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Handedness and earnings

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We examine whether handedness is related to performance in the labour market and, in particular, to earnings. We find a significant wage effect for left-handed men with high levels of education. This positive wage effect is strongest among those who have lower than average earnings relative to those of similar high education. This effect is not found among women.

Does handedness matter? The literature addressing that simple question is immense and provides mixed evidence regarding the relationship between handedness and various measures such as health outcomes, accident rates, and cognitive skills.[1] Numerous studies have shown that left-handed individuals have different health outcomes. For example, some studies find they have a higher rate of high blood pressure (Bryden, Bruyn, & Fletcher, 2005) and irritable bowel syndrome (Dancey, Attree, Bàrdos, & Kovacs, 2005), but a lower rate of arthritis and ulcer (McManus & Wysocki, 2005). Meta-analyses did not find convincing evidence that left-handedness was correlated with immune disorders (Bryden, McManus, & Bulman-Fleming, 1994), but did find a positive correlation with schizophrenia (Dragovic & Hammond, 2005).

Evidence as to the relationship between accident rates and handedness may be even more mixed. Higher accident rates for the left-handed are found in some studies, such as Coren (1989) and (at least for traffic accidents) Dutta and Mandal (2006a), but not in others such as Hicks, Pass, Freeman,

[1] For a review of various theories regarding handedness, see Beaton (2003).

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Bautista, and Johnson (1993), and Pekkarinen, Salminen, and Järvelin (2003). However, a recent meta-analysis supports the positive correlation between handedness and accident rates (Dutta & Mandal, 2006b).

Turning to measures of cognitive skills, the evidence is complex. A meta-analysis found a "small but reliable increase" of dyslexia among nonright-handed individuals (Eglinton & Annett, 1994). Some studies have found average performance in high school is lower for left-handed students (for example, Williams, 1987), while others have found the contrary—Faurie, Vianey-Liaud, and Raymond (2006) find handedness to be positively correlated with school performance and leadership skills for boys, while the correlation was negative for girls. Generally, studies seem to find differences in cognitive skills that favour right-handed individuals (Hardyck & Petrinovich, 1977; Porac & Coren, 1981), but averages (central tendencies of the distribution) can be deceiving. Benbow (1986) found that gifted youths were more than twice as likely to be left-handed than those in a control group. Geschwind and Galaburda (1987, p. 98) concluded that "non-righthanded populations are over-represented in all populations with high talent" (see also McManus & Bryden, 1991).

It has also been argued that differences may lie not in cognitive abilities but rather cognitive styles. Coren (1995, p.313) estimates the relationship between handedness and two styles of thinking that he refers to as convergent ("a fairly focused application of existing knowledge and rules to the task of isolating a single correct answer") and divergent ("moves outward from conventional knowledge into unexplored association"). Divergent thinking is shown to be positively related to the degree of left-handedness, though only for males.

In light of the previous findings, it is worth noting the relationship between handedness and brain lateralisation and anatomy. It is well documented that lateralisation of speech is correlated with handedness. A review article reported that 95% of right-handers have speech lateralised in the left hemisphere, while this is the case with only 62% of left-handers (Hellige, 1990). In a meta-analysis, Driesen and Raz (1995) found that the corpus callosum was larger in left-handers.

In this paper, we take a different approach to exploring whether handedness matters by examining how people perform in the labour market. More specifically, is a person's handedness related to their earnings? If left-handedness is associated with poorer health, higher accident rates, and lower average cognitive skills, it is natural to expect that these result in lower labour productivity and thereby lower earnings. An analysis of handedness and earnings can be interpreted as demonstrating whether these factors affect, cumulatively and on net, a fairly universal measure of economic performance.

There are additional reasons that handedness might be related to earnings. Left-handed people may be less productive in those occupations that use tools, machines, and systems that are designed for right-handers. Examples that have been noted include electric food slicers, keyboards, drill presses, band saws, and roadways (Coren, 1993). Second, it is possible that handedness and earnings are related through occupational choice. Some studies have found disproportionately more left-handers among university architecture students and faculty (Peterson & Lansky, 1974), university mathematics students and faculty (Annett & Kilshaw, 1982), artists (Mebert & Michel, 1980), and musicians (Byrne, 1974). But again the evidence is mixed, which led one study to report: "The results reported in the literature relating professional choice and handedness are not consistent" (Cosenza & Mingoti, 1993, p. 494). Our analysis will control for occupational choice with rather coarse occupational classifications. A third possibility is that there is discrimination against left-handed people when it comes to hiring, promotion, and pay (Altonji & Blank, 1999). There is a history of discriminatory attitudes towards those who are not right-handed (Coren, 1993) and this, if present in the labour market, ought to show up as lower earnings.

In the economics literature there has been a large amount of work exploring how years of education, experience in the labour market, race, gender, native ability, and family background influence how much an individual earns (Altonji & Blank, 1999; Weiss, 1986; Willis, 1986). In addition to these conventional characteristics, economic research has examined the influence of health characteristics (Currie & Madrian, 1999), height (Heineck, 2005), and even physical appearance (Biddle & Hamermesh, 1994). To this literature, we add the individual trait of a person's laterality—as measured by handedness—which research in biology and psychology has established as a significant trait.

Denny and O'Sullivan (in press) have also studied this issue, finding that left-handed males earn slightly more than right-handed males, that non-manual left-handed workers had a slightly higher premium, and that left-handed females earned less than right-handed females. This is the only other study to our knowledge on this subject.[2]

Our findings are quite contrary to our expectations, and also differ from those of Denny and O'Sullivan. We do not find any evidence that left-handed individuals earn less, as might be suggested by the literature referred to above which generally finds that left-handed people tend to suffer more from factors that would reduce labour productivity. On the contrary, we find that left-handed men with higher levels of education have *higher* earnings than right-handed individuals. More specifically, among the

[2] We only became aware of this work in July 2006, after our analysis was completed.

college-educated men in our sample, those who report being left-handed earn 15% more than those who report being right-handed. The size of this effect is economically and statistically significant. Interestingly, this wage differential is found for males but not for females. We explore some possible explanations for these findings but are not able to provide concrete evidence leading to a theory that can reconcile all of the various facts we identify. We recommend this as an avenue for future research.

DATA AND MODEL

Our data are taken from the National Longitudinal Survey of Youth (NLSY), a nationally representative survey of approximately 5000 men and women used extensively in economic research on earnings determination (U.S. Bureau of Labor Statistics, 2003). The sample consists of individuals who were of ages 14–21 in 1979 and were interviewed annually for many years thereafter. In 1993, the year we use for analysis, they were aged 28–35. We use only what is known as the "cross-section" sample, and we delete oversamples of disadvantaged and minority groups.

The 1993 NLSY questionnaire included the following question:

> Were you born naturally left-handed or right-handed?
> (Interviewer: If neither, record explanation in comment screen.)

About 12% of the sample of men responded that they were left-handed as did 10% of women; these figures are close to estimates from other data. Nearly 3% of the sample volunteered an answer of "ambidextrous", and a few reported an answer of "neither". While these are interesting groups, there are too few observations for us to analyse and hence we delete them from the analysis.[3] However, these answers do highlight the fact that the measure of handedness in this survey glosses over many of the distinctions made in the literature between handedness in different activities and the question of whether everyone can be uniquely assigned to only two possible handedness classifications (right- or left-handed).

The survey obtained data on the individual's hourly wage rate, which is the most common measure of earnings and which will be our primary outcome variable as well.[4] Educational attainment is measured as the

[3] In unreported regressions, we investigated the inclusion of the "neither" and "ambidextrous" respondents in addition to those that identified themselves as right- or lleft-handed but obtained results little different from those reported below.

[4] For those who are not actually paid by the hour, the NLSY data set follows the usual practice of dividing earnings in the last paycheque by the number of hours worked in that period to obtain an estimate of the implicit hourly wage rate.

number of years of post-kindergarten schooling. For a measure of IQ, we use the Armed Forces Qualification Test (AFQT), developed by the U.S. Department of Defense to test potential enlistees on their arithmetic reasoning, word knowledge, paragraph comprehension, and numerical operations (Center for Human Resource Research, 2002). The AFQT is the most common measure of IQ used by economists and was collected from the NSLY respondents. This scale is a relatively crude measure of IQ compared to more sophisticated measures used by developmental psychologists, and no doubt leaves many dimensions of IQ unmeasured. The survey also obtained information on hours of work per week, age, gender, marital status, race, and whether of Hispanic origin.

Outliers on the outcome variable, hourly wages, were deleted in order to avoid their distorting the analyses using ordinary least squares regression, which describe relationships among means. For men, we removed those with wages greater than $80/hour or less than $0.45/hour, annual earnings greater than $100,000/year, or hours worked per week greater than 120. For women the trimming removed those with wages greater than $41/hour or less than $0.50/hour, or annual earnings greater than $78,000/year. (These figures are all in 1993 US dollars.) These extreme values are likely to be the result of data errors, and resulted in only about 3% fewer observations for men and 2% fewer for women.

Economists have devoted a great deal of study to the differences in earnings of men and women, and have found that the earnings determination process is very different for the two groups. This has led to the almost universal practice of considering the two groups separately, estimating separating regressions for them, and conducting all statistical tests separately (Altonji & Blank, 1999). This practice is followed here. We will first concentrate on an analysis of men, and then report our analysis of women and discuss how the results differ.

The means of the variables used in the analysis of men are listed in Table 1. There are very few significant differences in labour market variables and demographic characteristics by handedness. Most notably, there is no significant difference in hourly wages between left-handers and right-handers, which is our first simple finding. We also report the means for the logarithm of wages, which will be our dependent variable in the regressions, as the economic literature invariably finds this to be the better-fitting variable. There is no significant difference for that transformation of the wage as well. It does appear that left-handers work slightly fewer hours than right-handers, however. We also see no significant differences in years of education, AFQT scores, or the percentages that are married, Black, or Hispanic.

The raw mean difference between left-handers and right-handers in hourly wages does not control for differences in other variables such as

TABLE 1
Means of variables used in the analysis (males)

	All subjects	Right-handed μ_R	Left-handed μ_L	Difference $\mu_{L-}\mu_R$
left: 1 if left-handed, 0 otherwise	0.12			
married: 1 if married, 0 otherwise	0.60	0.60	0.57	0.25
Black: 1 if Black, 0 otherwise	0.11	0.11	0.10	0.00
Hispanic: 1 if of Hispanic origin, 0 otherwise	0.07	0.07	0.06	0.01
age: age at 1993 interview date	31.8 (2.24)	31.8	31.7	0.06
AFQT: raw AFQT score	71.0 (22.0)	71.0	71.4	−0.39
education: years of education by 1993	13.2 (2.53)	13.2	13.2	0.01
Hourly wage rate in 1993	13.1 (7.94)	13.1	13.4	−0.30
log of hourly wage rate	2.43 (0.55)	2.42	2.45	−0.03
Hours worked in week, including zeroes	42.2 (18.6)	42.4	40.2	2.20†
Conditional hours worked (excluding zeroes)	46.2 (13.9)	46.3	45.6	0.69
1 if employed, 0 otherwise	0.92	0.92	0.89	0.03†
Total observations	2295	2027	268	

Underlined variable names are found in later tables' reported regressions. We mark a significance level of † = 10% or better for a variable's difference between the two groups. Standard deviation is in parentheses for variables that take on values other than 0 and 1.

age, education, and race, although the fact that these variables are not highly correlated with handedness suggests that controlling for them may not make much difference. Nevertheless, the standard tool for eliminating the influence of these confounding variables is linear regression analysis, using ordinary least squares. We estimate regressions of the following form, where *lwage* is the logarithm of the hourly wage rate, *left* is a dummy variable equal to 1 if the individual is left-handed and 0 if the individual is right-handed, x_{dem} is a column vector of demographic variables (education, age, race, marital status, Black, Hispanic), and ε is a regression error term. We will also test for interactions between *left* and these demographics by entering variables for the product of *left* and demographic variables ($x_{dem} \cdot left$).

$$lwage = \beta_0 + \beta_L \cdot left + x'_{dem} \cdot \beta_{dem} + (x_{dem} \cdot left)' \cdot \beta_{inter} + \varepsilon \quad (1)$$

The coefficient β_L estimates the effect on the log wage of being left-handed instead of right-handed, holding other characteristics fixed. Since the dependent variable is measured in logarithms, the coefficient will have a percent interpretation; for example, if the coefficient equals +0.10, this implies that left-handers have 10% greater hourly wage rates than right-handers. The coefficient vector β_{dem} will estimate the corresponding effects of demographic variables on the log wage. The coefficients β_{inter} on the interaction variables allow us to determine whether the effect of being left-handed differs for those with different values of the demographic variables. For example, if the regression contains *education* as well as *left*education*, then the coefficient on *education* will measure the effect of education on the log wage for right-handers, while the coefficient on the interaction variable *left*education* will measure the difference between the effect of education on earnings for left-handers and right-handers. If the interaction coefficient is positive, this implies that the log wage differential between being left-handed and being right-handed is greater for those with higher levels of education. Interaction variables are an easy way to test for subgroup differences, although another way to test for those differences is simply to run a separate regression for different demographic groups (for example, high and low education groups); we use the latter method as well in some cases.

EMPIRICAL RESULTS

Table 2 reports the results of our first set of regressions for men. Column (1) shows a regression for the log hourly wage containing a variable for left-handers and controlling for the demographic characteristics, but without any interactions. The coefficient on the left-handed variable is positive and implies a 4.5% advantage in hourly wages of left-handers over right-handers, but it is statistically insignificantly different from zero at the 10% level of confidence. Thus, we find that the insignificant raw difference we found in Table 1 persists after we control for demographic characteristics.[5]

The other coefficients show that the log wage is positively affected by AFQT, education, age, and being married, and is negatively affected by being Black or Hispanic (relative to White).[6] These coefficient signs are the same as those widely found in the economics literature. The coefficient on education, for example, implies that a 1-year increase in education leads to a 5.0% increase in the hourly wage. In the economics literature, the coefficient on education in a log wage regression is generally called the economic "return" to education, because education is generally seen as an investment

[5] We estimated similar regressions by replacing the dependent variable with hours of work per week, employment status, and the logarithm of annual earnings. The handedness variable was statistically insignificant in those regressions as well.

[6] We do not include the square of age, as most economic models do, because our men are relatively young in age and thus their wages have not yet started to exhibit much curvature.

TABLE 2
Basic regression results (males)

Dependent variable: log hourly wages	*(1) No interactions*	*(2) Interactions included*
left	0.0458 (0.032)	−0.758 (0.51)
age	0.011 (0.005)*	0.009 (0.005)†
AFQT	0.0056 (0.0007)**	0.0059 (0.0007)**
education	0.050 (0.005)**	0.0461 (0.006)**
married	0.179 (0.021)**	0.192 (0.023)**
Black	−0.073 (0.037)*	−0.074 (0.039)†
Hispanic	−0.034 (0.041)	−0.039 (0.043)
left*age		0.0170 (0.015)
left*AFQT		−0.002 (0.002)
left*education		0.035 (0.017)*
left*married		−0.092 (0.068)
left*Black		0.0013 (0.12)
left*Hispanic		0.010 (0.13)
Constant	0.906 (0.16)**	1.00 (0.17)**
N	2190	2190
Adj. R^2	0.2309	0.2316

Significance levels are † = 10% or better, * = 5% or better, and ** = 1% or better. Standard errors are in parentheses.

in future earning power, and the term "return" is borrowed from the literature on investing in financial assets.

The second column in Table 2 shows tests for whether the handedness difference is significant in any demographic subgroup by adding interaction variables to the regression. As the results show, there is no significant difference in the log wage of left-handers and right-handers of different ages, marital status, race, AFQT, or ethnic status. However, we do find a significant difference by education, with the interaction coefficient (on *left*education)* of 0.035, implying that left-handers have a 3.5% greater return to a year of education than right-handers, whose return to a year of education is 4.6%; hence left-handers have a return to education of 8.1% (= 3.5 + 4.6). We therefore pursue this education difference in detail.

Handedness and higher education

A standard finding in the economics literature on education is that the effect of education on wages and earnings is nonlinear, in that most effects occur at educational transition points such as high school and college graduation. A common regression specification then allows the education effect to be separated for those with less than 12 years of education, those with exactly 12 years of education (i.e., a high-school degree), those with some college (at least 13 years of completed education), and those with a college degree or more (16 or more years of education). Partitioning the data into these educational categories, let us first return to examining the raw data in order to assess where the log wage differences associated with handedness are occurring.

Table 3 shows mean log hourly wages for the two handedness groups using these categorisations of education. There are no significant differences for those with 12 or fewer years of education, but the differences are significant for those with 13 or more years; the table shows an 11% greater hourly wage for left-handers for this group. The difference remains significant and is larger (14%) when we examine only those with 16 or more years of education. Hence we conclude that the significant education difference we found in Table 2 is mainly occurring among those who have gone on to higher education; no differences appear for the less educated men.

We pursue this finding with regression analysis by estimating separate regressions for those men with 13 or more years of education, and those with 16 or more years of education, including the same set of demographic control variables we used in the first column of Table 2. These results are reported in Table 4. For the group with 13 years or more education, the coefficient on the left-handed variable is 0.039 and statistically insignificant, indicating that the hourly wage differences between left-handed and right-handed individuals in this group can be accounted for by the control variables. The interaction term in column (3) indicates that the difference occurs only in the group with 16 or more years of education: of men entering

TABLE 3
Mean log hourly wages by education group (males)

Group	*Entire group*	*Right-handed* μ_R	*Left-handed* μ_L	*Difference* $\mu_L - \mu_R$
educLT12: less than 12 years education	2.10	2.10	2.13	0.03
educ12: exactly 12 years education	2.32	2.32	2.90	0.58
educ13+: at least 13 years education	2.62	2.61	2.72	0.11*
educ16+: at least 16 years education	2.75	2.73	2.87	0.14*

Underlined variable names are found in later tables' reported regressions. * = significantly different from zero with p value $\leq 5\%$.

TABLE 4
Regression results for higher education groups (males)

Dependent variable: log hourly wage	*(1) Full sample*	*(2) 13 or more years of education*	*(3) 13 or more years of education*	*(4) 16 or more years of education*
left	0.0436 (0.032)	0.0394 (0.034)	−0.00629 (0.039)	0.155* (0.066)
educ12	0.0522 (0.036)			
educ13–15	0.146** (0.043)			
educ16+	0.340** (0.046)	0.254** (0.028)	0.234** (0.029)	
left*educ16+			0.164* (0.075)	
Constant	1.419** (0.15)	1.397** (0.16)	1.402** (0.16)	1.175** (0.32)
N	2190	1927	1927	539
Adj. R^2	0.2328	0.2064	0.2079	0.1023

Additional demographic controls included in regressions but not shown above (for the purpose of brevity) are age, AFQT, married, Black, Hispanic. Standard errors in parentheses, † = 10% or better, * = 5% or better, and ** = 1% or better confidence.

college, those that are left-handed have a return to completing a college education that is 16.4 percentage points higher than the 23.4% return received by those that are right-handed. Focusing solely on the group with 16 years or more education in column (4), the coefficient indicates again that there are large hourly wage differences between the two handedness groups for those who have completed college—the left-handed have 15.5% greater hourly wages—even after controlling for other demographic differences (listed in the table's notes).

College major and occupation

Previous studies mentioned in the Introduction have found a relationship between handedness and occupational choice or career choice (as reflected in college major). It is then possible that the wage differential experienced by college-educated left-handers may reflect the choice of, or aptitude for, higher-paying jobs rather than higher productivity. We now explore that possibility.

Although the NLSY does not contain a variable that summarises college major, we used the available variables to generate indicators of types of degree (associate, bachelor, master, and other) and classification of most recent undergraduate major. Three larger super-categories were also created by combining "Sciences" with "Engineering" and combining "Social Sciences" and "Humanities" with "General", leaving "Business and Management" on its own. Specific majors for which the handedness literature contends that left-handed individuals may have proclivities are

"Fine and Applied Arts", "Mathematics", and "Architecture and Environmental Design". Unfortunately, only about one fifth of the respondents could be said to have reported a most recent undergraduate major. Among those who responded, however, neither the targeted definition of majors for which we would expect a bias towards left-handedness, nor any of the other categories or super-categories of most recent undergraduate major showed significant correlation with handedness (as measured by the Pearson correlation coefficient). However, these majors are broad in definition and are only loosely correlated with earnings, let alone handedness.

The NLSY questionnaire also asked respondents for their occupation of work. However, our sample size is not large enough to study more than broad occupation categories: professionals, managers, sales workers, clerical workers, craft workers, operatives, service workers, and labourers. The data show that there is a slight tendency for more left-handers to be found in the skilled occupations, but the differences are not large. Recalling from Table 1 that the representation of left-handedness in the 1993 male population (and our sample) is about 12%, we draw the following comparisons with individual occupations. In our sample, 11% of professionals are left-handed, but 14% of managers are left-handed. In contrast, less than 10% of operatives, service workers, and labourers are left-handed. There is then a weak relationship in the expected direction. However, left-handed men are 14% of craft workers and 15% of clerical workers as well. These occupations are in the middle of the skill distribution. Thus we find a slight positive correlation between occupational skills and left-handedness, but one that is not monotonic.

We also analyse the effect of occupation on hourly wages by including dummy variables for each of the occupation groups, omitting one (professionals) and interacting our left-handed dummy variable with these occupation dummy variables. As shown in Table 5, the interaction coefficients between *left* and occupation are generally statistically insignificant. The one exception is for the category of labourer, where a positive and significant coefficient appears in the one specification in which our *left* variable is interacted with other variables in the equation, implying that the increased wages received by professionals as compared to labourers are significantly different between those that are left- and right-handed. In fact, this leads left-handed labourers to actually earn more than left-handed professionals. In other occupations it is merely a flattening: the advantage of being a professional, as compared to other occupations, is mitigated by being left-handed. (The other occupational interactions in the third column, while not statistically significant at conventional levels, are positive.)

The size and statistical significance of the coefficients on the interactions between left-handedness and education (*left**educ13–15* and *left**educ16+*)

TABLE 5
Regression results with occupational categories (males, with at least 12 years education)

Dependent variable: log hourly wages	*(1) No education variables*	*(2) Education variables, but not interacted w/handedness*	*(3) Full interactions*
left*(*managers, officials, proprietors*)	−0.0424 (0.11)	−0.0407 (0.11)	0.115 (0.11)
left**sales*	0.100 (0.16)	0.0761 (0.16)	0.168 (0.17)
left**clerical*	0.0388 (0.14)	0.0476 (0.14)	0.224 (0.15)
left*(*craftsman, foremen*)	−0.0384 (0.11)	−0.0448 (0.11)	0.177 (0.13)
left**operatives*	−0.118 (0.12)	−0.102 (0.12)	0.155 (0.15)
left*(*service workers, except private household*)	−0.0373 (0.14)	−0.0303 (0.14)	0.151 (0.16)
left*(*labourers, except farm)*	0.213 (0.14)	0.197 (0.14)	0.420** (0.16)
left	0.0227 (0.079)	0.0261 (0.078)	−0.572 (0.53)
educ13–15		0.0737* (0.029)	0.0551+ (0.031)
educ16+		0.251** (0.033)	0.216** (0.036)
left*educ13-15			0.159+ (0.091)
left*educ16+			0.260* (0.10)
Constant	1.666** (0.16)	1.546** (0.16)	1.607** (0.17)
N	1891	1891	1881
Adj. R^2	0.2227	0.2451	0.2430

The constant represents right-handed professionals with exactly 12 years education (each of these groups did not have its own coefficient and dummy variable). Additional variables included in the first two columns' regressions (but not shown for the purpose of brevity): demographic controls (as in Table 4) and non-interacted professions. In addition to those variables, the third column's regression also included variables that interacted left-handedness with the demographic controls. Standard errors in parentheses, ** $p < .01$, * $p < .05$, $+p < .1$.

in the final column show that occupation (labourer) certainly does not explain the greater returns to education realised by left-handed men that we found previously. We still estimate a 15.9-percentage-point larger increase in wages for left- than right-handed men for completing some college, and a 26-percentage-point larger increase for completing college (in both cases compared to completing no college).

That occupational effects on wages are not more generally significant may be a result of the coarseness of the occupation classifications. In particular, one might have expected that there would be a positive wage effect for left-handers for the two highest-skilled occupations—professionals and managers—given the previous finding of a higher return to education for those that are left-handed. However, there is great heterogeneity in the nature of the intellectual work required within these categories. More surprising is the positive wage differential for the unskilled category of labourer, which is puzzling in light of our earlier results. There might be several forces at work here, as we discuss further after investigating differences in the return to education at different points in the distribution of returns. We will also discuss a potential link between occupational differences and the returns to education.

Changes in the distribution of the returns to education

As mentioned above, the differential return to higher education for the left-handed persists even after controlling for our admittedly coarse measures of college major and occupation. To dig deeper into where this differential return is arising in the wage distribution, we will use quantile regression (Buchinsky, 1998; Koenker & Bassett, 1978; Koenker & Hallock, 2001).

This technique allows the measurement of differences in wages for different education and handedness groups at different points in the overall wage distribution of the population, e.g., those at the 90th percentile or 10th percentile, holding constant other demographic characteristics in the usual regression framework. Individuals at the 90th percentile are those who have very high earnings and individuals at the 10th percentile are those who have very low earnings relative to all others in the population, again holding constant other characteristics. Another way of saying that we are holding other characteristics (demographics and AFQT score) constant is to refer to the "conditional distribution" of wages—conditional, that is, on the other measured characteristics. This parallels discussions of the mean in ordinary least squares results.

Our preceding results on education and handedness have told us that, on average over the conditional wage distribution, those with higher education who are left-handed do particularly well. With quantile regression, we can examine whether these advantages are the same for those who end up in the top or bottom of the conditional wage distribution. We can therefore examine education and handedness differences at different strata of the wage distribution, rather than simply changes in the mean as modelled by ordinary least squares regression.

Table 6 reports the coefficients from the quantile regressions showing how the return to 16 or more years of education differs for left- and right-handed subjects who are at different percentile points of the hourly wage distribution, conditional on the other variables included in these quantile regressions. (For purposes of brevity, we do not report the other coefficients.) The second row shows that right-handed individuals have monotonically increasing returns to a college education as one moves from lower to higher

TABLE 6
Hourly wage gain to higher education by handedness and percentile point of the conditional wage distribution for the entire sample (males)

	Percentile point				
	10	*25*	*50*	*75*	*90*
Hourly wage gains to 16+ years of education					
Left-handed	0.486**	0.467**	0.465**	0.462**	0.507**
	(0.153)	(0.092)	(0.057)	(0.100)	(0.109)
Right-handed	0.19*	0.23**	0.35**	0.37**	0.41**
	(0.08)	(0.05)	(0.04)	(0.06)	(0.07)
Difference, Left – Right	0.297*	0.234**	0.119*	0.088	0.099
	(0.145)	(0.082)	(0.051)	(0.092)	(0.103)

Based on separate quantile regressions of log wages for each of the given percentile points, estimated jointly. The regressors were the left-handed dummy variable (left), education category dummy variables (educ12, educ13–15, educ16+), interactions of education categories with left-handedness, and all demographic controls. The cells in the row labelled "Left-handed" contain the sum of the coefficients on left, educ16+, and the interaction between left and educ16+. The rows labelled "Right-handed" contain the coefficient on educ16+. The rows labelled "Difference" contain the difference in the first two rows. Standard errors in parentheses, ** $p < .01$, * $p < .05$, $+p < .1$.

percentiles in the wage distribution; the return ranges from 19% at the 10th percentile up to 41% at the 90th percentile. This finding for right-handers is consistent with previous studies that did not control for handedness (such as Buchinsky, 1994), which is not surprising since presumably around 90% of such population samples are right-handed. Economists typically interpret these types of differences as reflecting unobserved differences in "ability" or, more precisely, a complementarity between ability and education (Arias, Hallock, & Sosa-Escudero, 2001; Mwabu & Schultz, 1996). We are controlling for an observed measure of ability, the AFQT score, but we know that it is only a crude proxy for dimensions of ability that are related to labour market performance.

In contrast, the first row of Table 6 shows that the return to a college education for a left-handed individual is fairly constant over the wage distribution, ranging from 46.2% to 50.7%. The third row of the table reports the difference between these two coefficients and shows the greater educational benefit to left-handers in the lower half of the wage distribution. The gain we found earlier—a 15.5% higher return to 16 or more years of education for left-handers—is not occurring uniformly over the wage distribution, but rather is considerably higher than 15.5% at the lower percentiles and lower than 15.5% at the upper percentiles. In fact, the difference is not significantly different from zero at the 75th and 90th percentiles. In our discussion below we consider reasons why we might not observe a complementarity between education and unobserved ability among left-handed men.

Gender

After completing the analysis of male subjects in the data, the exact same sequence of analyses was conducted for the female sub-sample. The results showed no significant differences between left-handed and right-handed females in any dimension, including those where significant differences were found for males. Among females, left-handers had no differences in hourly wages even among those with 16 or more years of education, and there were no significant differences in wages at any point in the distribution of wages for any education group. Some speculation on possible reasons for this result is provided in the next section.

DISCUSSION

Our analysis has revealed four findings, presented in order of robustness rather than in the order of their exposition above. First, left-handed individuals earn a higher wage than right-handed individuals but only among the college educated. Second, this positive wage effect is strongest in the lower half of the wage distribution because the return to college education is constant for left-handers throughout the conditional wage distribution, but for right-handers the return is greater at higher conditional wage percentiles. Third, we have a weak result that left-handed labourers earn a higher wage than right-handed labourers. Fourth, the previous effects apply only to men.

We do not have a theory that reconciles all of these findings. On one level, that is not surprising since the preceding literature on handedness shows that its correlates and effects are multi-dimensional, often subtle, and often poorly measured by the available data. Our goal here is to suggest some possible explanations for the results and to relate these findings to previous work. Future work can explore these results further, presumably with data that better target the links between biology, educational choices, occupational choices, and labour market outcomes.

One explanation for the first two findings has to do with differential ability for left-handed individuals and occupational choice. Focusing on higher-educated people, suppose there are two unobservable traits: general ability and a taste for (or ability for) jobs that require high levels of education but which do not pay well (examples will be provided shortly). Next suppose that left-handed individuals have high levels of both traits relative to right-handers. The first trait (general ability) drives up their return to education while the second one drives down the level of their wage and also puts them in the lower part of the conditional wage distribution. The net result is that it appears that the return to higher education does not go up with the level of (unobserved) ability, but in fact it would if we were holding the second unobservable trait constant (which we are not). As we noted previously, our measured variable for ability is unlikely to adequately capture the first trait. Our measures of an interest and aptitude in jobs that require high levels of education but provide relatively low pay (the second trait) are also relatively inexact.

As evidence consistent with our explanation, past studies mentioned in the Introduction have documented that left-handed individuals are disproportionately represented among artists, musicians, and university faculty, at least in some disciplines. Artists and musicians are occupations in which the individual typically has a high level of education but relatively low earnings. University faculty also have lower salaries than those with comparable education who have taken jobs in business, industry, or government. These types of jobs are personally but not financially highly rewarding. Furthermore, it was also noted in the Introduction that studies have found that left-handed individuals are disproportionately represented in the upper tail of the distribution on measures of cognitive skills, which is consistent with higher ability of left-handers among the most educated.

Following up on this tentative explanation, we have also explored how occupation varies with handedness for those in the lower percentiles of the wage distribution with 16 or more years of education. Although our sample sizes are not large enough to break down occupation distributions within small ranges of the wage distribution for college-educated left-handed men, we are able to obtain acceptable sample sizes by examining those in the lower 25% of the conditional distribution.[7] The results (not shown in a table) show that left-handed men are more concentrated in the higher-skilled occupations within this subpopulation. For example, 53% of those who are left-handed are in professional occupations, compared to 38% of those who are right-handed.[8] We calculated a chi-squared statistic of 22.7 for the difference in the occupational distribution of the left-handed group as compared to the right-handed group, which is larger than the critical value for 95% confidence, 12.6. These findings are, therefore, consistent with the argument

[7] For this discussion, we took our estimates of the wage regression at the 25th percentile point (see footnote to Table 5 for the variables in the equation), predicted the 25th percentile point for each individual, and selected those individuals with 16 years of education whose actual wages were below that predicted value for the 25th percentile. We then tabulated the occupational distributions of left-handed and right-handed individuals within this group.

[8] The other two groups that had significantly large standard errors in the calculation of the chi-squared statistic were clerical workers and operators. Both are lower-skilled occupations, and both had fewer left-handed individuals than the right-handed distribution would predict.

we have put forth, although what is really needed is a larger data set with finer or more targeted occupational categories.

The finding of a positive wage for labourers is difficult to reconcile with these other explanations because that occupation is neither high in education nor high in non-financial, personal rewards. However, an inspection of the coefficients in the relevant regression reveals that left-handed individuals in all non-professional occupations earn more than professionals, contrary to right-handed individuals for whom the expected ascending wage profile with occupational skill occurs. For example, while left-handed labourers earn 20% more than left-handed professionals, left-handed managers, sales workers, and craft workers earn 17% more, almost the same amount. Indeed, the wages of labourers are usually not statistically different from those of other non-professional occupations among left-handed individuals. The relatively flat profile of wages by occupation exhibited in the data is quite similar to the flat profile of wages by percentile point in the distribution, and may likewise reflect the low pay of professionals more than any other factor, for which we have given an explanation above. More research is needed using data with greater numbers of observations on detailed occupation to address this finding.

The final issue is why none of these effects are observed for women. We hypothesise several possible reasons for this difference. One is that the female occupational distribution in 1993 was (and is still today) quite different from that of males. Women are in more clerical and service positions, while men are found more in craftsman, operative, and non-farm labour jobs. Also, 11% of women in our sample are managers compared to 17% of men, but population figures show that professional women are heavily concentrated in “education, training, and library occupations” and have a weaker representation in the category “computer specialists, engineering, maths and architecture”, the groups for whom we hypothesise that left-handed individuals have an advantage (U.S. Bureau of the Census, 2003). These occupational differences have been extensively discussed in the literature on gender differences in the labour market and are thought to arise from a number of sources, including possible gender discrimination.

Gender discrimination may, more generally, provide an additional explanation for our findings for women. The same forces described for higher-educated left-handed males may be at work with higher-educated left-handed females, but discrimination against women for those types of positions may be counteracting it so that no wage effect is found. Consistent with these points is that women are typically underrepresented among artists, musicians, and university faculty, which are three of the occupations identified as requiring high levels of education but that pay low or modest wages, and where we have speculated that some of the greatest relative earnings gains among left-handed men occur.

Finally, recall the study by Coren (1995) mentioned in the Introduction that found “divergent thinking” to be more common among left-handed people, although only for males. If it is this differential cognitive style that is the source of the higher earnings for college-educated left-handed men, it would explain why it is not observed for women.

CONCLUDING REMARKS

Building on the very large literature studying laterality in biology and psychology, this study is one of the first to explore whether handedness correlates with measures of economic performance. We find that handedness is correlated with the financial return to education in that left-handed college-educated people earn 15% more than right-handed college educated people. This wage differential is found for males but not for females.

Clearly, more research using different data sets is required to determine whether our findings are robust. It is especially important to better control for how occupational choice varies with handedness. In spite of the limitations of our data set in that regard, we do find several suggestive and economically and statistically significant results that suggest further support for the notion that handedness matters.

Our findings also differ from those Denny and O’Sullivan (in press) in several respects. While we both find a wage advantage for men, we find it only for more educated males whereas Denny and O’Sullivan find it for all men and for non-manual workers in particular. Also, Denny and O’Sullivan find a wage penalty for left-handed women whereas we find none. There are many differences between the studies. Our work has been conducted on the US, whose labour market may differ from that in the UK examined by Denny and O’Sullivan. Another possible difference is that our measure of handedness comes from a contemporaneous question asked of individuals as adults, whereas the measure used by Denny and O’Sullivan was a parental report when the child was 7 years old. Further research is called for on these issues.

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