differences between East and West German labour markets, youth employment and individual's retirement decisions.[4] In the wage equations, we analyse the earnings of full-time workers only, and exclude apprentices. In total, the sub-sample consists of 493 observations, while 393 respondents are in the labour force and 215 full-time workers are available for the earnings analyses.[5] Descriptive statistics are given in Table 1.

[Table 1 about here]

First, we investigate the relationship between cognitive abilities and economic activity. We estimate the effect of the ability test score measures on an individual's probability of being unemployed by using a binary choice model of the following structure:

$$z_i^* = \beta' x_i + \gamma' c_i + \varepsilon_i ,$$

where z_i^* is the latent propensity of the individual *i* to be unemployed, x_i is a vector of individual and employer characteristics, and c_i the individual's ability test score. β and γ are vectors of parameters to be estimated, and ε_i denotes the idiosyncratic error term. As z_i^* is a latent variable, it is not observable. What one observes is

$$z_i = \begin{cases} 1 & if \ z_i^* > 0 \\ 0 & otherwise \end{cases}$$

[4] We do not provide analyses for East German workers separately because of sample size restrictions.
[5] Note that missing values in the two intelligence test measures respectively lead to sub-sample sizes of less than 493.

Assuming an underlying logistic distribution for ε_i, we get the following probability model:

$$\Pr ob(y_i = 1) = \frac{\exp(\beta' x_i + \gamma' c_i)}{1 + \exp(\beta' x_i + \gamma' c_i)}$$

Marginal effects are calculated for ease of interpretation. The covariates included are age, education, marital status, the number of dependent children, the local unemployment rate, and ability test scores.[6] Since economic activity of men and women is determined in systematically different ways, males and females are estimated separately.

Second, we expand a standard Mincer-type earnings regression to include measures of cognitive abilities. The dependent variable in the OLS regression is the log of gross monthly earnings.[7] Let y_i be individual i's monthly earnings, x_i worker characteristics, and c_i the ability test score. The specification of the earnings regression is:

$$\ln y_i = \beta' x_i + \gamma' c_i + u_i$$

β and γ are vectors of parameters to be estimated, and u_i denotes the idiosyncratic error term. Since earnings can only be observed for employed workers, the estimation of earnings involves a potential bias arising from non-random sample selection. It might well be the case that workers with lower abilities or other unobserved characteristics are more likely to stay out of employment due to redundancy or non-participation. Therefore, persons are not randomly assigned to the sample of workers for which earnings can be observed. As consequence, the error term might be correlated with the explanatory variables, and the estimates of the OLS model might be biased. To correct for this selectivity bias, wages are estimated in a Heckman two-step selection model, where the probability of being full-time employed is estimated dependent on gender, age, education, the number of dependent children, and cognitive ability. In both the OLS and the 2SLS model, a gender dummy, education in years, age, and actual working hours are included as explanatory variables in the earnings regressions. A dummy variable for large firm

[6] Due to the potential bias which arises from using aggregate unemployment information with individual data, the estimates will be adjusted for within-cluster correlations.

[7] Missing income data has been imputed using multiple imputation techniques with the Stata implementation of the MICE (multivariate imputation by chained equations) method of multiple multivariate imputation (Royston, 2004).

size, public sector, blue-collar worker, and job tenure are included as additional controls in supplementary estimations.

Equations with earnings as a linear function of schooling, ability, and an uncorrelated random variable imply that education and ability are perfect substitutes. However, previous research has shown that there is a positive interaction between ability and education levels and that the linear model may be misspecified by not allowing for this interaction (Hause, 1971). Therefore, we additionally include an interaction term of ability test scores and schooling in the described models above in order to investigate the separability of these variables.

RESULTS

The results from the logit model suggest a statistical link between general intelligence and economic activity for both types of measured cognitive ability (Table 2). With increasing speed test scores, males are less likely to be unemployed, compared to being full-time or part-time employed (column II).[8] Evaluated at the means of the independent variables, an increase in the speed test score by 10 signs (which approximately corresponds to one standard deviation) reduces the probability of being unemployed for men by 5%. However, the inclusion of an interaction term of mechanic ability and education leads to the insignificance of both the main effect of cognitive ability and the joint effect.[9] Moreover, the schooling coefficient is barely affected by the inclusion of the speed test score. In contrast, taking into account test scores of the word fluency test results in a considerable reduction of the education coefficient which completely loses statistical significance, when an interaction term of pragmatic ability and education is included (column V). The combined effect on the probability of unemployment is found to be significantly negative, whereas there is no significant main effect with or without the inclusion of this interaction term.

For women in the labor force, there is no measurable impact of mechanics of cognition on their economic activity, regardless of whether separability of ability and schooling is assumed (column II and III). However, when pragmatic ability is taken

[8] A separate analysis for full-time and part-time employment revealed very similar results.

[9] Since in nonlinear models, the marginal effect of a change in both years of education and test scores is not equivalent to the marginal effect of changing only the interaction term, correct marginal effects of the interaction terms are additionally computed as the cross-partial derivatives of the expected value of being unemployed (Ai and Norton, 2003).

into account, the unemployment probability is found to be negatively determined by intelligence. The marginal effects computed at the means of the independent variables, show that an increase in the speed test score by 10 signs is associated with a 3% lower probability of being unemployed for women. This effect is comparable with the negative impact on the unemployment probability which results from a fall in the local unemployment rate by 2 percentage points. Like in the estimates for men, the education coefficient is only reduced, when word fluency test scores are included, and becomes totally insignificant after the inclusion of an interaction variable of crystallised pragmatics and schooling. Moreover, while the combined effect is negative at the 10% significance level, there is no statistically significant main effect of the word fluency test scores. Hence, for both men and women, cognitive ability as measured by word fluency seems to be an important – yet inseparable from schooling – determinant of employment status.

[Table 2 about here]

The results of the Mincer-type earnings regressions reveal that even after controlling for education, earnings are significantly positively affected by the speed test scores (given the relatively small sample size), while the coefficients on the word fluency test are not statistically significant (Table 3). The education coefficient is barely affected by the inclusion of the test score measures, but the explained variation slightly increases to an adjusted R-squared of 20.5% compared to 17.6%, when the speed test score is excluded. When adding job characteristics as control variables to the Mincer-type model, the coefficient on speed test scores loses slightly significance, but is of the same size.[10] An increase in the speed test score by one standard deviation is associated with a 7% earnings increase for full-time workers, which is almost twice as large as the return to one year of schooling. This type of measured cognitive ability therefore seems to be an important determinant of earnings, which might indicate that workers benefit from their flexibility and competence to adapt to new problems and situations in the workplace, in addition to their education and potential experience.[11]

[10] The coefficients of the richer model which includes a dummy variable for large firm size, public sector, blue-collar worker, and job tenure as additional control variables are not reported here, but are available from the authors on request.

[11] These results show to be robust to variations in the ability measures, such as including normalised test scores, dummies for test scores above and below the average, dummies for quantiles in the test

As indicated above, it is important to take into account possible interactions between ability and schooling. The inclusion of a multiplicative term of test performance and years of education reveals a significantly positive joint effect of these variables and a main effect of ability which is negative and insignificant. Furthermore, the negative main effect is outweighed for a schooling level as low as 7 years, which is the minimum in our sample, i.e. higher cognitive ability test scores are beneficial for every full-time worker, and even more beneficial for those with higher education.

[Table 3 about here]

The Heckman two-step selection model, which corrects for the non-random sample selection of full-time workers, confirms the results of the OLS regressions (Table 4). Again, the word fluency test scores have no significant impact in any of the specifications. The coefficient on fluid mechanics is of the same size and again statistically significant at the 5% significance level. The inclusion of the speed test score affects both the size and significance of the education coefficient. This points to an omitted variables bias in the specification without ability measures and to the importance of controlling for ability when estimating the return to education. Taking into account possible interaction between measured ability and education again leads to a negative main effect of the speed test score measure, which is however outweighed by the positive joint effect even for the lowest level of schooling. Our results support the findings of Heckman and Vytlacil (2001) who remark that ability and schooling appear to be inseparable, i.e. interaction effects matter, and not main effects.

[Table 4 about here]

CONCLUSION

The aim of this study was to analyse whether labour market outcomes are determined by cognitive abilities. Taking into account ability effects is relevant when estimating the returns to schooling and may help to reduce the gap of unexplained variation in earnings. Using data from the German Socio-Economic Panel (SOEP), the results of

score distribution, and the normalised residuals from regressions of ability test scores on age and education.

the empirical model reveal that measures of fluid mechanics and crystallised pragmatics are negatively correlated with the probability of being unemployed versus being full-time or part-time employed for West German males and females. The inclusion of a multiplicative term of education and word fluency test scores shows a positive joint effect on the employment probability and no main effects. Hence, employment relationships seem to be built on the combination of the workers' education and their ability of using past experience and accumulated knowledge to solve specific tasks.

In addition, the earnings analysis reveals a positive relationship between mechanic ability and labour income, while the pragmatics of cognition have less importance. The loss in size and significance of the education coefficient after the inclusion of the speed test scores points to an omitted variables bias when estimating returns to education without controlling for cognitive ability. After allowing for the interaction between cognitive ability as being measured by speed test scores and schooling, the model yields no measurable main effects of ability, but a positive joint effect. That is, educational sorting makes it difficult to disentangle the effects of education and ability on earnings. Overall, it seems to be important to stress both educational training and cognitive abilities when determining labour market success.

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Table 1: Summary Statistics of Variables by Economic Activity (Means)

	Men				Women			
	Employed		**Unemployed**		**Employed**		**Unemployed**	
Years of education	13.0	(2.8)	10.6	(1.9)	12.9	(2.7)	11.3	(1.9)
Age in years	41.5	(9.5)	37.9	(11.7)	41.3	(10.1)	36.1	(10.6)
Married	0.77		0.51		0.67		0.57	
Number of children	0.9	(1.1)	0.7	(1.1)	0.6	(0.9)	0.8	(1.0)
COGNITIVE ABILITIES								
Speed test score	30.5	(10.2)	25.2	(11.0)	29.1	(8.7)	31.1	(8.7)
Word fluency test score	24.1	(12.0)	20.5	(9.8)	24.3	(11.0)	22.6	(9.9)
Observations (Total: 393)	155		37		167		34	

Notes: Standard deviations in parentheses, weighted calculations.
Source: SOEP 2005

Table 2: Logit Estimates of Cognitive Ability Effects on Unemployment Probability

(Marginal Effects)

	Without ability	**Speed test**		**Word fluency test**	
	(I)	(II)	(III)	(IV)	(V)
Men					
Years of education	-0.048	-0.041	-0.049	-0.030	0.001
	(7.14)***	(6.72)***	(4.10)***	(3.75)***	(0.13)
Local Unemployment	0.006	0.005	0.005	0.008	0.008
	(2.48)**	(3.88)***	(5.38)***	(4.49)***	(4.55)***
Ability test score		-0.005	-0.008	-0.005	0.013
		(4.35)***	(1.52)	(1.47)	(1.40)
Ability x education			0.000		-0.002
			(0.57)		(2.05)**
Log-likelihood	-73.6	-70.0	-70.0	-65.2	-64.5
Pseudo-R-squared	0.16	0.18	0.18	0.16	0.17
Observations	175	171		157	
Women					
Years of education	-0.036	-0.035	-0.088	-0.030	0.007
	(3.81)***	(3.81)***	(1.59)	(2.67)***	(0.29)
Local Unemployment	0.014	0.014	0.014	0.015	0.014
	(6.24)***	(5.03)***	(4.46)***	(7.16)***	(6.90)***
Ability test score		-0.002	-0.023	-0.003	0.017
		(0.84)	(1.08)	(1.80)*	(1.56)
Ability x education			0.002		-0.002
			(0.97)		(1.87)*
Log-likelihood	-70.5	-68.3	-67.5	-64.8	-63.7
Pseudo-R-squared	0.13	0.13	0.14	0.12	0.14
Observations	172	166		158	

Notes: Marginal effects are evaluated at the mean values of the independent variables, full interaction effects are additionally computed as the cross-partial derivative of the expected value of being unemployed.
Absolute value of z statistics in parentheses.
* significant at 10%; ** significant at 5%; *** significant at 1%
Reference category: full-time or part-time employed
Further control variables: Age, married, and number of dependent children.

Source: SOEP 2005

Table 3: OLS Estimates of Cognitive Ability Effects on Earnings (Full-time workers)

	Without ability	**Speed test**		**Word fluency test**	
	(I)	(II)	(III)	(IV)	(V)
Years of education	0.039	0.038	-0.014	0.044	0.066
	(4.12)***	(3.96)***	(0.46)	(4.08)***	(2.63)***
Ability test score		0.007	-0.015	-0.002	0.009
		(2.45)**	(1.14)	(0.69)	(0.78)
Ability x education			0.002		-0.001
			(1.76)*		(0.94)
R-squared	0.19	0.22	0.24	0.20	0.20
Observations	215	207		195	

Notes: Absolute value of t statistics in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
Dependent variable: log of monthly gross earnings
Further control variables: Male, age, and weekly working hours.

Source: SOEP 2005

Table 4: 2SLS Estimates of Cognitive Ability Effects on Earnings (Full-time workers)

	Without ability	**Speed test**		**Word fluency test**	
	(I)	(II)	(III)	(IV)	(V)
Years of education	0.061	0.021	-0.027	0.061	0.089
	(5.36)***	(1.94)*	(0.88)	(4.79)***	(3.46)***
Ability test score		0.007	-0.014	-0.001	0.014
		(2.08)**	(1.11)	(0.18)	(1.18)
Ability x education			0.002		-0.001
			(1.69)*		(1.26)
Observations	493	476		450	

Notes: Absolute value of z statistics in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%
Dependent variable: log of monthly gross earnings
Further control variables: Male, age, and weekly working hours.
The probability of being full-time employed in the first stage is estimated dependent on gender, age, education, the number of dependent children, and ability test scores.

Source: SOEP 2005