Brainstorm: Occupational Choice, Manic Depression And Creativity

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Abstract

Although economists have analyzed earnings, unemployment, and labor force participation for manic-depressives, occupational choice has yet to be explored. Psychiatric case studies suggest links between manic depression and occupational creativity, but they likely suffer from selection bias. To avoid this problem we employ two population-based data sets: the National Health Interview Survey, 1989: Mental Health Supplement (MHS) and the Epidemiologic Catchment Area (ECA) data set. We use these data sets to estimate a multinomial logit model of occupational outcomes matched to a measure of occupational creativity. Manic-depressives appear to be disproportionately concentrated in the most creative occupational category, which we confirm by estimating nonparametric kernel densities of occupational creativity for bipolar and non-bipolar samples. We find significant differences; the probability of employment in creative jobs is higher for bipolar than non-bipolar workers.
If a man comes to the door of poetry untouched by the madness of the Muses, believing that technique alone will make him a good poet, he and his sane compositions never reach perfection, but are utterly eclipsed by the performances of the inspired madman.

_Socrates\(^1\)

The hypothesized association between creativity and manic-depressive illness is an age-old controversy.\(^2\) Manic depression or 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 their labor market outcomes (Frank and McGuire, 2000).

There is a fair amount of economics literature regarding mental illness in general and in the labor market. As might be expected, research on the mentally ill as a group has shown that they earn less than the well on average, all else equal (Bartel and Taubman, 1979, 1986; Benham and Benham, 1982, with the exception of neurotics; Frank and Gertler, 1991, for two of three measures of mental illness). Further, even when accounting for endogeneity, the mentally ill are less likely to be employed (Hamilton et al., 1997).

The employment of the bipolar population is approximately 71 percent compared to about 82 percent for the general population, and manic-depressives earn about 57 percent 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 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.

\(^1\)Plato (1974 translation).

\(^2\)See Jamison (1993) for a thorough history and literature review of the topic.
None of the economic studies to date have addressed the issue of occupational outcomes for those with manic-depressive illnesses. Yet there is a substantial body of research on the possible link between creative and artistic occupations and manic-depressive 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 may suffer from small sample sizes or from selection bias. For example, biographers likely do not choose their subjects at random. Manic-depressives may be more interesting and colorful to writers and to readers, and if so, focusing on biography subjects may result in an erroneous apparent correlation between the illness and artistic ability. In addition, researchers may over- or under-diagnose bipolar disorder among creative figures, being influenced by the prominence of the hypothesis at the time.

To address the link between manic-depressive illness and occupational creativity, we use two samples: the first is a large population-based sample with automated implementation of the diagnostic criteria to distinguish manic-depressives from the rest of the sample (the Epidemiologic Catchment Area (ECA) data set); the second is also a large population-based sample but with self reported diagnosis of bipolar illness (the Mental Health Supplement (MHS) of the National Health Interview Survey). These should help to avoid small sample and selection biases. Our goal here is to examine the link between manic depression and occupation by estimating a traditional economic model of occupational outcomes, namely a multinomial logit model of occupational choice. We also investigate whether manic-depressives are concentrated in more creative occupations based on a measure from the Dictionary of Occupational Titles.

Social stigma plagues individuals with bipolar disorders and other mental illnesses. Those who are unable to hide their illness in the workplace may face discrimination, and those who are able to hide their illness may fear being exposed. Lack of information about long periods of wellness and productivity contribute to the stigma and potential discrimination. If there are benefits to bipolar illnesses in terms of occupational creativity, and if employers become aware of these benefits, they may be more willing to hire
and retain individuals with bipolar illnesses. Perhaps exposure to this information would lessen the social stigma and workplace barriers for those with other mental illnesses as well.

1 The Nature of Manic Depression and its Relation to Creativity

And Something’s odd within
That person that I was
And this One do not feel the same
Could it be Madness this?

*Emily Dickinson*

The expression of manic-depressive illness varies considerably across individuals and over time for a given individual. There is a spectrum of severity of symptoms, both on the depressive and manic side, and considerable variation in the age of onset, presence and severity of hallucinations and delusions, and the frequency, duration, and pattern of manic, depressive, and normal episodes. For example, in a recent study, Post et al. (2003) follow the daily course of illness for 258 bipolar outpatients for one year. They find that even with state-of-the-art medications, 26.4 percent spent at least 9 months of the year in a manic or depressive state. An additional 40.7 percent were episodically ill, while 32.9 percent of the patients were minimally impaired over the year. This sample probably overstates the severity of illness of the bipolar population since these patients were at “treatment centers with a record of excellence” which may draw an over-representation of people with particularly severe or treatment-resistant illness. Those who are functioning well do not usually seek help, and those with manageable symptoms are readily treated by local psychiatrists.3

3Post el al. argue that daily participation in the project requires motivation and commitment which may counter the selection bias discussed above. It may be however, that those who are most impaired have the greatest to gain from participation in the study.
The clinical definition of mania may help to clarify the meaning of manic depression. Depression characterizes both unipolar and bipolar illness; thus it is an episode of mania that distinguishes manic depression (or bipolar I disorder) from unipolar illness. Detailed symptoms of mania are included in the first column of appendix table A.1, but 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. Physiological evidence of manic phases are displayed in Illustration 1 of brain scans of a patient during manic and depressive phases, which is reproduced from Goodwin and Jamison (1990, p. 458b).

The aforementioned list of symptoms provides some motivation for the link between the disorder and creativity. For example “flight of ideas” evokes images of poets, writers or musicians in the throes of creativity. The “talkativeness” feature enables some manic-depressives to easily and fluently vocalize rhymes and formulate word associations, facilitating the writing of poetry and verse (Jamison, 1993). Increased activity and decreased need for sleep may bolster productivity in a number of occupations. As an example, Illustration 2 (reproduced from Goodwin and Jamison, 1990, p.348) tracks the career history of the composer Robert Schumann. The numbers on the Illustration identify each opus written in each year, while the lower portion indicates the psychiatric diagnosis and suicide attempts. The cyclical pattern of Schumann’s work and its correspondence with his psychiatric state is striking. On the other hand, many of the symptoms of mania listed above, such as distractibility, would typically be associated with reduced effectiveness in virtually any occupation.

Because they experience the height and depth of emotion, manic-depressives may be able to produce rich and moving poetry, art, and music to a greater extent than if they were well. Additionally, the disease may drive manic-depressives to use artistic expression to soothe their turmoil. Perhaps creative persons are prone to manic depression due to genetic factors. Unafflicted close relatives of bipolars tend to be more creative than the general

\[4\text{Hypomania is a mild, non-psychotic, form of mania.}\]
population (Jamison, 1993), suggesting that there is a genetic link between the illness and creativity. We do not presume to disentangle these potential causal factors here, but attempt to first establish whether or not there is an association between manic depression and occupational creativity.

2 Data and Methods

The main dataset we utilize is the Epidemiologic Catchment Area Study (ECA), collected by researchers at Yale University, Johns Hopkins University, Washington University, Duke University 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, 1994). Data were obtained by personal interviews of 20,861 adults residing in the communities of these universities: New Haven, Baltimore, St. Louis, Durham and Los Angeles. Respondents were selected using multistage probability sampling. We use the most recent wave of the survey, Wave II, which was collected in 1981-1985.

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). Appendix Table A.1 compares the DSM-III criteria to the corresponding DIS questions for the diagnosis of mania. Once the DIS responses are entered into a data file, the DSM-III criteria are operationalized by computer, and diagnoses are generated for mania as well as a number of other mental illnesses. The fraction of the sample with a DSM-III manic episode diagnosis is 0.62.\(^5\)

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

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\(^5\)Individuals who have had a manic episode but experienced psychotic symptoms before or independent of an episode or who have an organic brain disorder are excluded from the mania diagnosis.
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 percent of the sample.

To supplement the ECA results, we consider information from another data source: the National Health Interview Survey, 1989: Mental Health Supplement (MHS). Rather than using the DSM-III or DSM-III-R criteria to identify bipolar illness in the sample, the MHS identifies manic depression by simply asking the respondent in the interview whether or not he or she has had the disease in the past 12 months. Thus, the reference is in the last 12 months rather than lifetime as in the ECA data, and the diagnosis is self-reported rather than identified based on symptoms as in the ECA. We would expect that those identified as bipolars in the MHS would typically be more severely impaired than those identified as bipolar in the ECA study.

Both the ECA and MHS samples also contain occupational codes. The ECA occupation variable applies to those currently and previously employed, and the MHS occupation variable applies to those currently employed or unemployed. Table 1 lists the percent of observations in each major occupational group by manic episode status for our two samples and 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 managerial and professional occupations.

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6 In a preliminary draft of this paper, we also made use of the National Comorbidity Survey (NCS), 1990-1992 (Kessler, 2002). The NCS mania variable overestimated the number of bipolar I cases according to a clinical reappraisal study, and the diagnostic criteria were adjusted (Kessler, et al., 1997). Only 15 of the newly identified bipolar cases had information needed for the logit model, a sample too small to obtain regression estimates. Further, recent lifetime prevalence rates exceed the 0.4 percent rate based on the new definition of mania, e.g., 1.6 percent in Jonas et al. (2003) and 3.9 percent in Kessler et al. (2005) for the revised NCS. The NCS-R has not yet been released to the public (Harvard, 2006).

7 The occupation recorded for those not currently employed is most recent occupation in both data sets. We explore employment statistics by bipolar status below.
and services based on the ECA sample data, but not in the MHS data. In both the ECA and MHS samples, bipolars are relatively ‘overrepresented’ in the services. In the MHS data bipolars are most highly concentrated in the technical, sales and clerical category. The occupational segregation index (Duncan and Duncan Index of Occupational Dissimilarity) corresponding to the figures in Table 1 for the ECA sample is 13.3, indicating that identical occupation distributions for manic-depressives and those with no history of mania would arise if 13.3 percent of either group changed occupations for bipolar DSM-IIIs . 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 the well is 18.7 percent, higher than for the bipolars diagnosed under the less restrictive DSM-III criteria. For the MHS sample the occupational segregation index is 17.23.

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

Table 2 shows that the mean and median values of the occupational creativity index vary substantially by occupation group. Managerial and professional occupations have the highest mean and median creativity level relative to the other occupational groups, and based on the ECA sample, this occupational category employs an ‘over-representation’ of those with manic depression, as shown in Table 1. Further, the managerial and professional occupational group includes all of the 3-digit occupations classified by Filer (1986) as “artistic.” In the services, where manic-depressives are also over-

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8 These statistics are based on bipolar and non-bipolar individuals.
9 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
represented (see Table 1), the extent of creativity is less clear. Taking a more
direct approach, we segment the sample by diagnosis status and compute the
occupational creativity index. For the ECA sample, we find that both the
mean and median values of the occupational creativity index are higher for
manic-depressive DSM-III-Rs (means = 4.35 and 4.54, medians = 0.46 and 0.38) than by those not so afflicted (mean = 3.07, median = 0.12). Also included in Table 2 are data for those who are classified as bipolar II. Bipolar II is a bipolar disorder with more moderate manic episodes than bipolar I disorder; they more closely resemble the non-bipolar population in
terms of the mean and median creativity indexes as one might expect. Fi-
nally the results for the bipolar I population in the MHS data set suggest that
mean and median creativity indexes are higher in the non-bipolar population.

We explore one other measure of creativity from the psychology and career
counseling literature: the Holland Artistic (A) Occupational Code (Gottfred-
son and Holland, 1996). We merged the Holland codes to our ECA sample
music; and artists, performers and related workers not elsewhere classified.

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 intel-
tlectual endeavors.” The Holland model classifies five additional occupational environments:
Realistic (R, e.g. carpenter or truck operator), Investigative (I, e.g. psychologist or mi-
crobiologist), 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).
by 3-digit occupational code, and we used the DSM-III criteria to distinguish manic-depressives 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 small sample of bipolar individuals, 75 in the non-artistic occupations and only 9 in the artistic occupations, limit the weight of this evidence.

In the next section we turn to traditional empirical models used in economics to analyze occupational choice. Specifically we use multinomial logit estimation of occupational choice to determine if bipolar status significantly affects occupational choice. We then return to analyzing the relationship between manic depression and the occupational creativity index. The large differences between the mean and median values of the index, displayed in Table 2, indicate that the distribution is highly skewed. Thus, parametric techniques may not be appropriate, particularly since the distribution is unknown. Consequently, we use kernel density estimation and nonparametric hypothesis tests to explore potential differences in the occupational creativity index densities for manic-depressives and for other individuals.

3 Results

3.1 Multinomial Logit Occupation Regressions

In what follows, we estimate a multinomial logit model of the probability of employment in each occupational group as a function of bipolar I 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), MARRIED = 1 if i is presently married (= 0 otherwise), and AGE. Sets of dummy variables for year of interview and interview site are also included. Although it would be desirable to include education level in the regression, it was not collected at Johns Hopkins or Washington University. For the set of observations from the Yale, Duke, and UCLA communities, the mean education level is higher for bipolar I’s than for the rest of the sample (12.97 compared to 11.53 years). Because education is likely correlated with occupational creativity, omitting it might result in biased parameter estimates.
Thus, we report estimates for the Yale-Duke-UCLA sample using education (ED) as a regressor as well as for the full sample excluding the education regressor. Multinomial logit estimates of marginal effects\textsuperscript{11} of the manic-depression dummy variable for alternative occupation groups are presented in Table 3a. These include results for the full sample with the base model (no education, no alcohol or drug variables included) as well as for the smaller sample for which we had information on education (the middle panel of the table). The ECA 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: managerial and professional and services, although the marginal effects are significant at the 10 percent or better level in only two cases: DSM-III for services in the base model, and DSM-III-R for the managerial and professional category in the small sample which controls for education. The marginal effect is consistently negative for the other ‘low creativity’ occupations, although again it is significant in only a few cases: for technical, sales and clerical for DSM-III-R in the base model; for operators, fabricators and laborers for DSM-III in the small sample controlling for education; and for crafts for DSM-III-R in the small sample controlling for education.

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 ECA sample to 46. Note that if we wish to investigate the relationship between manic depression and occupational creativity, and if occupational impairment is used as a criterion for manic depression, 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 numerical value of the bipolar marginal effect, most strikingly in the smaller sample which controls for education, suggesting even stronger selection of bipolars into relatively creative occupations.

\textsuperscript{11}We used the margin module developed by Tamas Bartus, Department of Sociology and Social Policy, Budapest University of Economic Sciences and Public Administration, Budapest, Hungary to estimate the appropriate marginal effects.
The occupational impairment rule in the DSM-III-R diagnostic criteria has identified manic-depressives 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 managerial/professional occupations than the manic-depressives 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 manic depression.

We also estimate the logit model using the MHS sample; recall that in this data set bipolars are self-identified based on their perception of manic episodes in the 12 months prior to the interview. We would expect this definition to identify only those with fairly extreme symptoms. The results for the logit model estimation are displayed in Table 3a; here we find a significant positive effect of the mania dummy on the technical, sales and clerical occupations, and a negative and significant marginal effect for the crafts. We next attempt to reconcile the discrepancy in results for the two data and to explore other plausible model specifications.

### 3.2 Alternative Specifications

We estimate a number of alternative specifications, and the substantive results are unchanged. First we consider three separate modifications to the set of demographic variables in the base model: excluding education; excluding marital status; and adding parental education. The presence of education or marital status in the model is subject to debate. If we focus on labor market effects, holding pre-market effects of the illness constant, education and marital status should be included as control variables. If we are interested

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12 Recall that for the ECA full sample, education is not available for all sites, and is therefore already excluded from the model. Because the base model for the 3-site sample does include education we are able to test for sensitivity of the model to the inclusion of education for that sample. Only the MHS data set includes parental education. Unfortunately, the occupations of adult family members are not known in either data set.
in the overall effects of the illness, and if bipolar illness affects educational achievement, controlling for education would mask part of the influence of the illness on occupational outcomes. Similarly, including marital status may bias the overall marginal effect estimates if those with bipolar disorder are less likely to wed or to have stable marriages. Thus, we estimate the model first without education and then without marital status for the ECA and MHS data sets. For the MHS, we also assess the sensitivity of the estimates to the addition of a parental education variable to the base model.

The signs of the estimated marginal effects on the manic-depressive dummy variables are robust to these specification changes. For the ECA data set, both full sample and 3-site sample, and both DSM-III and DSM-II-R criteria, the signs are the as in the base model: positive for the managerial and professional 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. For the MHS data set, the estimated signs from the alternative specifications are also consistent with the signs from the MHS base model: negative for managerial and professional occupations; positive for technical, sales and clerical jobs; essentially zero for services; negative for crafts; and positive for operators, fabricators and laborers. Although consistent with prior results for each data set, the ECA and MHS results continue to differ from each other.

We next consider another set of specifications which control for co-morbid psychiatric illnesses. Pooling manic-depressives who are schizophrenic, for example, with those who have only manic depression, distorts estimated marginal effects. For the ECA, a number of models are estimated, each with a dummy variable for schizophrenia, obsessive-compulsive disorder, phobia, panic disorder, anti-social personality or alcohol and drug abuse. For the MHS, we construct dummy variables for schizophrenia, paranoia and/or delusional illness, personality disorder, and alcohol or drug abuse and estimate the separate models using a dummy for each of these diagnoses, along with the manic-depression dummy variable. The signs on the marginal effects of manic depression do not change from the original base models for either the MHS or the ECA.

Due to small sample sizes for the ECA as well as the MHS, only one co-morbid psychiatric illness can be represented in the model at a time.
Perhaps the difference in results for the two samples relates to the time frame of reference for the disease diagnosis. In the ECA, the bipolar diagnosis is made if one has ever had bipolar illness. In the MHS, the diagnosis is made if one has had manic depression in the past year. In the third set of alternative specifications, we replace the lifetime illness dummy variable in the ECA with a variable for illness in the past year. The results become more similar to the MHS, but there are still important differences. On the one hand, for the ECA full sample, the marginal effect of manic depression in the last year becomes negative and the marginal effect in the operators group becomes positive, as in the MHS. But the negative effects in the technical group and the positive effect in the services group remain, unlike the MHS. When a second bipolar variable is added to the model, the presence of the illness after one year, the estimated signs on its marginal effects are consistent with the ECA signs on the lifetime bipolar illness marginal effects estimates in the base model. This indicates that there is a difference in the effect of bipolar illness in the past year and in the effect over the long term. Those who have been ill longer are more likely to be in professional and managerial occupations.

We might suspect that those who survive in the workplace over a longer time period have exceptional talent and that bipolar workers without exceptional talent may have to become unemployed or to drop out of the labor force. But the ECA and MHS occupation variables apply to those who are previously as well as currently employed. The estimates we report refer to the impact of bipolar illness on current or most recent occupation. Those who are unemployed or out of the work force are still represented in the marginal effect estimates. At the same time, it may be of interest to examine the samples of non-workers in the ECA and MHS. In the MHS 64.39 percent of those not manic-depressive are employed compared to only 38.10 percent of the manic-depressives.\textsuperscript{14} Unemployment rates are higher for manic-depressives (4.76) relative to others (2.65), but these figures are merely anecdotal since there are only 7 unemployed manic-depressives in the sample. These 7 individuals display lower mean and median creativity levels than the non-bipolar unemployed (16.94).

\textsuperscript{14} These figures are low relative to usual employment rates as they are based on all people 18 and over, including those beyond retirement age.
Out of the labor force rates in the MHS are 57.14 percent for manic-depressives and 32.97 for others. Manic depressives are more likely to keep house and less likely to go to school. They are also more likely to be in a government job or self-employed than non-bipolars. The same results hold, in general, for men and women. This indicates that those self-reporting manic depression in the past year are relatively less productive as private sector employees or are relative more productive in flexible environments. In the ECA, nonworkers were identified at 3 of the ECA sites: UCLA, Duke and Hopkins.\footnote{This subset differs from the earlier subset referred to as the ‘3-site’ sample (Yale, UCLA and Duke).} Altogether this subset contains 7858 individuals who are either currently working or who have previously worked. The employment rates for those who are bipolar I according to the DSM-III criteria are 41.7 percent compared to 53.1 percent for those not classified as bipolar I. For the other diagnostic categories, half of DSM-III-R bipolars are employed for pay, while only one-third of bipolar II’s presently work. We caution the reader, however, regarding the small sample sizes for bipolar individuals who are not currently working; 21 bipolar I’s by the DSM-III criteria, 10 by the DSM-III-R criteria, and 10 bipolar II’s. With these limited samples we find that bipolar and non-bipolar workers have far lower mean and median creativity levels than those working, with one exception. Those nonworkers diagnosed as bipolar I by the DSM-III criteria maintain a median creativity level (0.47) comparable to bipolar I workers (0.46) and above non-bipolar workers (0.12) and non-bipolar nonworkers (0.07). Working and nonworking bipolars in the ECA, as identified by the DSM-III criteria, appear to be better off than the individuals identified as bipolar I in the ECA by the DSM-III-R criteria, the bipolar I’s or the MHS manic-depressives.

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 for each data set. The results are not consistent, however across data sets. Those who self-identify as manic-depressive in the past 12 months in the MHS display less creativity than those who do not, and are less likely to be in the most creative occupational category, professional and managerial, by both occupational distributions and logit estimates. In contrast, the ECA bipolars fare better in terms of
creativity and job placement. People who know and admit to being manic-depressive in the MHS may be more severely affected than those diagnosed as manic-depressive in the ECA. The MHS will only identify manic depression for people who are sufficiently impaired to seek help, who can afford to seek help, who admit to having the disease, and who have experienced manic depression in the past year.

Next we turn to some additional evidence based on nonparametric tests and estimation.

3.3 Additional Evidence

In the previous section we reported results concerning occupational choice of those with bipolar disorder relative to those without this disorder. These results provide some evidence that bipolars select into occupations which have relatively high occupational creativity indexes as discussed in section 2. In this section we provide additional empirical evidence relating to the occupational creativity indexes and bipolar illness. We begin with our efforts to statistically test for differences in occupational creativity in the bipolar and non-bipolar samples.

3.3.1 Nonparametric Tests

We would like to test whether the differences in occupational creativity we noted in section 2 are statistically significant. This is not straightforward, however, since the density of the occupational creativity index is unknown and the empirical density is highly skewed; thus traditional t-tests are not appropriate to test for significant differences in location parameters. Consequently, we turn to nonparametric tests and estimation techniques to address these issues. We begin by conducting a nonparametric test for a difference in the median of the occupational creativity index for DSM-III manic-depressives and for others in the ECA sample and find that the difference in medians is marginally significant (Fisher’s exact p-value = 0.080 and the p-value for the Pearson $\chi^2 = 0.076$). Next we conduct a Wilcoxon rank-sum (Mann-Whitney) test and obtain an insignificant test statistic (p-value = 0.217). Using a Kolmogorov-Smirnov test for the equality of distributions results in a corrected p-value of 0.103. For the MHS data (where bipolar ill-
ness is self-reported), the median, Wilcoxon and Kolmogorov-Smirnov tests indicate no significant difference in the occupational creativity index for the two groups. Overall, the evidence of significant differences in occupational creativity densities by manic history status from these nonparametric tests is weak, suggesting the need for further empirical evidence.

Next we estimate nonparametric kernel densities for the occupational creativity index for 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 for the ECA data using Silverman’s plug-in bandwidth are displayed in Figure 1. The data are very concentrated near zero, indicating that many workers do not perform creative activities in their jobs, although bipolar workers are far less concentrated near zero than non-bipolar workers. To better see the behavior of the densities away from zero, we superimpose plots of the estimated function on the intervals [0,10) and [10,100], separately. The upper inset displays the [0,10) interval. The lower inset for the [10,100] range shows that the tails of both kernel densities are undersmoothed.

To deal with the tail distribution without over smoothing 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; details are in Appendix B. Our results using this method are displayed in Figure 2. It is clear from the larger graph that the non-bipolar population is more concentrated at the lowest creativity levels. Again we superimpose the plot of the estimated function for the [10,100] interval to better see what is happening in the tail of the function. Over the 10-80 range of the creativity index, the bipolar population has higher density. By inspection, the 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. Next we present values of the tail probabilities for alternate values of the occupational creativity index.
To better see what is going on in the tails, we calculate the probabilities of observing the occupational creativity index above various values (integers 1 through 10) for each group. These are displayed in Table 4. Recall that the median level of the occupational creativity index \( c \) lies between 0.12 and 0.46 for the ECA bipolar and non-bipolar samples, respectively (see Table 2b). The probability that \( c \) is greater than or equal to one in column (1) represents part of the “tail” above the median. For the ECA data we see that the probability of observing an occupational creativity index greater than one is higher for bipolars than non-bipolars (.3095 versus .2599). 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 \( H_0: f(x) = g(x) \) 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
\[
I = \int (\hat{f} - \hat{g})^2;
\]
details are in appendix B. For our ECA sample, the estimated test statistic is \( Z = -3.008 \) with a p-value of 0.0013, so \( H_0 : f(x) = g(x) \), that the density functions of the occupational creativity index for non-bipolars and bipolars is the same, is rejected. That is, the densities are significantly different.

Next we turn to our other data set, the MHS sample. Recall that the MHS identifies manic depression by simply asking the respondent in the interview whether or not he or she has had the disease in the past 12 months. Again we estimate kernel densities for manic depressives and those without manic depression in the MHS. The densities are similar to those for the ECA; the spike near zero (i.e., lowest occupational creativity) is higher for non-bipolars than bipolars as before. Also, in Table 4 we see that the probabilities are higher for non-bipolars for values of the occupational creativity index greater than or equal to 1, 2, and 7, but greater for bipolars for all other values. The tail behavior is less clearcut than with the ECA data: bipolars have higher density between values of the occupational creativity index of 10 and 30. Based on the statistical test described above, we cannot reject the null hypothesis that the bipolar and non-bipolar groups have identical density functions of the occupational creativity index, see Appendix Table B.1.
3.3.2 Other Forms of Manic-Depressive Illness

Bipolar II disorder and cyclothymia are also manic-depressive illnesses but with milder, non-psychotic manic periods termed hypomania. Bipolar II disorder occurs when an individual experiences periods of depression and hypomania, and cyclothymia is characterized by only mild depression and hypomania. Thus we might expect these milder forms of bipolar illness to more closely mimic the non-bipolar population in terms of occupational choice and occupational creativity. Previous evidence is, however, mixed. Berndt et al. (1998) find poorer labor market outcomes of unipolar depressives, suggesting that bipolar II’s (with as serious depression as bipolar I’s but milder manic periods) may also have adverse effects. On the other hand, the psychiatric literature indicates that (unipolar) depression is also associated with creativity.

We estimate densities for the bipolar II and non-bipolar samples and bipolar II and bipolar I samples from the ECA data using the two stage method described above. The resulting estimates are plotted in Figures 4 and 5. In both cases a swell in the density for the bipolar II sample at a creativity index level of about 30 is evident. The tail for both non-bipolars and bipolar I’s is thicker than that for bipolar II’s starting at about an index value of 37. For values of the index near zero, bipolar II workers are relatively less common than non-bipolar workers but more common than bipolar I workers. The bottom panel of Table 4 confirms that bipolar II’s are concentrated in the 1-3 range of the creativity index to a greater extent than non-bipolars, and in the 2-3 range compared to bipolar I’s. Based on the Li (1996) test described above, we cannot reject the hypothesis that the densities of the occupational creativity index are the same for bipolar I and bipolar II as well as for bipolar II versus non-bipolar workers. See Appendix Table B.1. Thus our tests find statistically significant differences in the estimated densities of the occupational creativity index only for the ECA sample in which we compare bipolar I’s to non-bipolars.

16In these last densities and tests, non-bipolar does not include bipolar I’s.
4 Conclusion

Earlier work investigating links between occupational creativity and bipolar illness (manic depression) is largely based on psychiatric case studies or very small samples. Here we use population based data sets and a traditional econometric framework—multinomial logit—to analyze occupational outcomes for those with bipolar disorder and the general population. We find some evidence that manic-depressives are concentrated in service occupations as well as in managerial and professional occupations. We match the occupations to a measure of occupational creativity from the Dictionary of Occupational Titles. The managerial and professional 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 and education levels for manic-depressives than for the general population. Finally, 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 in the ECA data set. 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.

These results suggest that the link between manic depression and creativity may hold for ordinary people as well as for the creative geniuses documented by Jamison (1993) and others. Further, the evidence paints a picture of a group of workers that does not resemble the ‘raving manic’ image of film and literature, a stereotype which may limit labor market opportunities for those with bipolar illness.

If so, the dissemination of information about the extensive symptom-free intervals, educational achievement, and occupational attainment, might facilitate the acceptance of manic-depressives in society and in the workplace. Research on the American with Disabilities Act (ADA) has shown that it has been ineffective at increasing the employment or earnings of disabled persons.\footnote{See Thomas De Leire, 2000.} The social stigma of psychiatric disabilities, perhaps even stronger
than the stigma associated with some personal traits and physical disabilities, may discourage those with mental illness from seeking help under the ADA. When manic-depressives seek accommodations either informally or under the ADA, understanding their potential contributions, particularly the apparent comparative advantage in creative occupations, might encourage employers to more readily hire and facilitate their productive capacities, through flexible hours, for example.

Medical treatment can also affect productivity. Medication can prevent mood swings and psychotic episodes to varying degrees. But manic-depressives often refuse medication citing blunted creativity and energy. If we treat madness, do we mute creativity? The few studies on medication and creativity for manic-depressives are inconclusive. Future research might investigate the links between medication, creativity, productivity and occupational choice for manic-depressives.

The information presented here may alleviate some of the stigma against those with bipolar disorder. If so, perhaps more openness in the workplace to persons with other mental illnesses will follow.
References


States: Results from the National Comorbidity Survey,’ *Archives of General Psychiatry* Vol. 51, No. 1 (January), pp. 8-19.


<table>
<thead>
<tr>
<th>Occupation</th>
<th>ECA DATA&lt;sup&gt;a&lt;/sup&gt;</th>
<th>MHS DATA&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No Manic Episode</td>
<td>Bipolar (DSM-III)</td>
</tr>
<tr>
<td>Managerial &amp; Professional</td>
<td>20.59</td>
<td>27.38</td>
</tr>
<tr>
<td>Technical, Sales &amp; Clerical</td>
<td>29.54</td>
<td>26.19</td>
</tr>
<tr>
<td>Services</td>
<td>17.27</td>
<td>23.81</td>
</tr>
<tr>
<td>Crafts</td>
<td>10.86</td>
<td>7.14</td>
</tr>
<tr>
<td>Operators, Fabricators &amp; Laborers</td>
<td>21.73</td>
<td>15.48</td>
</tr>
<tr>
<td>Total Percent</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Total Count</td>
<td>13,570</td>
<td>84</td>
</tr>
</tbody>
</table>

<sup>a</sup>ECA data: DSM-III: Prior episode defined over lifetime.
ECA data: DSM-III-R: Same as DSM-III, but must also have been hospitalized or markedly occupationally impaired.

<sup>b</sup>MHS: Manic episode or manic depression self-reported in last 12 months.
### Table 2a

#### Occupational Creativity Index by Occupation

<table>
<thead>
<tr>
<th>Occupation:</th>
<th>ECA Mean</th>
<th>MHS Mean</th>
<th>ECA Median</th>
<th>MHS Median</th>
<th>ECA N</th>
<th>MHS N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Managerial &amp; Professional</td>
<td>10.14</td>
<td>11.20</td>
<td>2.00</td>
<td>3.80</td>
<td>(2814)</td>
<td>(14899)</td>
</tr>
<tr>
<td>Technical, Sales &amp; Clerical</td>
<td>0.95</td>
<td>1.20</td>
<td>0.17</td>
<td>0.34</td>
<td>(4029)</td>
<td>(16733)</td>
</tr>
<tr>
<td>Services</td>
<td>3.47</td>
<td>4.98</td>
<td>0.05</td>
<td>0.05</td>
<td>(2374)</td>
<td>(6957)</td>
</tr>
<tr>
<td>Crafts</td>
<td>0.66</td>
<td>0.48</td>
<td>0.05</td>
<td>0.05</td>
<td>(1482)</td>
<td>(6498)</td>
</tr>
<tr>
<td>Operators, Fabricators &amp; Laborers</td>
<td>0.45</td>
<td>0.30</td>
<td>0.02</td>
<td>0.07</td>
<td>(2964)</td>
<td>(8347)</td>
</tr>
</tbody>
</table>

### Table 2b

#### Occupational Creativity Index by Diagnosis

<table>
<thead>
<tr>
<th>Diagnosis:</th>
<th>ECA Mean</th>
<th>ECA Median</th>
<th>MHS Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bipolar (DSM-III)</td>
<td>4.35</td>
<td>0.46</td>
<td>84</td>
</tr>
<tr>
<td>Bipolar (DSM-III-R)</td>
<td>4.54</td>
<td>0.38</td>
<td>46</td>
</tr>
<tr>
<td>Bipolar II</td>
<td>2.08</td>
<td>0.13</td>
<td>48</td>
</tr>
<tr>
<td>Non-bipolar</td>
<td>3.07</td>
<td>0.12</td>
<td>13888</td>
</tr>
<tr>
<td>Non-bipolar&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.13</td>
<td>0.21</td>
<td>54972</td>
</tr>
</tbody>
</table>

<sup>a</sup> Non-bipolar here means not Bipolar I.
Table 3a
Multinomial Logit Marginal Effect Estimates of Manic-Depression Status on Occupational Outcomes

<table>
<thead>
<tr>
<th></th>
<th>Managerial &amp; Professional</th>
<th>Technical, Sales &amp; Clerical</th>
<th>Services &amp; Lab.</th>
<th>Crafts &amp; Sales &amp; Fabr.</th>
<th>Oper., &amp; Lab.</th>
<th>N</th>
<th>LR(^d)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ECA DATA</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Base Model, Full Sample</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manic Dep</td>
<td>0.05</td>
<td>-0.05</td>
<td>0.08(^c)</td>
<td>-0.03</td>
<td>-0.06</td>
<td>13622</td>
<td>2184(^a)</td>
</tr>
<tr>
<td>(DSM-III)</td>
<td>(1.17)</td>
<td>(1.00)</td>
<td>(1.77)</td>
<td>(0.99)</td>
<td>(1.54)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manic Dep</td>
<td>0.09</td>
<td>-0.10(^c)</td>
<td>0.09</td>
<td>-0.05</td>
<td>-0.04</td>
<td>13584</td>
<td>3265(^a)</td>
</tr>
<tr>
<td>(DSM-III-R)</td>
<td>(1.42)</td>
<td>(1.73)</td>
<td>(1.50)</td>
<td>(1.51)</td>
<td>(0.61)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Yale/UCLA/Duke with Educ</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manic Dep</td>
<td>0.07</td>
<td>-0.02</td>
<td>0.07</td>
<td>-0.03</td>
<td>-0.08(^b)</td>
<td>8744</td>
<td>5518(^a)</td>
</tr>
<tr>
<td>(DSM-III)</td>
<td>(1.53)</td>
<td>(0.49)</td>
<td>(1.50)</td>
<td>(0.91)</td>
<td>(2.11)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manic Dep</td>
<td>0.12(^c)</td>
<td>-0.08</td>
<td>0.11</td>
<td>-0.07(^b)</td>
<td>-0.07</td>
<td>8707</td>
<td>5485(^a)</td>
</tr>
<tr>
<td>(DSM-III-R)</td>
<td>(1.95)</td>
<td>(1.27)</td>
<td>(1.63)</td>
<td>(2.12)</td>
<td>(1.27)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>MHS DATA</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manic Dep</td>
<td>-0.07</td>
<td>0.09(^c)</td>
<td>-0.004</td>
<td>-0.05(^c)</td>
<td>0.03</td>
<td>53326</td>
<td>30531(^a)</td>
</tr>
<tr>
<td>(1.64)</td>
<td>(1.75)</td>
<td>(0.01)</td>
<td>(1.88)</td>
<td>(0.85)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Base Model does not control for alcohol/drugs or education.

Note: Absolute values of t-ratios are in parentheses.

\(^a\) Significant at 1 percent
\(^b\) significant at 5 percent;
\(^c\) significant at 10 percent.
\(^d\) Likelihood ratio.
Table 3b

Multinomial Logit Marginal Effect Estimates of Manic-Depression Status on Occupational Outcomes: Model Controlling for Alcohol and Drugs

<table>
<thead>
<tr>
<th>Managerial &amp; Professional</th>
<th>Technical &amp; Sales &amp; Clerical</th>
<th>Services &amp; Crafts</th>
<th>Oper. &amp; Lab.</th>
<th>ECA DATA</th>
<th>Full Sample</th>
<th>Yale/UCLA/Duke</th>
<th>N</th>
<th>LR&lt;sup&gt;4&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manic Dep (DSM-III)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>13622</td>
<td>8744</td>
<td>8744</td>
<td>5547</td>
</tr>
<tr>
<td>0.05</td>
<td>0.03</td>
<td>0.10</td>
<td>-0.06&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.11&lt;sup&gt;a&lt;/sup&gt;</td>
<td>(0.89)</td>
<td>(0.47)</td>
<td>(1.60)</td>
<td>(-3.72)</td>
</tr>
<tr>
<td>0.05</td>
<td>0.06</td>
<td>0.09</td>
<td>-0.07&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.12&lt;sup&gt;a&lt;/sup&gt;</td>
<td>(0.83)</td>
<td>(0.88)</td>
<td>(1.56)</td>
<td>(-3.27)</td>
</tr>
</tbody>
</table>

Notes: Absolute values of t-ratios are in parentheses.

<sup>a</sup> Significant at 1 percent; <sup>b</sup> significant at 5 percent; <sup>c</sup> Significant at 10 percent.

<sup>d</sup> Likelihood ratio.
## TABLE A.1

DIS Questions to Evaluate DSM-III Criteria for Manic Episode*

<table>
<thead>
<tr>
<th>A. One or more distinct periods with a predominantly elevated, expansive, or irritable mood.</th>
<th>Has there ever been a period of one week or more when you were so happy or excited or high that you got into trouble, or your family or friends worried about it, or a doctor said you were manic? When you were feeling that way (i.e., experiencing symptom 1-7 in B), were you unusually irritable or likely to fight or argue?</th>
</tr>
</thead>
<tbody>
<tr>
<td>B. Duration of at least one week during which at least three of the following symptoms have persisted (four if mood is only irritable):</td>
<td>Has there ever been a period of a week or more when you:</td>
</tr>
<tr>
<td>1. Increase in activity (either socially, at work, or sexually) or physical restlessness.</td>
<td>Were so much more active than usual that you or your family or friends were concerned about it? Your interest in sex was so much stronger than is typical for you that you wanted to have a lot more frequently than is normal for your for with people normally wouldn’t be interested in?</td>
</tr>
<tr>
<td>2. More talkative than usual or pressure to keep talking.</td>
<td>Talked so fast that people said they couldn’t understand you?</td>
</tr>
<tr>
<td>3. Flight of ideas or subjective experience that thoughts are racing.</td>
<td>Thoughts raced through your head so fast that you couldn’t keep track of them?</td>
</tr>
<tr>
<td>DIS Questions to Evaluate DSM-III Criteria for Manic Episode*</td>
<td></td>
</tr>
<tr>
<td>---------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>4. Inflated self-esteem</td>
<td>Felt that you had a special gift or special powers to do things others couldn’t do or that you were a specially important person?</td>
</tr>
<tr>
<td>5. Decreased need for sleep</td>
<td>Hardly slept at all but still didn’t feel tired or sleepy?</td>
</tr>
<tr>
<td>6. Distractibility, i.e., attention is too easily drawn to unimportant irrelevant external stimuli</td>
<td>Easily distracted so that any little interruption could get you off the track?</td>
</tr>
<tr>
<td>7. Excessive involvement in activities that have a high potential for painful consequences which is not recognized.</td>
<td>Went on a spending spree-spending so much money that it caused you or your family some financial trouble?</td>
</tr>
</tbody>
</table>

* Reproduced from Weissman et al. (1991)
Table 4

Occupation Creativity Index Distribution(c) by Manic Episode Status

<table>
<thead>
<tr>
<th></th>
<th>ECA DATA (n=13,971)</th>
<th>MHS DATA (n=53,685)</th>
<th>ECA DATA (n=13,862)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P(c ≥ 1 )</td>
<td>P(c ≥ 2 )</td>
<td>P(c ≥ 3 )</td>
</tr>
<tr>
<td><strong>Bipolar I</strong></td>
<td>0.3095</td>
<td>0.1786</td>
<td>0.1667</td>
</tr>
<tr>
<td><strong>N-bplr I</strong> (^a)</td>
<td>0.2599</td>
<td>0.1627</td>
<td>0.1424</td>
</tr>
<tr>
<td><strong>Bipolar II</strong></td>
<td>0.2933</td>
<td>0.2267</td>
<td>0.2267</td>
</tr>
<tr>
<td><strong>Non-bipolar II</strong> (^b)</td>
<td>0.3275</td>
<td>0.2350</td>
<td>0.2170</td>
</tr>
<tr>
<td><strong>Bipolar II</strong></td>
<td>0.2917</td>
<td>0.2083</td>
<td>0.1875</td>
</tr>
<tr>
<td><strong>Non-bipolar II</strong> (^b)</td>
<td>0.2560</td>
<td>0.1626</td>
<td>0.1422</td>
</tr>
</tbody>
</table>

Note: \(^a\) includes workers with bipolar II, \(^b\) excludes workers with bipolar I.
Illustration 1. Positron emission tomographic scans of the brain of a drug-free rapid-cycling manic-depressive patient. The colors in the scans correspond to glucose metabolic rates, with the lowest rates associated with the coolest end of the color spectrum (blue) and the highest rates with the warmest (red). PET scans in the top row were made on May 17, when the patient was depressed. The second row shows the identical planes scanned the next day, when the patient had become hypomanic. The third row shows the scans on May 27, when the patient was again depressed (adapted from Baxter et al., 1985). For text discussion, see page 521.
Figure 14-1. Schumann’s works by year and opus number (adapted from Slater and Meyer, 1959).
Appendix B: Kernel density estimation and testing

We use the kernel method to estimate the densities of the occupational creativity index for non-bipolar as well as bipolar samples. There are two factors that will affect our final estimate: the choice of the kernel function and the bandwidth selection. For the kernel, we pick the most widely used kernel, the Gaussian (standard normal density) function, because of its convenience in application.\(^1\) The bandwidth selection is of crucial importance in density estimation and various methods have emerged in the past thirty years.\(^2\)

Considering the well-known tradeoff between the bias and variance of estimators computed from different bandwidth choices, it will be desirable to have an automatic bandwidth selection method that is optimal in the sense of balancing the tradeoff. The automatic bandwidth choice method described in Silverman (1986) is a good candidate since this bandwidth is chosen to minimize the integrated squared error (ISE) between the estimated function and the objective function\(^3\). More precisely, the optimal bandwidth is defined as:

\[
h_{\text{opt}} = 0.79 R n^{-\frac{1}{5}}
\]  

where \( R \) is the interquartile range of the distribution and \( n \) is the number of observations. Simulation results suggest that this bandwidth is robust for heavily skewed data (Silverman, 1986). The kernel estimates of densities using Silverman’s plug-in bandwidth are those plotted in Figure 1. The data are highly concentrated at zero so estimated densities, non-bipolar in particular, are very steep at the origin and very flat in the tail. To better discern the behavior of the densities, we also plotted the estimated functions on the intervals \([0, 10)\) and \([10, 100]\) separately. By inspection, the non-bipolar density is more concentrated at zero. However, it is obvious that the tails of both densities are undersmoothed, which can be expected when applying a fixed bandwidth on heavily skewed data.

To deal satisfactorily with the tail distribution without oversmoothing near the origin, we apply another bandwidth selection method, known as “adaptive two-stage estimator” (A2SE), first considered by Breiman et. al. (1977) and Abramson (1982). The basic idea of A2SE is to use a broader bandwidth in the regions of low density to smooth the tail part of the function. The A2SE bandwidth is defined as:

\[
h_{ni} = h \delta_{ni}, \quad \delta_{ni} = \left[ \frac{\hat{f}(x_i)}{G} \right]^{-\lambda}
\]

\(^1\)There is some evidence that efficiency can be improved by choosing kernel functions other than Gaussian, the Epanechnikov-type kernel is one example, but since the improvement is only marginal we instead focus our effort on the more controversial bandwidth choice.

\(^2\)See Silverman (1986) for a more detailed survey.

\(^3\)We used several different subjectively chosen bandwidths in our initial estimation and all the results consistently suggest that one density has a flatter tail than the other. The results are available upon request.
where $h_{ni}$ is the bandwidth used for the $i^{th}$ point in the sample of size $n$, $G$ is the geometric mean of the preliminary estimated $\hat{f}(x_i)$ over all $x_i$ and $\lambda, 0 < \lambda \leq 1$, is a sensitivity parameter. $\hat{f}(x_i)$ can be any initial estimator with bandwidth $h$, evaluated at each observation point. Abramson (1982) states that $\lambda = 0.5$ gives good results. The adaptive kernel estimate $\hat{f}(x)$ is defined by:

$$\hat{f}(x) = \frac{1}{n} \sum_{i=1}^{n} \frac{1}{h_{ni}} K\left(\frac{x_i - x}{h_{ni}}\right)$$  \hspace{1cm} (3)$$

In our application, we use Silverman’s plug-in bandwidth to estimate $\tilde{f}(x_i)$. The resulting estimates are plotted in Figures 2, 3, 4 and 5. Again, we superimpose separate plots of the tails to better reveal the tail behavior.

To test the equality of the two densities, we follow the method proposed by Li (1996). Specifically, we test $H_0 : f(x) = g(x)$ against $H_1 : f(x) \neq g(x)$. The basic idea is to construct a nonparametric approximation for the integrated squared difference between the two estimated functions. The test statistic, based on $\tilde{I} = \int (\hat{f} - \hat{g})^2$, can be written in compact form as:

$$\tilde{I} = \frac{1}{h} \left\{ \sum_{i=1}^{n_1} \sum_{j=1, j\neq i}^{n_1} \frac{1}{n_1(n_1 - 1)} K\left(\frac{x_i - x_j}{h}\right) + \sum_{i=1}^{n_2} \sum_{j=1, j\neq i}^{n_2} \frac{1}{n_2(n_2 - 1)} K\left(\frac{y_i - y_j}{h}\right) \right.$$

$$- \sum_{i=1}^{n_2} \sum_{j=1, j\neq i}^{n_1} \frac{1}{n_1(n_2 - 1)} K\left(\frac{y_i - x_j}{h}\right) - \sum_{i=1}^{n_1} \sum_{j=1, j\neq i}^{n_2} \frac{1}{n_1(n_2 - 1)} K\left(\frac{x_i - y_j}{h}\right) \left\} \right.$$

$$- \frac{1}{h} \left\{ \sum_{i=1}^{n_1} \sum_{j=1, j\neq i}^{n_1} \frac{1}{n_1(n_1 - 1)} K\left(\frac{x_i - x_j}{h}\right) + \sum_{i=1}^{n_2} \sum_{j=1, j\neq i}^{n_2} \frac{1}{n_2(n_2 - 1)} K\left(\frac{y_i - y_j}{h}\right) \right.$$

$$- \sum_{i=1}^{n_2} \sum_{j=1, j\neq i}^{n_1} \frac{1}{n_1(n_2 - 1)} K\left(\frac{y_i - x_j}{h}\right) - \sum_{i=1}^{n_1} \sum_{j=1, j\neq i}^{n_2} \frac{1}{n_1(n_2 - 1)} K\left(\frac{x_i - y_j}{h}\right) \right\} \right\} \left[ \int K^2(u)du \right]$$ \hspace{1cm} (4)$$

where $n_1$ is the number of observations in the first sample and $n_2$ is the number of observations in the second, $x$ represents the sample point from the first sample and $y$ represents the second. Li (1996) has shown that, under $H_0$ and assumptions: (i) $\lambda_n = \frac{n_1}{n_2} \to \lambda$, a constant; (ii) $h \to 0$ and $nh \to \infty$ as $n \to 0$, we have

$$T = nh^{\frac{1}{2}} \tilde{I} / \hat{\sigma}_{\lambda_n} \sim N(0, 1)$$ \hspace{1cm} (5)$$

where

$$\hat{\sigma}_{\lambda_n}^2 = 2 \sum_{i} \sum_{j} \left\{ \frac{1}{n_1^2} K\left(\frac{x_i - x_j}{h}\right) + \frac{\lambda_n^2}{n_2^2} K\left(\frac{y_i - y_j}{h}\right) + \frac{\lambda_n^2}{n_2^2} K\left(\frac{y_i - y_j}{h}\right) \right\} \int K^2(u)du$$ \hspace{1cm} (6)$$

where $h$ is calculated as the average of Silverman’s plug-in bandwidths for the two densities. The calculated test statistics and the corresponding p-values for different setups are given in Table B.1.
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<th>Z-statistic</th>
<th>p-value</th>
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<tbody>
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<td>Bipolar vs. Non-bipolar</td>
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