Economics and Human Biology 8 (2010) 233–241

Contents lists available at ScienceDirect

Economics and Human Biology

journal homepage: http://www.elsevier.com/locate/ehb

Brainstorm: Occupational choice, bipolar illness and creativity

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ARTICLE INFO

Keywords:
Bipolar illness
Mental health
Occupation
Creativity

ABSTRACT

Although economists have analyzed earnings, unemployment, and labor force participation for those with bipolar illness, occupational choice has yet to be explored. Psychological and medical studies often suggest an association between bipolar illness and creative achievement, but they tend to focus on eminent figures, case studies, or small samples. We seek to examine occupational creativity of non-eminent individuals with bipolar disorder. We use Epidemiologic Catchment Area data to estimate a multinomial logit model matched to an index of occupational creativity. Those with bipolar illness appear to be disproportionately concentrated in the most creative occupational category. Nonparametric kernel density estimates reveal that the densities of the occupational creativity variable for the bipolar and non-bipolar individuals significantly differ in the ECA data, and suggest that the probability of engaging in creative activities on the job is higher for bipolar than non-bipolar workers.

1. Introduction

The association between creativity and bipolar illness is an age-old controversy.[2] Bipolar illness is characterized by pronounced mood swings—alternating periods of elation, normalcy, and despondency, which can be accompanied by hallucinations or delusions during the peaks and troughs of the cycles. Although we might expect bipolar illness to hamper occupational and artistic achievement, the creativity and energy characteristic of persons with mania may actually improve some aspects of their labor market outcomes (Frank and McGuire, 2000).

Estimates of prevalence of bipolar illness fall around 1.2% of the population (Weissman et al., 1991).[3] With respect to the labor market, the employment of the bipolar population is approximately 71% compared to about 82% for the general population, and those with bipolar illness earn about 57% of the earnings of others, all else equal (Ettner et al., 1997). In contrast to poorer employment and earnings outcomes in the Ettner et al. (1997) study, Marcotte et al. (2000) find that bipolar status in the past year does not significantly affect income or employment for men or women, but that length of time with a bipolar

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[2] See Jamison (1993) for a thorough history and literature review of the topic.

[3] This figure is controversial, however. Some psychiatrists claim that bipolar illness is not a discrete phenomenon, but is better characterized as a bipolar spectrum. The fraction of the general population with bipolar spectrum disorder has been estimated at 4.5% in the National Comorbidity Survey Replication (Merikangas et al., 2007) and at 6.4% in the Epidemiological Catchment Area survey (Judd and Akiskal, 2003). At the same time, Zimmerman (2008) find that bipolar disorder is often overdiagnosed by health care professionals. In our work the diagnoses are made based on the National Institute of Mental Health Diagnostic Interview Schedule. There appears to be no difference in the prevalence of bipolar I disorder by sex, race, or ethnicity, and the typical age of onset is 20 years (APA, 2000).

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doi:10.1016/j.ehb.2010.01.001

disorder positively and significantly affects employment for women. Further, the lifetime number of bipolar episodes appears to significantly increase income for men. These mixed findings for the bipolar population suggest a need for further study.

None of the economic studies to date have addressed the issue of occupational outcomes for those with bipolar illnesses. Yet there is a substantial body of research on the possible link between creative and artistic occupations and bipolar illness in the medical and behavioral sciences literature. About 75% of these studies find evidence of such a link (Jamison, 1993). Much of this research derives from case studies, biographies of prominent historical figures in the arts, or diagnostic and psychological studies of living writers, artists, and composers. Although rich and informative in their own right, these studies suffer from small sample sizes or from selection bias. In contrast to the case study approach, we employ a population based data set to contribute to the literature on bipolar disorder and creativity as well as the labor market literature on occupational outcomes.

The clinical definition of mania may help in understanding the link between bipolar illness and creativity. Depression characterizes both unipolar and bipolar illness; thus it is an episode of mania that distinguishes bipolar illness (or bipolar I disorder) from unipolar illness. Generally speaking, a manic episode entails "a distinct period of abnormally and persistently elevated, expansive or irritable mood," which may alternate with depressive mood. A manic episode is characterized by at least three of the following symptoms: increased activity, talkativeness, flight of ideas, inflated self-esteem, decreased need for sleep, distractibility, and excessive involvement in risky activities. Some of these symptoms encourage creativity, for example "flight of ideas" and "talkativeness" (which might facilitate rhyming and verse). Increased activity and decreased need for sleep may bolster productivity in a number of occupations.

Another explanation is that there may be a genetic tie between bipolar disorder and creativity. Richards et al. (1988) find that unafflicted close relatives of bipolar patients tend to be more creative than the general population. In addition, Kèri (2009) studied the genomic DNA of 200 healthy, high intellectual achievement individuals, and found that those who carried a genotype related to psychosis risk had the highest creativity levels.[4] Some evolutionary psychologists argue that the positive benefits of creativity might account for the persistence of bipolar disorder in the gene pool in spite of the negative aspects of the illness, although there appears to be some controversy over the reasons for that persistence (Keller and Miller, 2006; Miller and Tal, 2007). It may be that the genetic complexities of mental illness have prevented its elimination by natural selection. For example, individual genes contributing to mental illness may not be harmful alone and may tie to creativity, but when in combination with other genes result in mental illness.

We do not presume to disentangle potential causal factors, but attempt to establish whether or not there is an association between bipolar illness and occupational creativity. Unlike prior studies, we bring a different kind of data, traditional methods from labor economics, as well as nonparametric statistical techniques to bear on this question. Rather than taking a case study approach, we focus on the non-eminent population and use a large population-based sample with automated implementation of the diagnostic criteria to distinguish bipolars from the rest of the sample (the Epidemiologic Catchment Area (ECA) data set).[5] To see if those with and those without bipolar illness have the same occupational outcomes, we use a multinomial logit model of occupational outcomes.

Once differences in occupational outcomes are evaluated, we investigate whether bipolars are concentrated in more creative occupations based on a measure from the *Dictionary of Occupational Titles*. To test for differences in this measure for bipolars we turn to nonparametric methods, since the distribution of the occupational creativity variable is highly skewed, rendering parametric regression analysis inappropriate. Instead we estimate separate nonparametric densities for bipolar and non-bipolar individuals, and test for differences in the distributions.

2. Data and descriptive analysis

The main dataset we utilize is the Epidemiologic Catchment Area Study (ECA), collected by researchers at Yale, Johns Hopkins, Washington, Duke and University of California at Los Angeles in collaboration with the National Institute of Mental Health (NIMH; U.S. Department of Health and Human Services, 1991). Data were obtained by personal interviews of 20,861 adults residing in the towns of these universities: New Haven, Baltimore, St. Louis, Durham and Los Angeles. Respondents were selected using multistage probability sampling. We use the second of two waves of the survey, which was collected in 1981–1985.[6]

To determine if an individual meets the criteria for having a particular mental illness, the ECA interviewers elicited responses to the NIMH Diagnostic Interview Schedule (DIS). Questions are designed to identify symptoms corresponding to criteria in the Diagnostic and Statistical Manual of Mental Disorders, third edition (DSM-III; American Psychiatric Association, 1980). Once the DIS responses are entered into a data file, the DSM-III criteria are operationalized by computer, and diagnoses are

[4] Psychosis refers to the experience of hallucinations and/or delusions (Goodwin and Jamison, 2007: 431; APA, 2000: 414).

[5] We also considered using data from the Mental Health Supplement (MHS) of the National Health Interview Survey. This is also a population-based sample, but with self reported diagnosis of bipolar illness in the last 12 months rather than lifetime as in the ECA. This is a less inclusive definition than that in the ECA sample, as reflected in the small percentage, 0.16, out of 53,441 respondents and more likely to include those with more acute symptoms than in the ECA. We focus instead on the ECA data.

[6] Although the sample is dated, the relationship between bipolar illness and creativity is not likely to change over time. The measure of occupational creativity, discussed below, corresponds to the 1980 occupational codes.

Table 1
Occupational distributions by manic episode status (%).

Occupation	No manic episode	Bipolar (DSM-III)	Bipolar (DSM-III-R)
Professional	20.59	27.38	30.43
Technical	29.54	26.19	21.74
Services	17.27	23.81	26.09
Crafts	10.86	7.14	4.35
Operators	21.73	15.48	17.39
Total percent	100.00	100.00	100.00
Total count	13,570	84	46

Note: Professional includes managerial occupations; technical includes sales and clerical; operators includes fabricators and laborers. DSM-III: Prior episode defined over lifetime. DSM-III-R: Same, but must also have been hospitalized or markedly occupationally impaired. *Source*: Epidemiologic Catchment Area survey, U.S. Department of Health and Human Services (1991), URL: http://dx.doi.org/10.3886/ICPSR08993.

Table 2
Occupational creativity index by occupation.

Occupation	Mean creativity	Standard error	Median creativity	*N*
Professional	10.14	0.40	2.00	2814
Technical	0.95	0.03	0.17	4029
Services	3.47	0.33	0.05	2374
Crafts	0.66	0.03	0.05	1482
Operators	0.45	0.04	0.02	2964
F	176.92			
Prob-F	<0.0001			
χ^2			2800	
Prob-χ^2			<0.0001	

Note: Index is from 0 to 100 with 0 the least creative. Professional includes managerial occupations; technical includes sales and clerical; operators includes fabricators and laborers.

generated for mania as well as a number of other mental illnesses. There are 84 individuals (that is, 0.62%) in the sample with information on occupation who have a DSM-III manic episode diagnosis.

We also consider an alternative diagnostic criteria, the 1987 revised version of the DSM-III, abbreviated DSM-III-R. In addition to the mania diagnosis requirements in the DSM-III, the DSM-III-R includes the criterion of hospitalization or marked impairment in occupational functioning or usual social activities. Excluding those who do not meet this severity criterion, reduces the number of individuals with a DSM-III-R manic episode diagnosis to a total of 46 or 0.34% of the sample.[7]

The ECA sample also contains occupational codes. The occupation variable applies to those currently and previously employed.[8] Table 1 lists the percent of observations in each major occupational group by manic episode status for the two forms of bipolar diagnosis in the ECA sample (DSM-III and DSM-III-R). There is a greater representation of those with a bipolar I diagnosis than the rest of the population in the professional and managerial occupations and services based on the sample data. Bipolars are relatively 'overrepresented' in the services. Likelihood ratio chi-squared tests for differences in occupation distributions by manic status show no significant difference. The probability values for the chi-square statistics are 0.15 for DSM-III criteria and 0.11 for DSM-III-R.

The occupational segregation index (Duncan and Duncan Index of Occupational Dissimilarity) corresponding to the numbers in Table 1 is 13.3, indicating that identical occupation distributions for bipolars and those with no history of mania would arise if 13.3% of either group changed occupations for bipolar DSM-IIIs.[9] To put this figure in perspective, note that it equals the value of the occupational segregation index for African and white American women in 1995 (Blau et al., 1998). The estimated occupational segregation index for DSM-III-R bipolars relative to non-bipolars is 18.7%, higher than for the bipolars diagnosed under the less restrictive DSM-III criteria.

To measure creativity for each individual, we use occupation creativity scores from England and Kilbourne (1988) matched to individuals by 3-digit occupation codes.[10] The occupational creativity measure represents the percentage of employees in a particular occupation

[7] There is a more recent diagnostic and statistical manual of mental disorders, the DSM-IV-TR. In this as well as the DSM-III and DSM-III-R, there is a list of factors that can cause "manic-like episodes" such as substance abuse or a medical condition like multiple sclerosis. When these factors precede symptoms of mania, a diagnosis of mania is not made. A primary change in criteria in the DSM-IV-TR, is that it expands and clarifies the list of factors that preclude a manic episode diagnosis to include factors such as medication and antidepressant light therapy treatment. Light therapy is such a recent tool, we do not believe that it is an issue in our data set. The DSM-IV-TR also lists antidepressant medication and electroconvulsive therapy, and although they are not listed in the DSM-III, they are in the DSM-III-R. For other differences in the manic episode criteria for the three manuals, see American Psychiatric Association (1980, 1987, 2000). The list of symptoms of a manic episode is virtually the same for the DSM-III, DSM-III-R, and DSM-IV-TR. To follow up on the medication and substance use issues we examine a model accounting for alcohol and drugs below.

[8] The occupation recorded for those not currently employed is most recent occupation.

[9] The occupational segregation index for bipolar and non-bipolar workers is given by: $D = (1/2)\sum_i |(B_i/B) - (NB_i/NB)|$ where i indexes occupation, B_i is the number of bipolar workers employed in occupation i, B is the number of bipolar workers in all occupations, NB_i is the number of non-bipolar workers employed in occupation i, and NB is the number of non-bipolar workers in all occupations. The value of the index ranges from 0 to 1, with 0 indicating no occupational segregation and 1 indicating complete segregation (Blau et al., 1998).

[10] The occupational creativity variable is derived from a measure of creativity from the Fourth Edition of the Dictionary of Occupational Titles (DOT) produced by the U.S. Department of Labor. The DOT contains extensive job requirement and characteristic information at a highly detailed level of occupation. The creativity variable reported by the DOT takes one of three values for the requirements of each detailed occupation: (−1)—preference for activities of a routine, concrete, organized nature; (0)—neither pole relevant to occupation; (1)—preference for activities of an abstract and creative nature. It is the latter value in which we are interested. The DOT data were merged with Census Bureau data by 3-digit occupational code, and the percentage of workers in the aggregated occupational group requiring a preference for abstract and creative activities was constructed. This is the occupational creativity variable we use here.

who engage in abstract and creative activities and ranges from 0 to 100.[11]

While Table 1 highlights the relationship between occupations and bipolar status, Table 2 focuses on the creativity levels of occupations, regardless of bipolar status. Table 2 shows the means, standard errors, and median values of the occupational creativity index by occupation group for all workers. Professional and managerial occupations have the highest mean and median creativity levels relative to the other occupational groups, and as shown in Table 1, this occupational category employs an 'over-representation' of those with bipolar illness. Further, the professional and managerial occupational group includes all of the 3-digit occupations classified by Filer (1986) as "artistic."[12] In the services, where bipolars are also over-represented (Table 1), the extent of creativity is less clear. Differences in mean creativity levels are highly significant across occupational groups by an F-test (p-value < 0.0001) as well as pairwise t-tests ($p = 0.001$ or better for all pairs). Differences in medians across occupations are also highly significant (p-value < 0.0001 for the Pearson χ^2 test). Thus creativity varies significantly by occupation for all workers, but the distribution of occupations differs, though not significantly, for bipolars and non-bipolars.

Taking a more direct approach, we segment the sample by diagnosis status and compute the occupational creativity index. Table 3 shows that both the mean and median values of the occupational creativity index are higher for bipolar DSM-IIIs and DSM-III-Rs (means = 4.35 and 4.54, medians = 0.46 and 0.38) than for those not so afflicted (mean = 3.07, median = 0.12).[13] The mean and median values of the bipolar and non-bipolar groups are not significantly different from one another, with the exception of the marginally significant difference in medians for DSM-III bipolars and non-bipolars.[14]

Table 3
Occupational creativity index by diagnosis.

	Mean creativity	Standard error	Median creativity	*N*
Diagnosis				
Bipolar (DSM-III)	4.35	1.62 **	0.46 *	84
Bipolar (DSM-III-R)	4.54	2.20 **	0.38	46
Non-bipolar	3.07	0.10	0.12	13,888

* Significantly different from the non-bipolar group at 10% by Fisher's exact two-sided test and Pearson χ^2 test.

** Variance of creativity variable significantly different from non-bipolar group at 5% or better.

We explore one other measure of creativity from the psychology and career counseling literature: the Holland Artistic (A) Occupational Code (Gottfredson and Holland, 1996).[15] We merged the Holland codes to our sample by 3-digit occupational code, and we used the DSM-III criteria to distinguish bipolars from others in the merged sample. We find that the percent of individuals who are in occupations with an Artistic component is greater for the bipolar group, 10.71 percent, than for the non-bipolar group, 8.40 percent. The difference is not statistically significant which is likely due to the small sample of bipolar individuals, 75 in the non-artistic occupations and only 9 in the artistic occupations.[16]

Interestingly, the variances of the creativity index differ significantly for the non-bipolar group and each of the bipolar groups (p-value = 0.010 for DSM-III and 0.044 for DSM-III-R by a variance ratio F-test). It might be possible that the variability in the expression of the illness across individuals—for example, the length and frequency of episodes, the severity of mania, depression and psychosis, the extent of impairment—results in a greater variance in occupational creativity than among the rest of the population.

In the next section we turn to traditional empirical models to analyze occupational choice. Specifically we use multinomial logit estimation of occupational choice to

[11] Examples of abstract and creative activities include: painting, hairstyling, writing, music teaching, interpreting public opinion surveys in light of contemporary society, creating dramatic stage lighting, planning advertising campaigns, and diagnosing illness (U.S. Department of Labor, 1972).

[12] These include actors and directors; authors; dancers; designers working in the theater, motion pictures, or art museums; musicians and composers; painters, sculptors, craft artists, and artistic printmakers; photographers; postsecondary teachers of art, drama and music; and artists, performers and related workers not elsewhere classified.

[13] The large differences between mean and median values of the creativity index reflect the highly skewed distribution of this variable, which we address below with nonparametric methods.

[14] Fisher's exact two-sided p-value = 0.080 and the p-value for the Pearson $\chi^2 = 0.076$ for the difference in medians for DSM-III bipolars and non-bipolars. p-Values for differences in means for those who are not bipolar relative to either bipolar group are p-value = 0.22 for DSM-III and 0.25 for DSM-III-R diagnoses for one-tailed t-tests with unequal variances. The difference in medians for the 46 persons diagnosed by DSM-III-R criteria and others is not significant by either the Fisher or the Pearson tests ($p = 0.363$ and $p = 0.379$, respectively). We also conduct a Wilcoxon rank-sum (Mann–Whitney) test and obtain insignificant test statistics (p-value = 0.217 for the DSM-III and p-value 0.5844 for the DSM-III-R group). Nonparametric estimation is further discussed below.

[15] According to Gottfredson and Holland (p. 2), the Artistic occupational environment "requires innovation or creative ability. It rewards the display of imagination in artistic, literary, or musical accomplishments, and allows the expression of unconventional ideas or manners. Occupations classified as Artistic generally involve creative work in the arts: music, writing, performance, sculpture, or other relatively unstructured and intellectual endeavors." The Holland model classifies five additional occupational environments: Realistic (R, e.g. carpenter or truck operator), Investigative (I, e.g. psychologist or microbiologist), Social (S, e.g. counselor or clergy member), Enterprising (E, e.g. lawyer or retail store manager), and Conventional (C, e.g. production editor, bookkeeper). For seven different occupational coding systems, Gottfredson and Holland assign three of the six categories, in descending order of importance, to each occupation. For example, the code for economists is ISA, investigative rated most important, followed by social (which includes teaching, mentoring and concern for the welfare of others), and then artistic (likely for the creativity and innovation features). The statistics referred to above apply to all occupations that have an Artistic component (i.e., Axx, xAx, or xxA where x = R, I, S, E, C).

[16] The p-values for a one-tailed t-test, a Pearson χ^2 test, and a Fisher exact test are 0.2226, 0.5537 and 0.2733, respectively. We include the p-value for the t-test because it is so commonly used. The t-test is not technically appropriate in this case, however, because the variable, percent of individuals who are in occupations with an Artistic component, derives from a set of discrete variables and is not normally distributed.

Table 4
Multinomial logit marginal effect estimates of bipolar status on occupational outcomes.

	Professional	Technical	Services	Crafts	Operators	*N*	LR
Base model, full sample							
Bipolar (DSM-III)	0.05 (0.96)	−0.05 (0.97)	**0.09** (1.75)	−0.03 (1.12)	−0.07 (1.49)	13,622	3235
Bipolar (DSM-III-R)	0.08 (1.16)	**−0.11** (1.76)	0.11 (1.49)	**−0.05** (1.69)	−0.04 (0.58)	13,584	3216
Full sample, controlling for alcohol and drugs							
Bipolar (DSM-III)	0.07 (1.43)	−0.04 (0.77)	0.07 (1.60)	−0.03 (1.24)	**−0.07** (1.84)	13,622	3378
Bipolar (DSM-III-R)	**0.11** (1.68)	−0.09 (1.51)	0.08 (1.32)	**−0.06** (1.77)	−0.05 (0.88)	13,584	3265

Note: Base model does not control for alcohol/drugs, marital status or education. Professional includes managerial occupations; technical includes sales and clerical; operators includes fabricators and laborers. Absolute values of *t*-ratios are in parentheses. N = number of observations. LR = likelihood ratio; all LR values are significant at 1%. Coefficients in bold are significant at 10%.

determine if bipolar status significantly affects occupational choice. We then return to analyzing the relationship between bipolar illness and the occupational creativity index. We use nonparametric techniques to estimate kernel densities of the occupational creativity index for bipolars and non-bipolars and test for differences in the distributions.

3. Results of multivariate analysis

3.1. Multinomial logit occupation regressions

We estimate a multinomial logit model of the probability of employment in each occupational group as a function of manic episode status. Control variables in the base model include RACE = 1 if individual i is African-American (= 0 otherwise), FEM = 1 if i is female (= 0 otherwise), and AGE. Sets of dummy variables for year of interview and interview site are also included. Although it might be desirable to include education level in the regression, it was not collected at Johns Hopkins or Washington University. For the set of remaining observations from the Yale, Duke, and UCLA communities, the mean education level is significantly higher for bipolar I's than for the rest of the sample at 1 percent or better (12.77 compared to 11.52 for the DSM-III group and 12.97 versus 11.52 for the DSM-III-R group). Since the sample is limited, results controlling for education are discussed below with alternate specifications.

Multinomial logit estimates of marginal effects of the bipolar dummy variable for alternative occupation groups are presented in Table 4. These include results for the full sample with the base model (no education, no marital status, no alcohol or drug variables included). The results show that the marginal effect of the bipolar dummy variable for a manic episode is positive across the board in the most 'creative' occupations: professional and managerial and services, although the marginal effects are significant at the 10 percent or better level in only one case: DSM-III for services. The marginal effect is consistently negative for the other 'low creativity' occupations, and is significant at 10 percent in two cases in the base model: for technical, sales and clerical and for crafts for DSM-III-R in both cases.

Recall that in contrast to the DSM-III diagnosis of bipolar illness, DSM-III-R requires hospitalization or marked impairment in occupational functioning or usual social activities, which reduces the number of individuals classified as bipolar in the sample to 46. Note that if we wish to investigate the relationship between bipolar illness and occupational creativity, and if occupational impairment is used as a criterion for bipolar illness, we might expect to understate occupational creativity for the DSM-III-R classification. However, when the DSM-III variable is replaced by the DSM-III-R dummy variable for a mania diagnosis in the logit model, we see an increase in the absolute value of the bipolar marginal effect[17] suggesting even stronger selection of bipolars into relatively creative occupations.

The occupational impairment rule in the DSM-III-R diagnostic criteria has identified bipolars as more frequently employed in creative occupations with a higher mean (but lower median) level of occupational creativity, a greater degree of occupational segregation relative to the well, and somewhat stronger multinomial logit evidence linking the presence of the disease to creative occupations than the bipolars identified under the DSM-III rules. Thus, even with the potential bias this new screen may impose, there appears to be some evidence of a link between occupational outcomes, creativity and bipolar disorder.

3.2. Alternative specifications

We estimate a number of alternative specifications, and the substantive results are unchanged. We add a marital status dummy variable and then an education variable to the set of demographic variables in the base model. Although we do not report them here, (results available on request), the signs of the estimated marginal effects on the bipolar dummy variables are robust to these specification changes. For both full sample and 3-site sample, and both DSM-III and DSM-III-R criteria, the signs are the same as in the base model: positive for the professional and managerial occupations, negative for the technical, sales and clerical jobs; positive for the service jobs; negative for the crafts; and negative for the operators, fabricators and laborers.

We next consider another set of specifications which control for co-morbid psychiatric illnesses. Each model includes a dummy variable for schizophrenia, obsessive-compulsive disorder, phobia, panic disorder, anti-social personality or alcohol and drug abuse.[18] The signs on the

[17] With the exception of the operators category.
[18] Due to small sample sizes, only one co-morbid psychiatric illness can be represented in the model at a time.

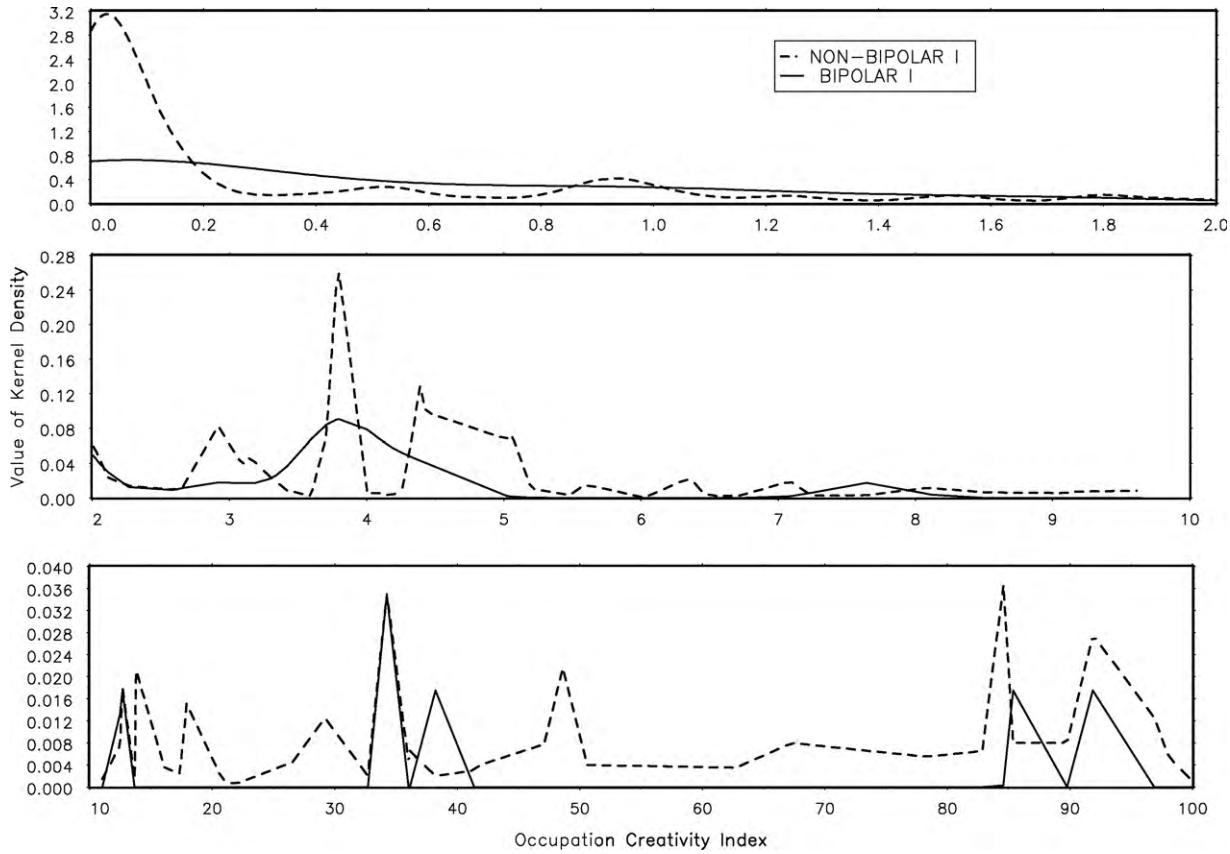

Fig. 1. Kernel density of the occupational creativity index with Silverman's bandwidth. *Note*: The value of 100 for the occupational creativity index indicates the highest level of creativity. The bandwidth selection method is from Silverman (1986).

marginal effects of bipolar illness do not change from the original base models.

The lower panel of Table 4 shows the results of the model that accounts for alcohol or drug abuse. Specifically, this model includes ALCDRGS, a dummy variable = 1 if the individual has a diagnosis of alcohol dependence and/or abuse, or drug dependence and/or abuse. The marginal effect estimates of manic episode status are similar in value as for the base model in the upper panel. Note that statistical significance on the marginal effect of the bipolar dummy is lost for the technical group (DSM-III-R) but gained for the operators group (DSM-III). For the 'creative' occupational categories, the estimate for the DSM-III bipolar dummy variable loses significance for services, but the estimate for the DSM-III-R bipolar variable gains significance at 10 percent for the professional and managerial group.

In summary, we have explored a number of alterations to the base model, and we find that the estimated marginal effects of bipolar illness are remarkably consistent across specifications. In particular, the influence of bipolar status on the probability of being in a professional and managerial occupation or a service occupation is uniformly positive. Next we turn to some additional evidence based on nonparametric tests and estimation.

3.3. Nonparametric evidence

Recall that we found large differences between the mean and median values of the occupational creativity index (Table 3) for bipolars and non-bipolars. Consequently, we turn to nonparametric tests and estimation techniques to address these distributional issues.

We first estimate Kolmogorov–Smirnov test statistics for the equality of occupational creativity distributions for bipolar and other individuals, and find corrected p-values of 0.103 for the DSM-III group and 0.519 for the DSM-II-R group. It is surprising that the p-values are not lower, based on our earlier results on the significant differences in the variances of the creativity index for bipolars and the rest of the sample for both DSM-III and DSM-III-R subsamples. We now use nonparametric kernel density estimation to further explore and test for differences in the occupational creativity index distribution for bipolars and other individuals.

3.3.1. Nonparametric density estimation

The advantage of nonparametric density estimation is that it is flexible and nonrestrictive. It can reveal the underlying density of a variable, even when that density deviates from the traditional normal form often assumed in parametric estimation. As the particular density of a

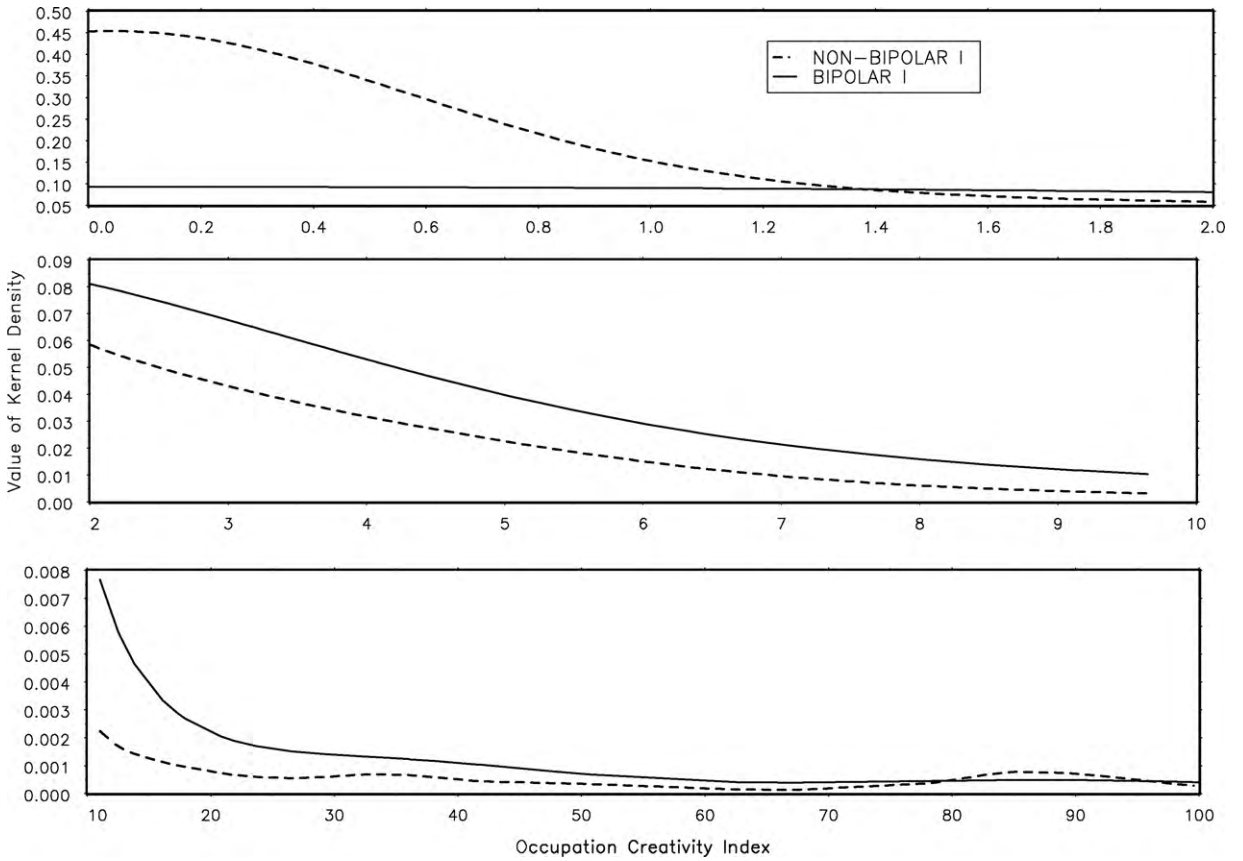

Fig. 2. Kernel density of the occupational creativity index with adaptive bandwidth.

variable need not be assumed a priori, specification errors can be avoided.

Here we estimate nonparametric kernel densities for the occupational creativity index for the bipolar and non-bipolar groups. For the kernel, we choose the Gaussian (standard normal) density function. The more difficult issue is the choice of bandwidth. We begin with the automatic bandwidth choice method described in Silverman (1986), which minimizes the integrated squared error (ISE) between the estimated function and the objective function. The kernel estimates using Silverman's plug-in bandwidth are displayed in Fig. 1.[19] The estimated densities are segmented into three intervals: [0,2) in the upper panel, [2,10) in the middle panel, and [10,100] in the lower panel. The upper panel highlights the heavy concentration of the data near zero, indicating that many workers do not perform creative activities in their jobs. The density is far less concentrated near zero for bipolar than for non-bipolar workers, however, evidence of greater occupational creativity for bipolars than non-bipolars. Note that the values of the kernel densities on the *y*-axis in the three panels dramatically decline from the upper to the middle to the lower panels. This reflects the skewness and lengthy tails of the distributions. Although Silverman's bandwidth produced a smooth density for values of the occupational creativity variable less than 2, the lower panels show that from 2 and beyond, the tails of both kernel densities are undersmoothed.

To focus on the tail distributions without oversmoothing the rest of the distribution, we employ another bandwidth selection method known as the 'adaptive two stage estimator' (A2SE), first considered by Breiman et al. (1977) and Abramson (1982). The basic idea is to use a broader bandwidth in the regions of low density to smooth the tail part of the function. Our results using this method are displayed in Fig. 2. Again we separate the kernel density into the intervals, [0,2), [2,10) and [10,100].[20] It is clear from the upper panel that the non-bipolar population is more concentrated at the lowest creativity levels. Over the 2–10 and 10–80 ranges of the creativity index, the bipolar population has higher density. By inspection, the

[19] Silverman's plug-in bandwidth is calculated as $h = 0.79RN^2$ where R is the inter-quartile range of the data and N is the sample size.

[20] The range of numbers on the *y*-axes in Fig. 1 differs from that in Fig. 2 because Silverman's bandwidth is much smaller than the A2SE bandwidth, on average. The area under a kernel density plot is one by design. With a larger bandwidth (A2SE), the weight of the density is allocated more evenly over the values of the creativity index in order to get a smoother curve, whereas with a smaller bandwidth (Silverman's) the weight is concentrated near the origin where most of the data points are located.

Table 5
Occupation creativity index dist. (c) by bipolar status.

Probability	Bipolar	Non-bipolar
$P(c \geq 1)$	0.3095	0.2599
$P(c \geq 2)$	0.1786	0.1627
$P(c \geq 3)$	0.1667	0.1424
$P(c \geq 4)$	0.1071	0.0922
$P(c \geq 5)$	0.0833	0.0724
$P(c \geq 6)$	0.0833	0.0576
$P(c \geq 7)$	0.0833	0.0531
$P(c \geq 8)$	0.0714	0.0495
$P(c \geq 7)$	0.0714	0.0466
$P(c \geq 8)$	0.0714	0.0441

Note: the highest value of c is 100.

area between the two densities from 10 to 80 (and about 95 to 100) exceeds the area from 80 to 95 where the bipolar density lies below the non-bipolar density. We also calculate the probabilities of observing the occupational creativity index above various values (integers 1 through 10) for each group. These are displayed in Table 5. The median level of the occupational creativity index (c) lies between 0.12 and 0.46 for the non-bipolar and bipolar samples, respectively (Table 3). The probability that c is greater than or equal to one in column (1) represents part of the "tail" above the median. We see that the probability of observing an occupational creativity index greater than one is higher for bipolars than non-bipolars (0.31 versus 0.26). The probability is higher for bipolars for every value of the creativity index up to greater than or equal to 10, which represents 4–7 percent of the samples.

To test if these densities are significantly different, we follow the method proposed by Li (1996). Let the two densities be $f(x)$ and $g(x)$, then test the null hypothesis $H_o : f(x) = g(x)$ against $H_1 : f(x) \neq g(x)$. The idea is to construct a nonparametric approximation for the integrated squared difference between the two estimated functions, i.e., the test statistic is based on $I = \int (\hat{f} - \hat{g})^2$. For our sample, the estimated test statistic is $Z = -3.01$ with a p-value of 0.001, so $H_o : f(x) = g(x)$, that the density functions of the occupational creativity index for non-bipolars and bipolars is the same, is rejected. That is, the densities are highly significantly different. This provides evidence of creativity differences for bipolar and non-bipolar persons.

4. Conclusion

Earlier work investigating links between occupational creativity and bipolar illness is largely based on psychiatric case studies or very small samples. In contrast we use a population based data set and econometric techniques to analyze occupational outcomes for those with bipolar disorder and the general population. We find evidence that bipolars are concentrated in service occupations as well as in professional and managerial occupations. We match the occupations to a measure of occupational creativity from the *Dictionary of Occupational Titles*. The professional and managerial occupations which include artists, musicians, and authors, are the most creative occupational category based on this index. We also find significantly higher median occupational creativity (DSM-III group) and education levels (both groups) for bipolars than for the general population.

After establishing the connection between occupation and creativity, we investigate the occupational outcomes of bipolars versus others in our sample using multinomial logit regressions. The results show that the effect of the bipolar dummy variable for a manic episode is positive in the most creative occupations: (1) professional and managerial, and (2) services. This result is robust to a number of alternative specifications.

We employ nonparametric density estimation methods to compare the densities of the occupational creativity index for the bipolar and non-bipolar samples. Based on these estimates we reject the null hypothesis that the densities are the same for bipolar I's and non-bipolars at the 0.1% level of significance. Probabilities based on these estimates also suggest that the data are more likely to reside in the tail of the creativity index density for bipolar than non-bipolar workers. That is, the probability of engaging in creative activities on the job is higher for bipolar than non-bipolar workers.

Still a number of caveats are in order. Some of the hypothesis tests here resulted in insignificant or marginally significant test statistics. Longitudinal data would better reveal the time patterns of illness onset, education, marital states and career paths. Selectivity issues, such as observing creativity of only employed or previously employed bipolar individuals, with longitudinal data as well. Future studies would also benefit from more recent data including the current diagnostic criteria (DSM-IV-TR).

Nevertheless we do find substantive evidence of a link between bipolar illness and occupational creativity using quite different data and methods than previous studies. This implies that productivity gains from enhanced creativity might outweigh productivity losses resulting from bipolar illness (for example, from absenteeism and lack of energy during depressive states). Thus, employers might be more willing to comply with the Americans with Disabilities Act of 1990, which prohibits discrimination against qualified persons on the basis of disability, including bipolar disorder, in all employment practices, and mandates employer provision of accommodations, such as modified work schedules and job reassignment, to enable performance of essential job functions.[21] Understanding their potential contributions might encourage employers to more readily hire and facilitate the productive capacities of individuals with bipolar illness.

The extent to which bipolar persons contribute to the stock of creative human capital in the workforce has implications for society's response to the inevitable identification and understanding of the genetic markers for bipolar disorder. The creative benefits of the disease is one factor weighing against its elimination via genetic

[21] U.S. Equal Employment Opportunity Commission (1997). Another example of disability employment policy is the U.K. Disability Discrimination Act (U.K. Government website, http://www.direct.gov.uk.) See Tremblay (2008) for accommodations that enhance performance of bipolar workers.

engineering or selective abortion (Goodwin and Jamison, 2007: 405–406, 461). The development of medication that reduces the social and private costs of the illness without inhibiting creativity might be a fruitful social investment.

Acknowledgements

The authors gratefully acknowledge helpful comments from Ronald Oaxaca, James F. Ragan, Jr., Victor J. Tremblay, James Walker, and our referees. We thank Adonis Yatchew for encouraging us not to give up on density estimation and Dr. James Phelps for providing medical expertise. The usual caveat applies.

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