THE ECONOMIC CONSEQUENCES OF BEING LEFT-HANDED: SOME SINISTER RESULTS

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The economic consequences of being left-handed : some sinister results[•]

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Abstract

This paper provides the first estimates of the effects of handedness on hourly earnings. Augmenting a conventional earnings equation with an indicator of left handedness shows there is a well determined positive effect on male earnings with non-manual workers enjoying a slightly larger premium. These results are inconsistent with the view that left-handers in general are in some sense handicapped either innately or through experiencing a world geared towards right-handers. The results for females however reveal the opposite, left-handed females are paid significantly less. This is consistent with some psychological evidence which suggests that left-hander males have particular talents such as enhanced creativity and some evidence on brain morphology which also suggests advantages for left-handed males.

Keywords: earnings, brain, left-handed, laterality

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Executive Summary

This paper provides the first estimates of the effects of handedness on hourly earnings using data from the National Child Development Survey. Handedness is an important and widely studied neuropsychological phenomenon. About 10% of the population are left-handed and is somewhat more common in males. Augmenting a conventional earnings equation with an indicator of left handedness shows there is a well determined positive effect on male earnings of about 5%. For non-manual workers there is a slightly higher premium but there is no evidence that individuals sort into different types of occupation on the basis of their handedness. These results are inconsistent with the view that left-handers in general are somehow disadvantaged either innately or through experiencing an environment geared towards right-handers. The results for females however reveal the opposite: left-handed females are paid significantly less, around 4%. Interactions between sex and handedness are common in the research literature. We discuss a large and varied literature on handedness that may explain these results. This includes research on brain morphology as well as psychometric and epidemiological evidence. The results are broadly consistent with a range of studies that point to there being some advantages associated with left-handedness (such as enhanced creativity) for males but some generic disadvantages associated with the polymorphism.

The economic consequences of being left-handed: some sinister results

1. Introduction

This paper presents the first estimates of the impact of left-handedness on earnings. In the canonical model of the determinants of an individual's earnings principally associated with Becker, Mincer and many others, earnings are determined by a relatively small number of variables, notably education and work experience or age. However it has long been the practise to augment the empirical models with a variety of covariates. Some of these are uncontentious, such as controls for cognitive ability, while others raise deeper theoretical questions. Recent work on the determinants of earnings (e.g. Carneiro & Heckman 2004) has argued that there are important effects of non-cognitive skills on earnings. In general, economists have avoided the use of other psychometric measures in earnings equations, partly due to a lack of data, but also because of the lack of an appropriate theoretical framework.

While the use of behavioural variables and/or psychometric measures is unusual it is becoming less esoteric: Bowles, Gintis and Osbourne (2001) survey the growing research on the behavioural determinants of wages. While some of the literature analyses the effects of character traits such as withdrawal and aggression on earnings, others include psychometric indices such as the Rotter index of locus of control as well as *Machiavellian intelligence*- the ability of manipulate other people[1]. While the notion that temperament or behavioural characteristics matter for an individual will come as

[1] Turner and Martinez (1977) find positive returns to this characteristic for high educated individuals and negative returns for those with low education. Mueller and Plug (2004) look at the returns to personality.

no surprise to psychologists (amongst others), it has been relatively slow in having an impact on empirical economics. A parallel recent development has been the rise of neuroeconomics, which involves applying neuroscience to the study of economic decisions. For example functional Magnetic Resonance Imaging (fMRI) has been used to see which parts of the brain are activated while a subject plays simple Prisoner Dilemma games[2].

This paper contributes to work linking the brain with economics by looking at one particular feature of individuals which relates to the brain: *laterality*. In particular we ask whether left-handed people are paid more or less than right-handers, controlling for the usual variables that appear in a conventional earnings equation. Our reasons for focusing on left-handedness are partly data-driven: aside from other measures of laterality, it is the only characteristic available in a large dataset which also includes the labour market data necessary for the investigation. Secondly, left-handedness has generated a significant body of scientific research and as discussed below there are grounds for arguing that there may be a connection between it and labour market outcomes. In the next section we discuss some of the scientific background to left-handedness and why it might matter in the labour market.

It might be argued that the inclusion of laterality in an earnings equation is *ad hoc* since it lacks a strong theoretical foundation. If so, the same argument applies to the inclusion of variables such as stature, beauty and sexual orientation, which have been increasingly used in earnings studies. The idea that features of the brain should influence one's experiences in economic and social life, 'though currently untested, is hardly controversial. Recent work on life-cycle skill formation builds directly on neuroscientific

[2] See Glimcher (2003) for an introduction and Rubinstein (2005) for an alternative view.

findings on how brains learn and are influenced by their environment; see Cunha *et al* (2005).

2. Laterality

Laterality is the scientific term for "sidedness", the characteristic of many objects and living things in which there is an asymmetry between one side and the other. The most obvious examples are in the animal kingdom where many species have important asymmetries. While humans and other primates appear symmetric from the front or back their inner organs are arranged asymmetrically. External asymmetries in humans are more subtle: the left and right side of the face are not quite mirror images and there are systematic differences in, amongst other things, feet, gonads and fingerprints.

In terms of biology, especially human, there is a very large literature examining the incidence, causes and correlates of laterality. The form that most people are familiar with is handedness. While most people identify this with whether an individual writes with their left or right hand, researchers stress the existence of a continuum of handedness since many people will use different hands for different tasks. Aside from handedness, other forms of laterality exist such as footedness as well as eye dominance and the inter-relationship between different lateralities is the subject of much research, see for example Bourassa, McManus and Bryden (1996)).

The existence of handedness has a long historical tradition with references to it appearing in the works of Socrates and the Old Testament for example. A consistent feature is the association between left-handedness and either abnormality or evil. The clearest example is the Latin word for left, *sinister*, and its French equivalent, *gauche*. Such associations occur in numerous languages. By contrast, to be *dextrous* (literally

right handed) is to be physically adept and a key aide is likely to be one's "right hand man". The idea of left-handers being clumsy is widespread. The British psychologist Sir Cyril Burt declared: "Not infrequently the left handed child shows widespread difficulties in almost every form of fine muscular coordination…Awkward in the house and clumsy in their games, they are fumblers and bunglers in almost everything they do"[3]. One explanation for this could be that left-handers tend to turn in the opposite direction to right-handers (anti-clockwise and clockwise respectively) so they are more likely to bump into people.

The degree to which left-handedness is stigmatised varies from culture to culture and also depends on religion but it is virtually universal. Children who wish to write with their left hand have often been forced to use the other hand. Since the vast majority of people are right handed it is not surprising that the world is geared towards the needs of right-handers. The extent to which it is so can be surprising as it is often subtle however and most right-handers are oblivious to it. Many tools and basic pieces of equipment such as corkscrews, knives, surgical instruments, computer keyboards and pencils are designed for right-handers. Power-tools and firearms are generally designed with right-handers in mind by the location of the key switches and safety catches. So it may be the difficulty of left-handers using right-handed equipment that has given rise to the idea that they are clumsy.

The incidence of left-handedness varies across culture, sex and over time. Typically 10% of the population would be classified (or classify themselves) as left-handed with a somewhat higher incidence amongst males than females. There is a lower incidence in eastern cultures, which may reflect greater cultural resistance to left-handers.

[3] Quoted in Coren (1993) p 244.

Some ingenious analysis of paintings and sculptures suggest that this incidence hasn't changed much over the last 5000 years (Coren and Porac 1977) although there is evidence that it has risen in the twentieth century[4]. This appears to reflect the diminishing tendency for left-handed children to be forced to write with their right hand. Anthropological evidence suggests that right dominance is over a million years old, preceding *homo sapiens*.

The scientific literature on laterality is extensive and only a few aspects will be touched on here[5]. One issue that should be mentioned is the debate on the causes of left-handedness since this has direct implications for how it might influence earnings. There are a variety of possible explanations for left-handedness. It is well known that left-handedness partly runs in families, which suggests a possible genetic basis. Published estimates of the heritability of the trait vary between 0.23 and 0.66. Bryden *et al* (1997) discuss several genetic models of the inheritability of handedness.

An early theory of the causes of left-handedness is that birth stress plays a key rôle; see Bakan *et al* (1973). The argument is that if, during birth, there is damage to the left side of the skull as it passes through the birth canal then this may be sufficient to cause an individual to switch from being a right-hander since our brains are `contra-lateral', that is the left hemisphere is normally responsible for the right side and vice versa. Damage to the right side, would have no effect except in the small number of left-handed individuals. Not surprisingly, the suggestion that left-handers are, in effect, brain damaged, is controversial. If true, it would suggest that left-handedness is a marker for

[4] See McManus (2002) figures 9.1 and 9.2.

[5] The books by Coren (1993) and McManus (2002) provide accessible introductions to the area.

the presence of neurological impairment and this is consistent with evidence on various other conditions that have a higher incidence amongst left-handers. However, there is a great deal of variation in the incidence of birth stress (due, for example, to variations in obstetric practice) and this is not correlated with the incidence of left-handedness. A more recent environmental theory is that exposure to ultrasound *in utero,* may increase the incidence of left-handedness, see Rothman (2001). It is likely that there are a variety of types of left-handedness which may explain the often inconsistent results in the literature on characteristics of that population.

Why might laterality in general and handedness in particular matter for economic outcomes such as earnings? There are two basic reasons for thinking that left-handedness may be associated with bad outcomes in life; *environmental*: the world is geared towards right-handers, or *biological*: left-handedness is a marker for some underlying deficit. The environmental theory is based on a long tradition of historical and scientific evidence that left-handers experience both prejudice and also practical difficulties largely because they are a small minority and many aspects of the environment are constructed to suit right-handers. Coren and Previc (1989) and Coren (1996) show a higher incidence of accidents occurring to left-handers in samples of US military personnel and university students respectively 'though this finding has not been found in other studies e.g. Hicks *et al* (1993), Barnes *et al* (1998) and Pekkarinen, Salminen and Järvelin (2003), so it is far from clear that this holds generally.

The biological argument comes in several forms. Firstly, there are numerous findings that left-handedness is associated with various undesirable outcomes such as low cognitive ability (e.g. Hardyck, Petrinovich, & Goldman 1976, McManus & Mascie-Taylor 1983) as well as a number of unusual and sometimes pathological conditions. For example a higher incidence of left handedness is found amongst groups with a history of

alcoholism, autism, criminality, depression, homosexuality, immune diseases, psychosis and schizophrenia to mention but a few[6]. One theory then is that left-handedness is a marker for the presence of other pathologies in the individual that have been caused by some other means, such as the birth stress theory of Bakan discussed above. In effect, then, a negative relationship between left-handedness and earnings may not be causal but point to the existence of some other underlying condition. Porac and Searlman (2002) find that left-handers do not experience a lower quality of life in terms of psychological health, physical health or cognitive performance 'though Bryden *et al* (2005) find that non right-handers are significantly more likely to report specific disorders (such as epilepsy and hypertension). Some early research that suggested excess mortality amongst left-handers has not been supported by extensive subsequent work, see Ellis *et al* (1998) or Peto (1994) for example.

So far, so bad for the southpaw. Is there an upside? Given the persistence of left-handedness over a long period of time then Darwinian natural selection would suggest that some benefit must accrues to it assuming that it is heritable. There is some evidence that left-handedness conveys some advantages. Benbow (1986) finds a higher incidence of left-handers among the extremely intellectually precocious, based on those in the .01% of students taking the American Scholastic Aptitude Test before age 13. The difference (relative to a control group) was greater for those who were verbally precocious rather than mathematically precocious. Similarly, Hicks and Dusek (1980) examine the handedness of gifted and non-gifted children (gifted being defined as having an I.Q.

[6] See Coren (1993), chapter 9. The list is not definitive or exhaustive and some of these associations are disputed. An exception to the trend is the finding that left-handers have a lower incidence of arthritis and ulcers; see McManus and Wysocki (2005).

greater than 131) and find a lower incidence of right-handedness amongst the gifted children. However given the small numbers involved this is unlikely to have much effect on earnings especially if one conditions on cognitive ability. There are advantages in certain competitive situations precisely because left-handers are in a minority for example cricket and fighting, see Brooks *et al* (2004), Faurie and Raymond (2004) respectively.

A recurring theme in popular accounts of left-handedness is that they are more creative or talented. Numerous web sites listing famous left-handers attest to the prevalence of this view. Is there more systematic evidence for this relationship? Conventional intelligence testing is not suited to answering this question since it relies on solving questions to which there are unique well-defined answers - that is, it tests "convergent thinking". Divergent thinking, by contrast, requires an individual to work outwards towards some unexplored association, for example asking someone to think of novel uses of a household object. A number of papers find evidence that creativity is higher amongst left-handers e.g. Newland (1981) and Coren (1995). The former paper uses the Torrance tests of Creative Thinking and finds a higher score for left-handers in all four domains (fluency, flexibility, originality and elaboration). A disadvantage of the approach taken in this paper is that these tests are "figural"; they depend on processing visual information and hence may be confounded by spatial abilities, which are known to be higher amongst left-handers.

Coren (1995) uses tests which do not involve spatial reasoning or drawing. This paper makes the important finding that creativity (specifically "divergent thinking") is associated with left-handedness in males only. These findings on creativity are also consistent with research which shows that, particularly in males, the right frontal lobes are critical for *cognitive novelty*: dealing with new tasks or situations where the brain's

existing "repertoire" cannot be applied whereas the left lobes deal with *cognitive routinization*: situations that the brain is familiar with and has pre-existing strategies to use. The argument then is that left-handers differ in cognitive *styles* rather than cognitive *abilities* which is what conventional intelligence tests measure[7]. Sex-handedness interactions such as the above are common in the literature. For example Faurie *et al* (2006) find that a negative correlation between left-handedness and several measures of school performance and leadership skills for girls but a positive association for boys. This trend in the literature would lead one to expect that the effects on earnings may differ by sex and, specifically, be more favourable to male left-handers than female left-handers.

Another candidate explanation for left-handed advantage relates to brain morphology. The main connection between the two hemispheres of the brain is a thick band called the *corpus callosum*; this is about 7cm in length and contains about 200-250 million axons that allow the cortical regions of the two hemispheres to communicate. In a series of papers Witelson (1985,1989) and Witelson and Goldsmith (1991) found that it is significantly larger in left-handers (more precisely, non-consistent right-handers compared to consistent right-handers) amongst males but not females.

It has been hypothesized that this callosal size difference could allow more rapid inter-hemispheric processing. This is based on the assumption that the difference in size was due to a greater number of axons. There are other explanations for this finding: axons are usually covered in a fatty sheath called myelin that acts as electrical insulation. It is possible that differences in callosal size are due to greater myelination or to thicker axons. However the evidence that exists suggests that callosal size is a good proxy for the number of axons, see Aboitiz *et al* (1992). Hines *et al* (1992) provide direct evidence of a relationship between callosal size and superior verbal fluency. It has also been

[7] See Goldberg *et al* (1994) or Goldberg (2001) for example.

hypothesized that greater inter-hemispheric processing could be the source of superior memory and there is evidence that those with familial left-handedness have advantages in some form of memory, see Christman and Propper (2001).

The above arguments may be summarized as follows: environmental effects, if any, on earnings are likely to be negative for left-handers. As a marker for some underlying pathology, left-handedness might also predict lower wages. There are several possible sources of advantage however (e.g. higher creativity and greater connective tissue in the brain) and these occur primarily for males only, so any negative effect is likely to be smaller or absent for males.

One argument that is frequently suggested but has not been studied may be called the "advantage of being disadvantaged" theory. Assume that both left-handers and right-handers each possess a certain set of abilities. Given that the environment is geared towards right-handers, left-handers have an incentive to invest effort in acquiring additional skills, naturally possessed by right-handers, that may foster creative behaviour, see Peterson and Lansky (1977). It follows then that they may end up with a higher over-all level of ability. This is consistent with a theory of competency which argues that individuals are motivated to achieve competency as a desire to master their environment, see White (1971). This theory would predict some advantage to being left-handed. Moreover it seems plausible that the advantage would be *greater* for manual workers since, effectively, they would be at more of a disadvantage in the first place[8].

[8] The only study that we are aware of which addresses this possibility is an unpublished paper by Bestebroer *et al* (1999) which finds that left-handers are more skilled with their right hand than right-handers are with their left, consistent with the general argument.

It has been long established that some brain functions are localized in particular areas. For example language is largely located in the left hemisphere and it is known that the left side of the body is controlled by the right hemisphere and vice versa. Subsequent work has shown that *to some extent* the left hemisphere is specialized for verbal, analytical, abstract thinking while the right hemisphere specializes for non-verbal (visual/spatial), holistic, intuitive thinking. However, the popular idea that individuals have dominant hemispheres so that one hears of "left brained" and "right brained" people, the latter being invariably more creative, artistic or emotional, over-simplifies a more complex relationship between the hemispheres. Since the left side of the body is controlled by the right side of the brain (and *vice versa*), hemisphericity is consistent with the folklore of greater artistic and creative abilities of left-handers.

3. Data

Our analysis is based on the 1958 National Child Development Survey (NCDS). This is a longitudinal study of all persons living in Great Britain who were born between 3rd and 9th of March 1958. The 1958 perinatal mortality survey has been followed by 6 subsequent waves (NCDS 1–6) at age 7, 11, 16, 23, 33 and the most recent, at ages 41-42. NCDS 1-3 comprised of interviews with the child, his parent's, his school and the report of a medical examiner. This data is an exceptionally rich source on child development from birth to early adolescence, child care, medical care, health, physical statistics, home environment, educational progress, parental involvement, cognitive and social growth, family relationships, etc. NCDS waves 4-6 are based largely on interviews with the cohort member and his/her partner. They document economic activity, income, training, housing as well as the development of the cohort member's own family.

The analysis is carried out separately for men and women. For males we exclude part-time workers: they would be less than 1% of the sample. For females, they are included: they are around 25% of the sample. Only individuals with non-missing observations for all variables used in our study have been included. Descriptive statistics are provided in Tables 1 and 2 for men and women respectively. Although missing values reduces the sample size considerably the means for the entire sample and that used in the empirical work are in most cases quite similar although, for example, for both men and women those with children are over-represented relative to the entire sample (67% in the sample and 42% overall for the males).

The dependent variable is the natural log of hourly earnings in 1991. A trimming of the earnings data at the top and bottom five percentiles took place to eliminate the effects of extreme values that we considered suspect.

Three forms of human capital are included in the model: schooling, cognitive ability and experience. The years of schooling variable was calculated from the monthly economic activity information recorded from 1974 to 1981. Respondents reporting school leaving ages of less than sixteen (the legal minimum) were dropped from the sample since the legal minimum was generally very well enforced..

The measure of ability is based on three separate tests, a mathematics test taken at ages 7 (taken from the Problem Arithmetic Test – Pringle *et al*, 1966) and tests of verbal and non-verbal ability taken at age 11 (from General Ability Test, Douglas 1964). We use the first Principle Component of the three. Unlike other NCDS studies (e.g. Dearden, 1999), we include a measure of work experience which was calculated by examining the detailed employment history of the cohort member since leaving school. The effects of experience were incorporated into the model in the usual quadratic form. The other

controls are type of school attended, union membership, marital status, parental status and for women, whether she is a part time worker or not.

There are several laterality variables contained in the dataset. Laterality has many different dimensions and degrees. The variable used in this study is the parent's opinion of the child's laterality at age 7. In introducing laterality into the model one has to note that the measurement of it is not simple. Ideally one constructs a *laterality profile* or *inventory* that measures the extent to which one is left or right dominant. This will depend not just on hand use but also on eye and foot use (people have a dominant foot and a dominant eye) and will vary in the number and nature of functions with which they use their hands. A "weak left-hander" might use their left hand for writing but otherwise use their right hand for most other tasks. The data contains measurements of foot and eye dominance and some other measurements of lateral ability (e.g. the speed at which they could pick up matches with either hand). These other forms of laterality are less well studied.

There is an argument for using an early record of laterality as individuals are more likely to be influenced by environmental pressures (such as school or family) as they get older. On the other hand, at a very early age a child may not have fully revealed their true handedness. So a disproportionately high number of children at age 7 are recorded (see Table 1) as being mixed-handed[9]. One could simply take this at face value. However over time one finds that mixed-handers "disappear" i.e. they become left or, mostly, right-handers. We make the assumption that the indication at age 7 of mixed handedness is largely measurement error. We considered two ways of dealing with this:

[9] Being mixed-handed is distinct from being ambidextrous (equally good with both hands) which is extremely rare.

either one could impute the handedness of the mixed-handers from data taken at age 11 or we could simply omit them. These two approaches give very similar results but in this paper we present results mainly using the second strategy. So our laterality variable indicates whether they were left-handed at age 7, the omitted category being right handed. A third approach, simply including the mixed–handers as a separate category, does not change the results. It is possible that the observed switching from left- and mixed- handedness is non-random. For example parents who are more concerned about their children's future may exert pressure on their children to switch to being right handed. We have investigated whether such switching can be predicted using various family characteristics such as socio-economic background, parents education and age, family size. None of these predict switching though we find that males are slightly more likely to switch handedness between ages 7 and 11.

4. Results

The model we estimate is the standard Mincer model in which the logarithm of hourly earnings is a linear function of years of schooling, a quadratic term in work experience (based on monthly records of labour market activity) and a number of additional controls such as cognitive ability as well as the variable of particular interest, a measure of handedness. The extensive literature on human capital models has considered a large number of variations on this basic model to deal with such issues as the possible endogeneity of schooling, non-linearities in returns and heterogeneous returns. As dealing

with these issues would take us a long way from the focus of this paper, we sidestep them[10].

The basic results for males are in Table 3. The first regression includes left-handedness only as a covariate. The results suggest that left-handed males earn 4% more per hour than right-handers. The second column adds variables that are normally in earnings equations, a quadratic in work experience and years of education. In addition controls for region and firm size are included. We allow for non-linearity in schooling by including a dummy variable for whether they stayed in education beyond the minimum school leaving age of 16. The marginal return to a year's education is 3.5%. This is lower than many published OLS estimates for the UK. It is difficult to compare with other estimates using the NCDS since most of these have very different specifications and, in particular, most look at the returns to particular levels of education rather than years of schooling. The average return to schooling here is higher since staying in education one year beyond the minimum school leaving age of 16 generates a return of nearly 8%. Given that the average level of education in this group is quite low (64% leave at age 16 and the average years of schooling is 11) the implied average return (close to 8%) is not very different from estimates which impose equality of marginal and average returns, for example Dearden (1999), who estimates returns to males of around 6%.

The returns to experience follow the usual shape but the coefficients are not individually (or jointly) statistically significant. This is not surprising since all the respondents were born in the same week so the variation is low. The return to one standard deviation of cognitive ability is nearly 7%. The effect of left-handedness is now

[10] Blundell, Dearden and Sianesi (2005) address these and other issues using the same data as this paper

somewhat higher, close to 5%. The third column adds an additional set of controls: for marital status, union membership, parenthood, indicators of school type and a measure of cognitive ability. The coefficient on left-handedness is essentially unchanged although the returns to education fall because of the inclusion of ability

Table 4 explores the robustness of these results further by considering several other specifications. In column 1, we include measures of two additional forms of laterality: eye and foot dominance. In general, the incidence of right-footedness is lower than right-handedness, (about 70%, 90% respectively). The measurement of eye dominance is more complicated. One criterion is *sensory dominance*, which records which eye's (monocular) vision one's binocular vision is closer to. In this data, the respondents were handed a tube and asked to look down it; the eye they use being designated as dominant: this is *sighting dominance*. However they are more likely to use their dominant hand to hold the tube so this can generate a bias[11]. There is a positive correlation between most forms of laterality (left-footedness is correlated with left-handedness and so on). For example, from Table 1 one can see that 94% of right-handers are also right footed but only 45% of left-handers are. In general eye dominance is much less well understood and the correlation with both hand and foot dominance is much smaller.

The results indicate that these other forms of laterality have no effect on earnings and the handedness result remains. In the second column, we use an alternative measure of left-handedness where those mixed-handers at age seven (who had been omitted

[11] These two measures are generally correlated. An alternative measure is based on differences in the strength of one's eyesight (*visual acuity*) and is generally not correlated with the first two; see Bourassa *et al*. (1996).

otherwise) were imputed with their handedness measured at age 11. This procedure increases the sample slightly. The argument for doing this is that a lot of the mixed-handedness recorded early in life is not genuine and their true handedness is revealed as they age. The counter-argument is that they are more open to environmental pressures later in life. It is difficult to distinguish between these two hypotheses and we have no firm view on this. In any event this has only a marginal effect on the results. We also considered the possibility that there may be an impact from being "cross-lateral" e.g. left-handed and right-footed but we found no evidence of such interactions[12].

The environmental hazard discussed in section two would suggest the disadvantage of being left-handed is more prominent in blue-collar occupations where manual skills are more important. The final two columns present estimates of the earnings equations for white and blue-collar workers separately. Contrary to one's intuition, the positive impact of left-handedness is *greater* amongst blue-collar workers and the hypothesis that the coefficients are the same can be rejected.

If the workplace really is more hazardous for left-handed workers one might expect them to sort into white–collar/non-manual occupations where such hazards would be smaller. In an earlier version of this paper (Denny & O'Sullivan 2004), we present separate estimates fore white and blue collar workers using an endogenous switching model based on the method of Lee (1978). The results were not very different from the OLS ones presented here. However the identification assumptions were problematic. In

[12] There is an influential theory associated with amongst others, Delacato (1966) that cross-laterality is associated with abnormal intellectual development and disorders such as dyslexia 'though the evidence in support of it is weak, see McManus and Mascie-Taylor (1983).

the probit determining whether workers select into blue- or white-collar occupations left-handedness was not statistically significant (a coefficient of 0.74 and a t statistic of 0.54) so there is no evidence that workers sort according to their laterality[13].

One can summarize the male results as follows: if left-handers were at a disadvantage because of the right handed environment they live in, one would expect them to be paid less, *ceteris paribus*, to select into non-manual occupations and to experience a greater penalty in manual/blue-collar occupations. One can reject all three hypotheses. The results can in principle be explained by several possible advantages to left-handers discussed earlier though it is not possible to distinguish between them at present.

Table 5 contains results for females with the same specifications as in Table 3. In the simplest specification one finds the reverse result to that of males: left-handers are paid *less*, over 8% in the first model. Adding additional controls reduce this by about half but the number is still well determined[14]. It is not obvious why the male and female results should be so strikingly different. However it could be argued that since our priors are so weak in the absence of any previous research there should not be a strong presumption that the effect is the same. It is not unusual in economics for a given variable

[13] The other covariates are school type, education, marital status, parental status, union membership, number of siblings, father's education, cognitive ability and regional dummies. Cosenza and Mingoti (1993) find that, controlling for sex, handedness has no effect on career choice.

[14] To increase the sample size, we include part-time female workers and hence a binary indicator for this is included in the model. The number of part-time male workers is negligible, about 1% of workers.

to have opposite effects for men and women, for example the presence of children in earnings equations (as in this paper) or labour supply functions. While in many of these cases one can readily think of an explanation, these are often *ad hoc*. A more pertinent comparison is recent work on the effect of sexual orientation on earnings (Berkhout and Plug (2004), Berg and Lien (2001)), which shows that homosexuality is associated with lower earnings in males and higher earnings in females. It is unclear why this is so. Similarly, Bowles *et al* (2001) report that for high status jobs, males are rewarded for aggression and penalized for being withdrawn whereas the reverse is true for females.

What evidence there is on interactions between sex and handedness (the evidence on colossal size, the evidence on divergent thinking and on cognitive novelty, discussed in section 2) points to advantages for left-handed males only, which is consistent with the results here. There is a considerable body of evidence which points to male/female differences being associated with asymmetry in general[15]. So it is not surprising from a biological point of view that results differ by sex.

Table 6 contains further results for females to explore whether those in Table 5 are robust. We first consider alternative forms of laterality by including measures of foot and eye dominance in addition to handedness. Unlike males, these have some explanatory value. What is surprising is that the effects are not qualitatively the same, specifically that footedness has a positive effect that is almost statistically significant. The second column eliminates the least well determined of the three, handedness, and the third includes the

[15] See Kimura (1999), chapter 12, Baron-Cohen (2004) or Faurie *et al* (2006). There is some evidence of behavioural differences for other primates: Westergaard *et al* (2004) find that for female rhesus macaques (*Macaca mulatta*) right-handers are more submissive than left-handers, the reverse of what is true for males.

only remaining statistically significant variable, left footedness. The penalty associated with left-footedness in column 3 is of a similar magnitude, around 5%, to that found for hand dominance in Table 5. In general very little is known about forms of laterality other than handedness except that they are correlated with each other to varying degrees, as Table 2 shows for the data used here. That left-footedness explains earnings better than left-handedness effectively rules out the possibility that the earnings penalty could be associated with discrimination: employers would be unaware of their employees' footedness and unlikely to care about it if they were. It also makes the environmental explanation (i.e. left-handers at a disadvantage in a world geared towards right-handed people) implausible since the variable does not measure handedness and there is no obvious handicap associated with any particular form of footedness. By default, one is left with some form of biological explanation: that left-footedness is a marker for some physiological disadvantage. What this is, is a matter for speculation since none has been documented that we are aware of and the general health of males or females individuals does not differ by footedness. The findings of Goldberg and his co-workers (1994, 2000) on differences in cognitive style could be an explanation but need a great deal of further testing[16].

If one estimates the model for women (column 3 of table 5) for white-collar and blue-collar workers, the coefficients and t ratios for being left-handed are -0.048 (2.00) and –0.044 (1.18) respectively. So, like males, being left-handed is better (or not so bad) if one is a blue-collar worker but the difference is very small and the small number of female blue-collar (manual) workers means the coefficient is not well determined.

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[16] Elias, Bryden and Bulman-Fleming (1998) and Elais and Bryden (1998) show that by certain criteria footedness better predicts cerebral lateralization than handedness.

Recoding mixed-handers on the basis of their handedness at age 11 has, as with males, no major effect on the results, (compare column 4 of Table 6 with column 3 of Table 5).

5. Conclusions

This paper looks at one particular feature of the brain, left-handedness, which has been widely studied in psychology and biology and has widespread cultural and scientific significance. It might be argued that the inclusion of laterality in an earnings equation is *ad hoc* since it lacks a strong theoretical foundation. If so, similar arguments apply to the inclusion of controls like employer size, school type, marital status or number of children, variables which are very common. Laterality by itself is a widespread phenomenon, being evident in every human (and many non-human) society and has existed for well over a million years.

Examining its relationship with economic success we find large effects that differ between the sexes. One explanation for the existence of such effects might be the "environmental hazard theory". In this view, left-handers are paid less as they struggle with a right-handed world. It would also predict that the penalty is greater for manual than non-manual workers and that hence that left-handers would sort into non-manual jobs. For males, all three predictions are rejected by the data. Left-handers are paid more, other things being equal; the premium is greater for manual workers and there is no evidence of occupational sorting by laterality. This suggests that the complaints of (male) left-handers of their tribulations in life, if correct, appear to be compensated for generously and the folklore of left-handers having particular talents appears to have some substance.

For females, however there is a significant penalty for being left-handed with the penalty being lower for manual workers (consistent with the male results). However the advantages that might be expect to exist from being left-handed arise primarily or exclusively in males so one there is no reason to expect any wage premium. Moreover, it is left-eye dominance which drives earnings in females which is also not consistent with an environmental penalty.

Research on the relationship between the brain and economic outcomes is in its infancy and has largely focused on a narrow set of behaviours that can be studied using brain imaging technology such as strategic behaviour. How much these results generalize to the real world is hard to determine. However it seems highly likely that neuroscience will, in the future, provide more and better data to better understand labour market and other market outcomes.

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Table 1: Descriptive statistics: Men by handedness.

	All NCDS			Sample	
	Right:	Left:	Mixed:	Right:	Left:
Log hourly wages 1991:	1.96	1.98	1.90	1.96	2.00
	0.29	*0.30*	*0.32*	*0.29*	*0.29*
Years of schooling	12.07	12.05	11.99	12.06	11.84
	1.88	*1.77*	*1.94*	*1.86*	*1.59*
Experience in years:	16.15	16.14	16.27	16.15	16.22
	1.45	*1.59*	*1.35*	*1.46*	*1.57*
Ability:	0.00	-0.13	-0.10	0.01	-0.04
	1.00	*1.06*	*1.01*	*1.00*	*0.97*
Left Eye-dominant (no mixed)	0.28	0.58	0.40	0.28	0.55
	0.45	*0.50*	*0.49*	*0.45*	*050*
Left Footed (no mixed)	0.06	0.55	0.20	0.06	0.57
	0.25	*0.49*	*0.40*	*0.23*	*050*
Married:	0.65	0.63	0.66	0.68	0.66
	0.48	*0.48*	*0.48*	*0.46*	*0.47*
Has children:	0.68	0.66	0.63	0.67	0.66
	0.49	*0.49*	*0.49*	*0.47*	*0.47*
Trade union member:	0.35	0.38	0.34	0.51	0.53
	0.47	*0.48*	*0.46*	*0.50*	*0.50*
Stayed in education post-16:	0.34	0.34	0.31	0.36	0.31
	0.47	*0.48*	*0.47*	*0.48*	*0.47*
Type of school:					
Selective:	0.65	0.68	0.67	0.67	0.68
	0.48	*0.48*	*0.49*	*0.47*	*0.47*
Maintained:	0.32	0.31	0.29	0.31	0.32
	0.47	*0.47*	*0.47*	*0.46*	*0.47*
Independent:	0.03	0.02	0.03	0.02	0.01
	0.17	*0.18*	*0.20*	*0.14*	*0.08*
N:	6008	870	598	2150	327

Standard deviations in italics.

Table 2: Descriptive statistics: Women by handedness.

	All NCDS			Sample	
	Right:	Left:	Mixed:	Right:	Left:
Log hourly wages 1991:	1.62	1.56	1.64	1.61	1.53
	0.37	*0.38*	*0.34*	*0.36*	*0.36*
Years of schooling:	12.5	12.2	13.08	12.06	11.87
	2.07	*2.18*	*2.36*	*1.75*	*1.59*
Experience in years:	15.47	15.76	15.49	15.23	15.20
	1.95	*2.09*	*1.69*	*2.60*	*2.79*
Ability:	0.65	-0.04	-0.13	0.01	-0.07
	0.98	*0.95*	*0.99*	*1.00*	*0.95*
Part-time worker	0.32	0.32	0.34	0.42	0.48
	0.47	*0.47*	*0.45*	*0.49*	*0.50*
Left Eye-dominant (no mixed)	0.30	0.52	0.30	0.31	0.62
	0.45	*0.50*	*0.47*	*0.46*	*0.49*
Left Footed (no mixed)	0.04	0.50	0.15	0.04	0.51
	0.20	*0.50*	*0.37*	*0.20*	*0.50*
Married:	0.65	0.67	0.64	0.61	0.66
	0.48	*0.48*	*0.48*	*0.49*	*0.48*
Has children:	0.74	0.78	0.75	0.65	0.71
	0.50	*0.50*	*0.50*	*0.48*	*0.45*
Trade union member:	0.25	0.24	0.25	0.41	0.33
	0.42	*0.41*	*0.43*	*0.49*	*0.47*
Stayed in education post-16:	0.41	0.35	0.39	0.40	0.35
	0.49	*0.48*	*0.49*	*0.49*	*0.48*
Type of school:					
Selective:	0.66	0.67	0.66	0.65	0.72
	0.48	*0.47*	*0.48*	*0.48*	*0.45*
Maintained:	0.32	0.29	0.33	0.33	0.27
	0.47	*0.46*	*0.48*	*0.47*	*0.45*
Independent:	0.02	0.04	0.01	0.02	0.01
	0.16	*0.16*	*0.11*	*0.15*	*0.10*
N:	6019	632	414	1934	200

Standard deviations in italics.

Table 3: Estimation results for full time men:

	(1) Log Hourly Wages	(2)* Log Hourly Wages	(3)* Log Hourly Wages
Laterality age 7 – left handedness:	0.04	0.048	0.049
	2.38	3.03	3.16
Years of education:	-	0.035	0.029
	-	6.94	5.69
Stayed in education post-16:	-	0.078	0.048
	-	3.99	2.44
Experience:	-	0.032	0.026
	-	0.74	0.62
Experience squared:	-	-0.001	-0.001
	-	0.64	0.53
Married:	-	-	0.059
	-	-	4.83
Has children:	-	-	0.038
	-	-	3.1
Trade Union member:	-	-	0.001
	-	-	0.09
School type – maintained:	-	-	0.003
	-	-	0.26
School type – independent:	-	-	-0.016
	-	-	0.36
Ability:	-	-	0.068
	-	-	12.02
N	2477	2477	2477
R Squared adjusted	.0022	.1654	.2248

Heteroscedastic robust t ratios below coefficients.

*Regional and employer size dummies omitted.

Table 4: Estimation results for full time men:

	(1)* Log Hourly Wages	(2)* Log Hourly Wages	(3)* Log Hourly Wages – White collar	(4)* Log Hourly Wages – Blue collar
Laterality age 7 – left handed	0.051	-	0.046	0.063
	2.68	-	2.12	2.81
Laterality age 7 – left handed (mixed recoded):	-	0.04	-	-
	-	2.76	-	-
Laterality age 11 – left eye dominant	-0.004	-	-	-
	0.37	-	-	-
Laterality age 11 – left footed	0.00	-	-	-
	0.02	-	-	-
Years of education:	0.029	0.027	0.02	0.05
	5.69	5.48	3.53	2.47
Stayed in education post-16:	0.048	0.047	0.049	-0.059
	2.42	2.43	2.21	1.38
Experience:	0.026	0.012	-0.011	0.051
	0.62	0.29	0.27	0.71
Experience squared:	-0.001	0	0.001	-0.002
	0.53	0.21	0.42	0.59
Married:	0.059	0.056	0.049	0.053
	4.82	4.57	3.09	3
Has children:	0.038	0.044	0.055	0.019
	3.09	3.64	3.72	0.97
Trade Union member:	0.001	-0.005	0.008	0.034
	0.09	0.5	0.59	1.91
School type – maintained:	0.003	0.007	0.016	0.001
	0.25	0.62	1.04	0.07
School type – independent:	-0.016	0.027	0.079	-0.212
	0.35	0.6	2.07	2.54
Ability:	0.068	0.071	0.056	0.045
	11.97	12.88	6.27	5.63
N:	2477	2671	1358	1055
R Squared adjusted	.2242	.2145	.1618	.1858

Heteroscedastic robust t ratios below coefficients.

*Regional and employer size dummies omitted.

In column 2, those recorded as mixed handed at 7 are recoded according to their reported handedness at age 11.

Table 5: Estimation results for working women:

	(1) Log Hourly Wages	(2)* Log Hourly Wages	(3)* Log Hourly Wages
Laterality age 7 – left handed	-0.085	-0.052	-0.04
	3.14	2.42	2.05
Years of education:		0.059	0.04
		10.5	7.19
Stayed in education post-16:		0.051	0.047
		2.54	2.44
Experience :		0.052	0.031
		3.49	2.34
Experience squared:		-0.002	-0.001
		2.87	1.94
Part time worker:		-0.21	-0.158
		15.45	10.71
Married:			0.042
			3.24
Has children:			-0.078
			5.01
Trade Union member:			0.176
			13.61
School type – maintained:			0.042
			3.29
School type – independent:			-0.011
			0.26
Ability:			0.068
			10.34
N:	2134	2134	2134
R Squared adjusted:	.0046	.3525	.4404

Heteroscedastic robust t ratios below coefficients.
*Regional and employer size dummies omitted.

Table 6: Estimation results for women:

	(1)* Log Hourly Wages	(2)* Log Hourly Wages	(3)* Log Hourly Wages	(4)* Log Hourly Wages
Laterality age 7 – left handed:	-0.029			
	1.33			
Laterality age 7 – left handed (mixed recoded):				-0.044
				2.32
Laterality age 11 – left footed:	-0.039	-0.054	-0.049	
	1.76	2.67	2.42	
Laterality age 11 – left eye dominant:	0.023	0.021		
	1.88	1.7		
Years of education:	0.04	0.04	0.04	0.04
	7.24	7.24	7.17	7.38
Stayed in education post-16:	0.048	0.048	0.048	0.047
	2.5	2.52	2.49	2.54
Experience :	0.031	0.031	0.032	0.031
	2.33	2.35	2.38	2.35
Experience squared:	-0.001	-0.001	-0.001	-0.001
	1.93	1.95	1.98	1.92
Part time worker:	-0.159	-0.16	-0.16	-0.156
	10.8	10.83	10.8	10.88
Married:	0.043	0.043	0.043	0.042
	3.32	3.32	3.3	3.36
Has children:	-0.077	-0.077	-0.078	-0.073
	4.96	4.98	5.02	4.85
Trade Union member:	0.177	0.177	0.177	0.173
	13.63	13.71	13.69	13.7
School type – maintained:	0.044	0.044	0.043	0.05
	3.41	3.45	3.33	3.98
School type – independent:	-0.003	-0.001	-0.004	-0.017
	0.08	0.02	0.1	0.42
Ability:	0.068	0.068	0.068	0.070
	10.37	10.36	10.32	11.19
N:	2134	2134	2134	2244
R Squared adjusted:	.4414	.4412	.4408	.4407

Heteroscedastic robust t ratios below coefficients.

*Regional and employer size dummies omitted.

In column 2, those recorded as mixed handed at 7 are recoded according to their reported handedness at age 11.