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ABSTRACT

The Changing Occupational Distribution by College Major*

In this paper we examine the occupational distribution of individuals who hold bachelor degrees in particular fields in the United States using data from the various waves of the National Survey of College Graduates. We propose and calculate indexes that describe two related aspects of the occupational distribution by major field of study: distinctiveness (how dissimilar are the occupations of a particular major when compared with all other majors) and variety (how varied are the occupations among those who hold that particular major). We discuss theoretical properties of these indices and statistical properties of their estimates. We show that the occupational variety has increased since 1993 for most major fields of study, particularly between the 1993 and 2003 waves of the survey. We explore reasons for this broadening of the occupation distribution. We find that this has not led to an increase in reported mismatch between degree and occupation.

JEL Classification: I23, J24

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I. Introduction

Different college degree programs train individuals for the labor market in distinct ways. Some fields of study are professionally or vocationally oriented, preparing individuals for rather specific occupations–examples are the engineering fields, accounting and nursing. Other undergraduate courses follow the tradition of a liberal arts education, in which the guiding principle is to teach people to think and write well, with little concern for what sort of work a student might do upon graduation.

The choice of college degree is influenced by desired occupation, but college degree also influences occupational choice. Research has shown that the choice of college major is responsive to the relative pay of graduates with those majors, as in Arcidiacono (2004), or Montmarquette, Canning and Majseredjian (2002), or the relative pay of occupations related to those majors, as in Long, Goldhaber and Huntington-Klein (2014). Similarly, Freeman and Hirsch (2008) show that the number of students that graduate with a particular college major is responsive to the knowledge content of occupations and the market payoff to that knowledge content. Choice of occupation is also likely influenced by knowledge and skills that are learned in a course of study. For example, Yamaguchi (2010) finds evidence that college graduates know more about suitable careers than those who do not attend college, so there is less career-changing among college graduates than among high school graduates.

In fact, the process of obtaining a degree in a specific field is much more complex than simply choosing a major. Altonji, Blom and Meghir (2012) and Altonji, Arcidiacono and Maurel (2015) develop models of major choice that incorporate preferences and innate ability, but also stress that students learn about their preferences and ability as they proceed in an educational program.

Although students may choose a college major with a particular occupation in mind, most college majors do not prepare students for particular occupations, and even for those degrees that are most occupationally oriented, there is a distribution of chosen occupations. In this paper, we examine the occupational distribution of individuals who hold college degrees in various major fields. We quantify the occupational distribution using two indices. The first is the well-known dissimilarity index, which measures the *distinctiveness* of occupations held by graduates with a particular major when compared to the occupations of all other majors. In our context we refer to this as occupational distinctiveness index (OD). Essentially, the distinctiveness index measures the occupational segregation of majors in the labor market. The second is an index that measures the *variety* of occupations held by individuals whose undergraduate degree was in a specific field, which we refer to as occupational variety (OV). On one end of the spectrum are degree fields whose graduates all have the same occupation, or nearly so. On the other end are degree fields which are represented among a wide variety of occupations.

The paper is organized as follows: Section II introduces the two indexes and discusses their properties. Section III gives an overview of the data from the National Survey of College Graduates. Section IV reports estimates of the indexes, and Section V documents the increase in occupational variety over the period from 1993 to 2010. Section VI discusses some possible reasons for this increase. Section VII summarizes.

II. Aspects of the Occupational Distribution of College Majors

To motivate our analysis of occupational distribution, consider Figure 1 which compares the distribution of occupations of economics majors and electrical engineering majors from the

2003 wave of the National Survey of College Graduates using 22 highly aggregated occupational groups. (We have chosen these two majors simply as an example of two majors that have rather different occupational distributions.) Economics majors appear in all of these broad occupational categories. However, they are highly concentrated in fields related to business, particularly sales and management, which together represent over 50 percent of all jobs held by economics graduates. Economics is also a relatively popular major for judges and lawyers, and (naturally) for economists. The occupational distribution of electrical engineering majors is much more concentrated, with more than half in the engineering field, although computer related occupations, managers and, sales/marketing also are fairly common. Clearly, the distributions are different, although there are areas of significant overlap. In order to characterize the job distributions of college graduates who hold a particular major, we use two indexes that are familiar to economists.

II.1. Distinctiveness

Our first index measures the degree to which the occupations of those in a particular major are segregated from the occupations of those holding other majors. We refer to this concept as "occupational distinctiveness," and we define this as

(1)
$$OD_j = \sum_{i=0}^{K} \left| s_{ij} - s_{i,not\ j} \right| ,$$

where s_{ij} is the fraction of those who have a major field j in occupation i, and $s_{i,\text{ not } j}$ is the fraction of those in all other majors who hold occupation i. This index is frequently used in economics and sociology to measure, for example, the level of occupational segregation between the sexes, or between different racial groups, as in Albeda (1986) or Ransom (1990). The index in those situations is called the dissimilarity index.

In order to make clear what we mean by distinctiveness, it is useful to refer to a graphic representation called the segregation curve. Figure 2 shows segregation curves for three different hypothetical majors, A, B, and C. In this example, there are also three possible occupations. The curve is piecewise linear, with a segment for each occupation. The slope of each segment is the ratio $s_{i,not\ j} / s_{i,j}$. The segments are ordered according to their slope, with those with lower ratio plotted first. The segments are connected so that a point on the curve shows the cumulative fraction of those not holding a major compared to the cumulative fraction holding the major. For example, the solid (green) curve shows that in its most distinctive occupation, 40 percent of those with major A are employed in the occupation, while only 4 percent of other majors are in the occupation. The slope of the first segment of curve A is thus, .04/.40 = 0.1. Restated slightly, those with major A are 10 times more likely than others to work in that occupation. The next segment of the curve is somewhat steeper, indicating that the fraction of those with major A holding that occupation is more similar to the fraction not holding A, while the last segment is very steep, indicating that those with major A are much less likely than other college graduates to be working in that occupation. Because of the segments of the curve are ordered by the slope of the segments, the curve will always be concave.

If the occupational distribution of a major exactly matched the occupational distribution of those not holding the major, then the segregation curve would be the diagonal line—no distinctiveness. If all those holding major A had a particular occupation, and none of those not holding major A had that occupation, then the segregation curve would be the bottom and right edges of the box—perfect distinctiveness.

Curves B and C demonstrate other hypothetical majors. Each line segment on these curves represents an occupation, but the ordering of the occupations is specific to the particular major. It is clear that major A is more occupationally distinctive than either B or C, since curve A is below curves B and C everywhere. However, it is not clear how to rank B and C, since the two curves intersect. B is more distinctive in its first occupation and C is more distinctive in its third occupation.

A numerical index implicitly makes certain value judgements in order to rank all possible distributions. In terms of the segregation curve, our distinctiveness index, OD, is the maximum distance between the curve and the diagonal line. (For major A in Figure 2, this is the length of the line segment xy.) Thus, OD summarizes the level of distinctiveness of a particular major by the maximum deviation of the segregation curve from "equality." One attractive feature of OD is that it can be interpreted as the minimum fraction of those holding a particular major that would have to change occupations in order to achieve the same occupational distribution as all other majors.

Hutchens (1991) and Hutchens (2004) suggest some essential properties for indexes of segregation, which are applicable in this situation.[1] These are:

D1. Scale invariance. An index is scale invariant if the index does not change when the number of people holding a major is changed without changing the proportions in each occupation.

D2. Symmetry: An index obeys symmetry if exchanging the two groups (in our case, switching those in major A with those not in major A) does not affect the index value.

[1] Hutchens (1991) discusses in detail these properties and their application to the dissimilarity index.

D3. Equilibrating transfers: Within a major, moving a person from an occupation where $s_{i,not\,j} / s_{i,j}$ is high to an occupation where $s_{i,not\,j} / s_{i,j}$ is low (or vice versa) will reduce measured distinctiveness.

D4. Proportional division: Splitting occupations groups into narrower occupations will not alter the index if the proportions in the groups of majors and non-majors is the same as it was in the original occupational groups.

Using the graphical definition presented in Figure 2, it is easy to prove that OD satisfies properties D1, D2, and D4, but not D3. Property D3 fails because the index is insensitive to some types of equilibrating transfers. In the example in Figure 2, transfers between occupations represented by the line segments to the left of point y will not affect OD since the cumulative shares of the two occupations groups do not change. The index will decrease (increase) only when individuals are moved from occupations on the left (right) of y to occupations on the right (left) of y. Another way to interpret this is that OD will change only by transfers from occupations where $s_{i,not\,j} / s_{i,j}$ is greater than 1 to occupations where it is less than 1, or vice versa.

While the insensitivity to equilibrating transfers is an undesirable property, the simple interpretation of the dissimilarity index has led to its almost universal adoption as a measure of segregation. That is, users have generally considered the simplicity of interpretation to outweigh the shortcomings of the index.

From the above discussion, and from the graphical representation of the index, the following properties are obvious:

1. The value of OD depends on the definition of majors and occupational groups which are inherently ad hoc, so care must be taken when comparing the index across time or

across different populations. If the definitions of majors or occupations differ, the indexes are not comparable.

2. If it is possible to rank distinctiveness by comparing segregation curves, OD will preserve this ranking (since OD is a maximum difference).
3. Changes in the size of a major do not affect the index. Thus, it is possible to compare changes over time even if a particular major increases or decreases in popularity.
4. Aggregation of occupational groups (say comparing a 2-digit versus 3-digit level of aggregation) will never increase the distinctiveness of a major and will almost always reduce it.
5. Broadening the definition of a major has an uncertain impact on the segregation index, depending on the occupational distributions within the majors that are combined. Generally, we would expect that measures of distinctiveness will fall when combining majors into more aggregated levels. However, because changing the definition of a major also changes the definition of who does not have that major, this intuition need not hold.

Furthermore, the index in this case is based upon a sample, and is thus, strictly speaking, a statistic. The sampling distribution of the index is discussed in Ransom (2000). He derives an estimator for the sampling variance, which we estimate and report for our samples.

II.2. Variety

Another related aspect of the occupational distribution is its variety. In other words, how widely distributed across the occupational distribution are graduates with particular majors? Variety is closely related to concentration. (In fact, for our proposed measure, variety is the inverse of concentration, so there is a one-to-one relationship between the concepts.) A popular measure of concentration is the Herfindahl index,

(2) $$H_j = \sum_{i=1}^{K} s_{ij}^2$$

where s_{ij} is the fraction of major j (say economics majors) who are in occupation i, and where K is the total number of occupational groups. While H is normally used to measure the concentration of firms in an industry, the index is useful in our context, although its interpretation is somewhat different. Suppose all economics majors chose the same occupation, then the value of the index would be 1. Suppose, on the other hand, that there were 10 possible occupations and economics majors were represented equally in each of them. Then the index would be:

$$H = \sum_{i=1}^{10} (1/10)_i^2 = 1/10.$$

The greater the number of occupations and the more equal the representation in each of the occupations, the lower will be the value of H. A more convenient way to interpret occupational variety is to use the inverse of H,

(3) $$OV = H^{-1} = \left[\sum_1^K s_{ij}^2\right]^{-1}.$$

We call this the index of occupational variety. If the distribution across occupations were equal for OV occupations (of N possible occupations), OV would be exactly the number of occupations in which economics majors would need to be represented in order to obtain an index value of H.[2] One might think of OV as the number of “effective” occupations held by individuals with a particular undergraduate major. Hannah and Kay (1977, p.55) suggest a general family of indexes for measuring industrial concentration. Our index, OV, is the Hannah-Kay index with $\alpha = 2$. In an application of the concept that we are attempting to measure, Blom, Cadena and Keys (2015) use the H as a measure of the occupational mobility afforded to those with a particular major. They treat this as a permanent characteristic of a major.

In order to discuss the properties of this index, it is helpful to refer to a graphical representation of the concept. Figure 3 shows the concentration curve for three hypothetical college majors, directly adapted from the concentration curve of Hannah and Kay (1977, p. 49). The curve for each major is piecewise linear, with each segment of the curve representing an occupation. The occupations are ordered from most to least popular within the major, so the first segment for major C need not represent the same occupation as in the first segment for major A. (In fact, the occupations represented on A need not match any of the occupations on C.) Curves that are higher and more to the left represent more concentrated majors.

For major A, the representation in each of five different occupations is almost identical. In this case, it would be natural to measure the occupational variety as simply counting the number of occupations held by those with major A. In contrast, for those with major C, almost all are concentrated in one occupation, with a small fraction spread across three other occupations. Counting the number of occupations in this case would clearly overstate the “variety” of occupations held by those with major C. OV measures variety by counting the

[2]In the context of measuring the diversity of species represented in an ecological community, OV is called “Simpson’s diversity index.” (See Magurran, 1988.)

number of "effective" occupations—the number of equally sized occupations that would yield the observed H value for that major.

Clearly, major A has more occupational variety than B or C. However, the ranking between B and C is uncertain, since these curves cross. A numerical index that provides a complete ranking will involve implicit value judgements when concentration curves cross. But there are some properties that are desirable for any such index. Hannah and Kay (1977, pp. 48-55) propose several reasonable and intuitive properties which we adapt slightly for this application:

V1. Dominance: If one concentration curve is everywhere above another concentration curve, the former represents a higher level of concentration (hence a lower level of occupational variety).

V2. Transfers: Moving a worker from a less popular occupation within a major to a more popular occupation represents an increase in concentration, decreasing variety.

V3. New occupations: Adding a new occupation to the distribution without changing the relative sizes of existing occupations will reduce concentration as long as the new occupation is not too large. (Additional occupations increase variety, if not too large.)

V4. Aggregation: Aggregating occupations leads to higher levels of concentration. (Merging occupational groups leads to lower variety.)

Hannah and Kay (1977) show that indexes of the type we propose obey V1-V4. Thus we can state the following about our index of occupational variety:

1. The value of OV depends on the definition of majors and occupational groups which are inherently ad hoc, so care must be taken when comparing the index across time or

across different populations. If the definitions of majors or occupations differ, the indexes are not comparable.

2. If it is possible to rank variety by comparing concentration curves, OV will preserve this ranking (by V1, above).
3. Changes in the size of a major do not affect the index. Thus, it is possible to compare changes over time even if a particular major increases or decreases in popularity (since the index is defined only on the shares in each occupation).
4. Aggregation of occupational groups (say using a 2-digit versus 3-digit level of aggregation) will decrease occupational variety (by V4).
5. Broadening the definition of a major has an uncertain impact on OV, depending on the occupational distributions within the majors that are combined. The insights from applications to industrial concentration do not apply because the occupations within different majors are treated like the same "firm." Thus, the effects of both V3 and V4 are manifested.   So combining two majors with very distinctive sets of occupations, say "accounting" and "nursing" will clearly lead to higher occupational variety in the combined major of "accounting and nursing" than was observed in either of the component majors. But it is possible to construct examples of occupational distributions where OV for the combined major does not increase (if they have identical occupational distributions) or, more commonly, where the result is somewhere between the value of the two.

As OV is based on sample information, it is also a statistic. The sampling distribution of this index has been studied by Phipps (2010), who derives an estimator for the variance for the statistic, which we calculate and report for our estimates.

In the following sections we apply these indexes to examine aspects of occupational distribution by major in the United States for the period from 1993 to about 2010. While we examine both distinctiveness and variety, we emphasize changes in variety.

III. Data

The primary data for this analysis comes from three waves of the National Survey of College Graduates (NSCG). The NSCG is conducted by the U.S. Census Bureau for the National Science Foundation as part of the NSF's efforts to track scientific manpower in the United States. We examine data from surveys conducted in 1993, 2003, and 2010.

The sample for the 1993 survey was drawn from individuals who responded to the long form in the 1990 Census, claimed to hold a baccalaureate (or higher) degree, and who were less than 72 years old as of April 1, 1990. The 2003 survey used a similar sampling framework, but based on the 2000 U.S. Census. In addition, it also drew some individuals from respondents to other National Science Foundation surveys. This sample represents individuals who were living in the United States on October 1, 2003, who held a baccalaureate degree or higher, and who were less than 76 years old. The 2010 survey drew part of its sample from the 2009 American Community Survey respondents who indicated that they had a bachelor's degree or higher. Part of the sample was also drawn from other National Science Foundation surveys. Technical documentation, questionnaires, and data for all three of these surveys are available through the Foundation's SESTAT Data Tool (National Science Foundation, no date).

Table 1 summarizes the demographic characteristics of the samples that we use in our analysis, which includes only individuals who are in the labor force and who reported an occupation. Age is slightly higher for the 2003 and 2010 samples than for the 1993 sample. The racial composition of college graduates changed significantly over this period—Hispanic graduates have increased from about 6 percent to about 10 percent of the population holding bachelor's degrees, while Asians have increased from about 10 percent to about 16 percent. Graduate education has also increased significantly—the fraction holding no advanced degree fell from 61 percent in 1993 to about 54 percent in 2010.

It is also important to note that labor market conditions differ across these surveys, particularly for the 2010 survey. Respondents in the 2010 NSCG report an unemployment rate of about 5 percent in 2010 compared to rates around 3.5 percent in the earlier waves. While the unemployment rate of college educated workers was much lower than for those without a college degree during the period following the 2007-2009 recession, Farber (2015) points out that college graduates experienced historically high rates of job loss in the recession leading up to 2010. This may have implications for the occupational distribution, although we are unable to examine this as a driver of the phenomena that we document in this paper.

The National Survey of College Graduates asks respondents to identify the job category that best describes the respondent's main job, or the most recent job if the respondent is not currently employed. Since the primary purpose of the survey is to analyze the scientific workforce and focuses on degree holders, the occupations tend to be more specific in some fields and less specific in others. Occupations with typically lower educational requirements are broadly grouped in categories such as "Construction trades, miners & well drillers" or "Operators and related occupations." Thus, the spectrum of occupations that are available is narrower than we would observe in the census or the American Community Survey, for example.

To compare the occupational distribution across time periods, it is necessary for us to harmonize the occupational categories used in the different waves of the survey. Our harmonized set includes 116 occupation groups. Appendix B explains how we grouped occupations in each survey for those small number of cases where it was necessary to combine occupation groups in order to maintain consistency over the entire study period. To the extent that the changes in definitions represent "new" occupations in later surveys, our approach will understate the true changes in occupational variety. However, almost all of these potentially new occupations are in the computer and information science fields, so any understatement is likely limited to a few majors with significant employment in computer related fields. The increased detail in the management related fields in the later surveys does not represent new occupations.

In the 1993 wave of the NSCG, the only choice for management occupations was "Top level manager," described in the survey as "Top level and mid-level managers, executives and administrators (people who manage other managers)." All other managers were instructed to "use the code that comes closest to the field you manage." Respondents could also choose "Other management related occupations." In the later surveys, a broad new related category was added: "Managers, other," described as "people who manage other managers." Within this group, a number of specific occupational groups were included, such as "Engineering Managers" and "Educational Administrators (e. g., registrar, dean, principal)," as well as "Other mid-level managers." We have grouped these "Managers, other" occupations with the "Top Level" management fields in our analyses. In this case, our harmonization appears to be imperfect, but we believe this will have little impact on our overall results, as the detailed analyses in Table 6 below suggests.

IV. Variety and Distinctiveness in the National Survey of College Graduates

Estimated values of the occupational variety index are reported in Table 2 for several selected large undergraduate majors. (These "popular" majors are among the 50 largest majors in each of the three years and constitute two thirds of all respondents in each of the three surveys.)

These indices provide numerical measures of the degree of occupational orientation of a particular major. For examples, "Nursing" has an occupational variety of less than 2. Engineering fields also have low occupational variety, in the range from about 3 to 5. Most of the undergraduate majors that we think of as vocationally or professionally oriented have relatively low values for OV, usually less than 5. At the other end of the spectrum, some liberal arts majors have rather large values--history and English have values of OV in the low 20s. Mathematics, political science and sociology have values of OV that are quite similar to that of economics—in the mid-teens. Geology and most of the life sciences appear to be much more "vocational" than mathematics or economics, at least in 1993.

Table 3 reports corresponding values of the occupational distinctiveness index.

Figure 4 shows the relationship between OV and OD for the 1993 NSCG data for the all majors.[3] The line represents a simple regression with OV as the independent variable, so circles above the line have higher than average distinctiveness for a given level of variety. The size of the circle reflects the sample size for that major. Obviously, the most distinctive major fields, like "Nursing" and "Pre-Med" also tend to have the lowest level of occupational variety, but the

[3] The estimated indexes for all 141 majors that we analyze are reported in Appendix Table A1 (variety) and Appendix Table A2 (distinctiveness).

relationship is not perfect. For example, “Accounting” and “Computer Science” both have low values of variety, but “Accounting” has a much lower distinctiveness. Accounting majors are concentrated in a few occupations, but those occupations are fairly common for individuals who hold other majors. “Computer Science” majors work in a small number of occupations where few other majors are found. “General Psychology” and “Anthropology & Archeology” have similar levels of distinctiveness but much different levels of variety. “Physics” and “General Psychology” have very similar levels of variety, but “Physics” is much more distinctive. Some small majors, like “Botany” and “Oceanography” are far above the regression line, but due to their small sample sizes, the position on the graph is subject to a lot of uncertainty.

Conceptually, OV could be low even if OD were high. For example, if everyone who received a degree in accounting worked as an accountant, then OV would have a value of 1 (very low). If graduates from other majors never became accountants, then OD would also be 1 (very high). On the other hand, if accounting were a common career for all other majors, the OD would be much lower. If accounting students took jobs in many different occupations, then OV would be high. If those occupations were limited to only those with accounting degrees, then OD would be very high, as well. In fact, the correlation between the two indices is very high (about -.78 for the 1993 NSCG sample). In this study we focus on changes in occupational variety.

V. The Increasing Occupational Variety by Major

For the same 32 majors reported in Tables 2, Figure 5 illustrates graphically the changes in occupational variety from 1993 to 2010. (The size of the circle representing each major is proportional to the average number of observations in the two waves of the sample. The line in the graph is the 45 degree line—values would fall on the line if variety had not changed between survey years.) Although occupational variety for some majors has fallen, most majors exhibit substantial increases in occupational diversity between 1993 and 2003. The congested grouping in the lower left of the figure appears to be associated with only small changes, but for these majors the changes are typically statistically significant and are proportionally quite large. Figure 6 displays the occupational variety for all majors, some of which have very small sample sizes in our data sets. In our analysis of all majors, the variety index increases for 77 percent of the majors between 1993 and 2010.

However, the above analysis ignores information in the 2003 wave of the survey, and, in fact, changes across survey waves are not entirely consistent. Figure 7 plots the change in occupational variety between the 2003 and 2010 survey years, against the change between the 1993 and 2003 waves. The points in the shaded area represent those 109 majors for which occupational variety increased between 1993 and 2010. The negative correlation between the inter-wave changes is apparent—majors which showed unusually large increases between 1993 and 2003 tend to have decreases between 2003 and 2010, and majors with decreases between the first two waves, tend to have increases between the latter two.

On the other hand, many of the changes are small, and many of the majors are represented in the sample by few individuals, so this graph fails to take into account the sampling variability of the index. Table 4 summarizes our statistical analysis of the changes between survey waves. For each major, we construct t-tests of whether the change between waves is positive or negative, under the assumption that the samples in each wave are independent. We report outcomes of 1-tailed tests, using a 5 percent significance level. We find that 63 (45 percent) showed a statistically significant increase in variety between 1993 and 2003, while 41

(29 percent) showed a statistically significant increase between 2003 and 2010. However, only 6 majors (4 percent) showed a statistically significant decline between the first two waves, and 20 (14 percent) showed a significant decline between the latter waves. Thus, changes over time are strongly suggestive of an increase in occupational variety over this entire period, although the changes appear to be concentrated in the 1990 and early 2000s.

For occupational variety, it is possible to also calculate a value for all college majors together. Table 5 reports this value for the three waves of the NSCG along with corresponding values from the 1990 and 2000 U.S. Census, calculated from the 5% Public Use Microsample data, along with the 2010 American Community Survey 3-year sample. In 1993, the occupational variety for all college majors, based on the NSCG sample and the NSCG occupational definitions, is about 33. In contrast, the value of OV for economics majors in 1993 is only about 16. Thus, economics majors show roughly half the occupational diversity that we observe among all college graduates. Liberal Arts/General Studies majors have the largest value of variety for 1993--about 28. History has a value of about 23, and English has a value of about 22. For comparison, the corresponding values for all college majors in the 1990 Census is about 35, while the value of OV for all job-holders, including those without a college degree, is approximately 77. For all majors together and for all workers, occupational variety has increased significantly since 1990 in the census samples as well as in the NSCG samples. But in the NSCG samples, there is a large drop in variety between 2003 and 2010.

It is important to keep in mind that those estimates based on the NSCG and those based on the census are not directly comparable, as the index value depends on the definition of occupational groups. We have not attempted to harmonize the occupational definitions between the NSCG and the census. Thus, the difference between the census and NSCG estimates reflects, in part, differences in the definitions of occupational categories—we observe over 300 occupations among census college graduates in 1990 versus 116 occupations among NSCG respondents in 1993. Also, changes in the "overall" measure for college graduates in Table 4 reflect two different sources of variety—variety within a particular major and variety in majors held. So, the falling overall index from 2003 to 2010 might be due to changing composition of college major, as well as changes in the distribution conditional on college major. However, the growth in occupational variety unconditional on major provides further evidence that occupations are changing in interesting ways over the period that we examine.

To study the question further, we have also examined data from the American Community Survey which began collecting information on undergraduate college major in 2009. Appendix Figure C1 shows the changes in occupational variety between 2009 and 2014 for the ACS data. Note that the ACS defines 170 fields, versus 141 in our analysis of the NSCG, and the sample sizes are typically much larger. There are no dramatic changes apparent, although there are slightly more major in which OV fell than increased. Using a 1-tailed test at the 5 percent significance level, we observe 40 (24 percent) majors with a statistically significant decline, compared to 31(18 percent) with a statistically significant increase.

The results from the ACS, along with the "all majors" results, certainly suggest that the dramatic increase in occupational variety in the 1990s has stopped, and may have slowed, or disappeared during the early 2000s.

VI. Why Has Variety Increased?

What has been happening in the labor market to bring about these changes in the occupational distribution of those who hold college degrees in specific fields? One approach to answering the question is simply mechanical. OV is the inverse of the Herfindahl Index (H), and H is computed by summing squares of the shares of each occupational group. So, the source of increase in OV can be identified by looking at the contribution of each occupation to the sum, since the difference in the sum can be expressed as the sum of the differences. In order for variety to increase, the distribution across occupations must have become somehow more even—occupations with higher shares must have fallen in popularity, and occupations with lower shares must have increased. In Table 6 we identify the "source" of the changes for three interesting cases from among the most popular majors: Biology, Sociology, and Elementary Teacher Education. These all show large increases in variety, either in absolute or relative terms.

For each major, we list six occupations that are particularly important in determining the H index (and thus the OV index) for that major. The first three are those that have the strongest effect in reducing H (increasing OV), and the last three have the strongest effect in increasing H (and thus decreasing OV). The far right hand column of the table shows the changes in OV and H. The change in H can simply be attributed to related changes in shares (*S*) of each occupation because the change in H can also be expressed as the sum of changes in the squares of the shares.

The top panel of Table 6 shows this analysis for biology. The change in H is -.055 (resulting in an increase in OV of 12.77). Between 1993 and 2010, the share of biology majors who worked as health care practitioners (what the NSCG calls "diagnosing and treating practitioners"—including physicians, dentists, optometrists) fell from about 28 percent to about 12 percent. The resulting difference in squares of shares is -.064. This is actually larger than the total change in H, so changes in other occupations mitigate the effect of the decline in the share working as health practitioners. Although we do not report the analysis here, an almost identical change occurred for those in the zoology major, and a similar change occurred for the biochemistry major. Thus, for three majors in the life sciences field, the dramatic change in occupational variety is mostly attributable to the dramatic decline in the number of majors who work in this single occupational area. Biology is much less of a "pre-med" or "pre-dental" major than it was twenty years previously.

The table also shows where the biggest increase in concentration has occurred—in this case, "other management," "secondary school teachers," and "biological scientists." However, these changes are all small relative to the change in the share of majors who work as health practitioners. This implies that the shift from health practitioners has been absorbed across a large number of different occupations.

A very similar pattern is visible in the case of sociology and elementary teacher education as well. In the case of sociology, the major decline occurs in the occupation of social worker. In the case of elementary teacher education, the decline is in elementary school teaching. In all three of the cases we examine in Table 6, the decline in the largest occupational group is more than enough to explain the overall change.

The above discussion is purely mechanical. It is likely that an individual analysis of changes in each major would provide insights into the particular aspects of the labor market that connects that college major with various occupations. However, it is unlikely that such an analysis would provide insights into the broader economic and social forces that have led to similar changes across a broad range of distinctive majors. It is unlikely that the forces affecting teacher education majors are the same forces that affect biochemistry majors.

We consider broadly two types of influences that might affect the occupational distribution. We refer to them as "push" and "pull." "Push" forces relate to an imbalance between higher education and the labor market and relate to the ideas of over-education and educational mismatch. If push forces dominate, fewer students are able to find jobs in the fields in which they are trained, so they seek jobs in other fields. This might be due to colleges and universities producing too many graduates for the jobs available in the economy. In the short run, changes in technology and tastes result in large reductions in the need for certain types of skills that may be associated with the college major. A recent example would be the sudden fall in petroleum prices, which has led to a dramatic reduction in drilling and petroleum exploration in the United States. Students who are now graduating with degrees in petroleum engineering are finding it very difficult to get jobs in the field. (Ailworth, 2015). Five years ago, all of these petroleum engineering graduates would be working in petroleum engineering occupations. Now they are forced to find jobs in other occupations. Thus, the occupational variety of petroleum engineering graduates has increased in this time period. Another example is how the expansion of the internet has disrupted the newspaper publishing industry. This has led to dramatic declines in the number of jobs available for newspaper reporters. Thus, many with journalism degrees who once worked as newspaper reporters have been forced out of their preferred field. This provides an explanation for the large change in occupational variety that we observe for journalism graduates, whose OV increased from 8 to about 17 between 1993 and 2010.

There is a large literature on "overeducation" and "occupational mismatch," although little of it touches directly on the connection between college major and education. Typical studies consider the educational requirements of a job. For example, Abel and Dietz (2015) link data from the O*Net database to identify jobs that "require" a college education. They find that a large fraction (almost 35 percent) of college graduates work in jobs that do not require a college degree. Other studies use surveys that ask respondents directly whether their job requires a college degree, such as Sicherman (1991). Robst (2007) actually addresses the question of whether an individual's work is related to their field of study. Most of these studies document the fact that: (1) Many college graduates apparently work in occupations that either do not require a college degree, or that use skills unrelated to the degree earned by an individual, and (2) Those who labor under such mismatch earn less money.

More generally, Beaudry, Green and Sand (2016) argue that the demand for cognitive skills has been decreasing since about 2000, and as a result, highly skilled workers have moved "down the occupational ladder" by taking jobs formerly held by less educated workers. Thus, their model would predict a broadening of the occupational distributions for many different college majors, which we do not observe.

Somewhat paradoxically, there is also a literature that suggests that there are too few college graduates with certain needed skills, epitomized in recent policies to increase the number of students studying the so-called STEM (science, technology, engineering, and math) fields. This idea is documented and reviewed critically in Capelli (2015).

On the other hand, some types of technical change may "pull" workers from one major into a field that was not previously associated with that major. Consider the dramatic changes in the financial industry--jobs that might once have been filled by economics or finance graduates might now be filled by physics or mathematics graduates. The growth of the biotechnology industry has changed the job options available to those with biology and biochemistry degrees and likely has changed the type of student who studies those fields. The dramatic changes in retail and advertising created new opportunities for majors in marketing or computer science. The effect of pull forces is to reduce the concentration of majors in the types of jobs that have traditionally been associated with the major and thus increase the occupational variety of those majors.

We do not have a way to test directly these alternative theories, although it seems likely that both push and pull forces are at work in the labor market. The period we have analyzed here clearly is a period of rapid technological change, so it is not too surprising that the relationship between college major and occupation has changed, too.

One thing we can examine is the self-reported match between an individual's work and their field of study. In each of the waves of the NSCG, employed respondents were asked the question: "To what extent was your work on your principle job . . . related to your highest degree?" Table 7 reports the responses to this question for holders of various degrees. Overall, the reported relatedness of degree and work actually increased slightly from 1993 to 2010, from about 80 percent to about 81 percent. The same pattern is observed for all types of highest degree, with the exception that those with professional degrees are slightly less likely to be closely related to their field of study. For those whose highest degree is a bachelor's degree, about 75 percent of employees do work that is at least somewhat related to the field of their degree, and almost half do work that is closely related to their degree. Thus, increasing occupational variety has not been associated with increasing mismatch between college degree and work tasks. This provides at least some support for the idea that increasing occupational variety is the result of graduates finding new occupational places in the labor market that take advantage of their field of study.

VII. Conclusions

In this paper we have suggested two indices to describe the occupational distribution for undergraduate major fields. Occupational distinctiveness, OD, measures the occupational segregation of individuals with a particular major. Occupational variety, OV, measures the dispersion of these individuals across occupations. Obviously, these measures are not independent, although we show that they are not deterministically linked.

We apply these indices to data from the National Survey of College Graduates. The most significant finding is that occupational variety increased substantially for most majors during the past two decades, although our analysis suggests that most of the change occurred in the 1990s or early 2000s.

We discuss some reasons why the changes in technology and tastes may influence the occupational distribution of those in a particular college major. On the one hand, these forces might make it difficult for graduates with particular majors to find work in the planned occupations, which would lead to greater mismatch between college major and occupation. On the other hand, changes may create new labor market niches for those with a particular major, pulling them away from occupations traditionally associated with that major.

We examine the question of education-occupation mismatch and find that workers in 2010 are just as likely as workers in 1993 to report that their work is at least somewhat related to the degree that they hold. Thus, the dramatic changes in occupational diversity do not appear to come at the expense of greater mismatch between field of study and job.

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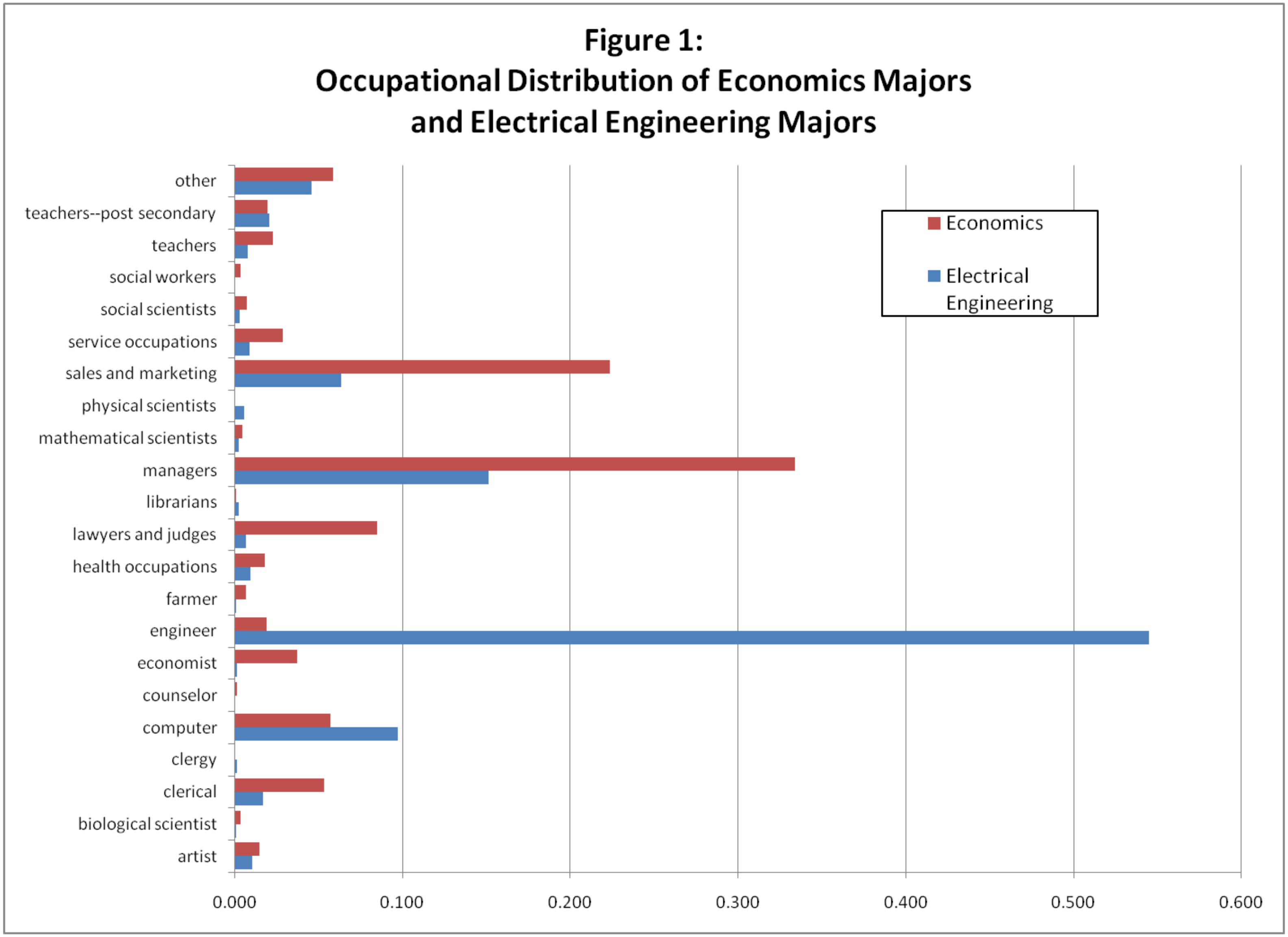
Figure 1:
Occupational Distribution of Economics Majors
and Electrical Engineering Majors
other
teachers--post secondary
teachers
social workers
social scientists
service occupations
sales and marketing
physical scientists
mathematical scientists
managers
librarians
lawyers and judges
health occupations
farmer
engineer
economist
counselor
computer
clergy
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Economics
Electrical Engineering

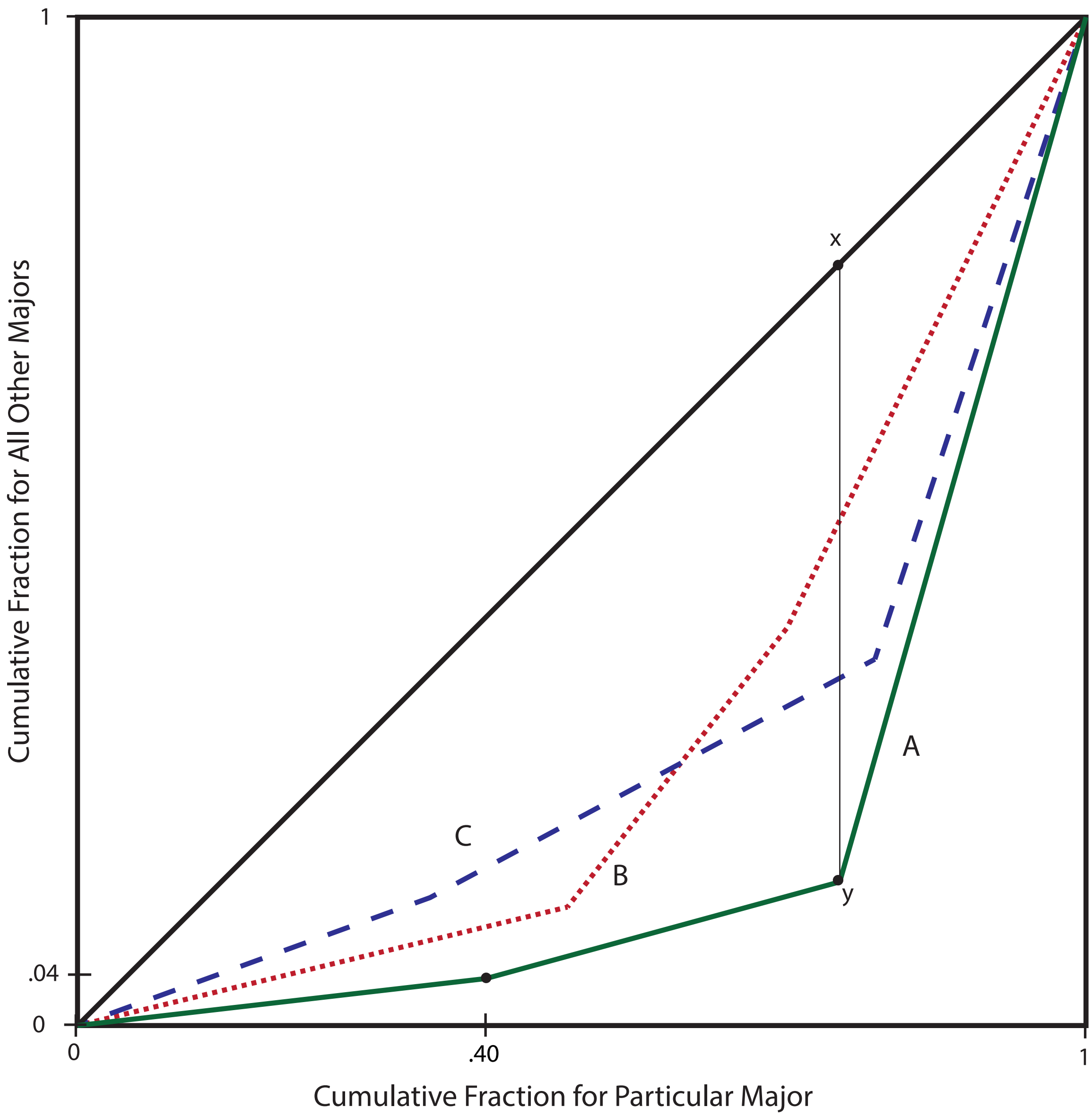

Figure 2: Segregation Curves for Three Hypothetical Majors

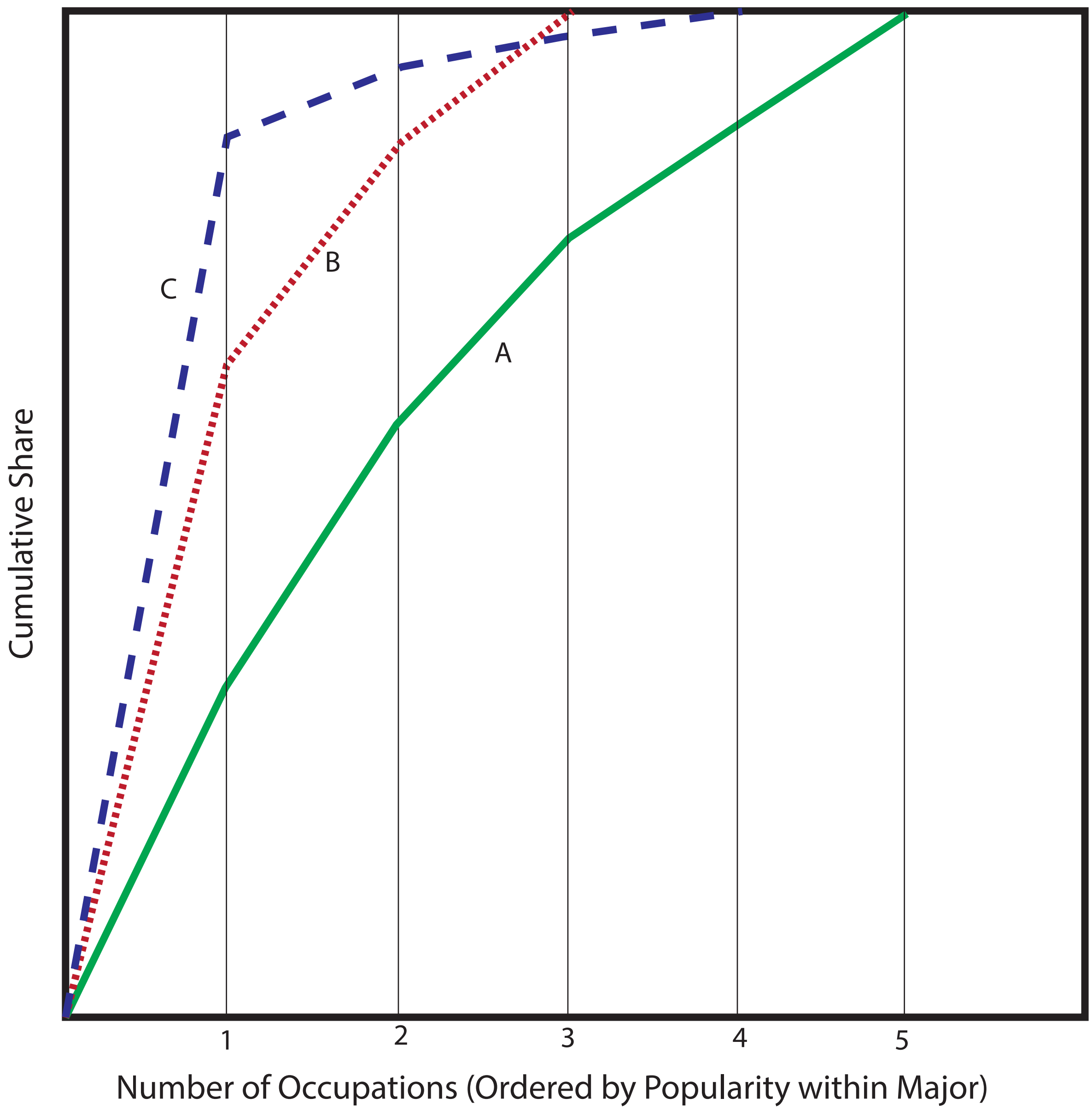

Figure 3: Concentration Curves for Three Hypothetical Majors

Figure 4: Occupational Variety and Distinctiveness, 1993

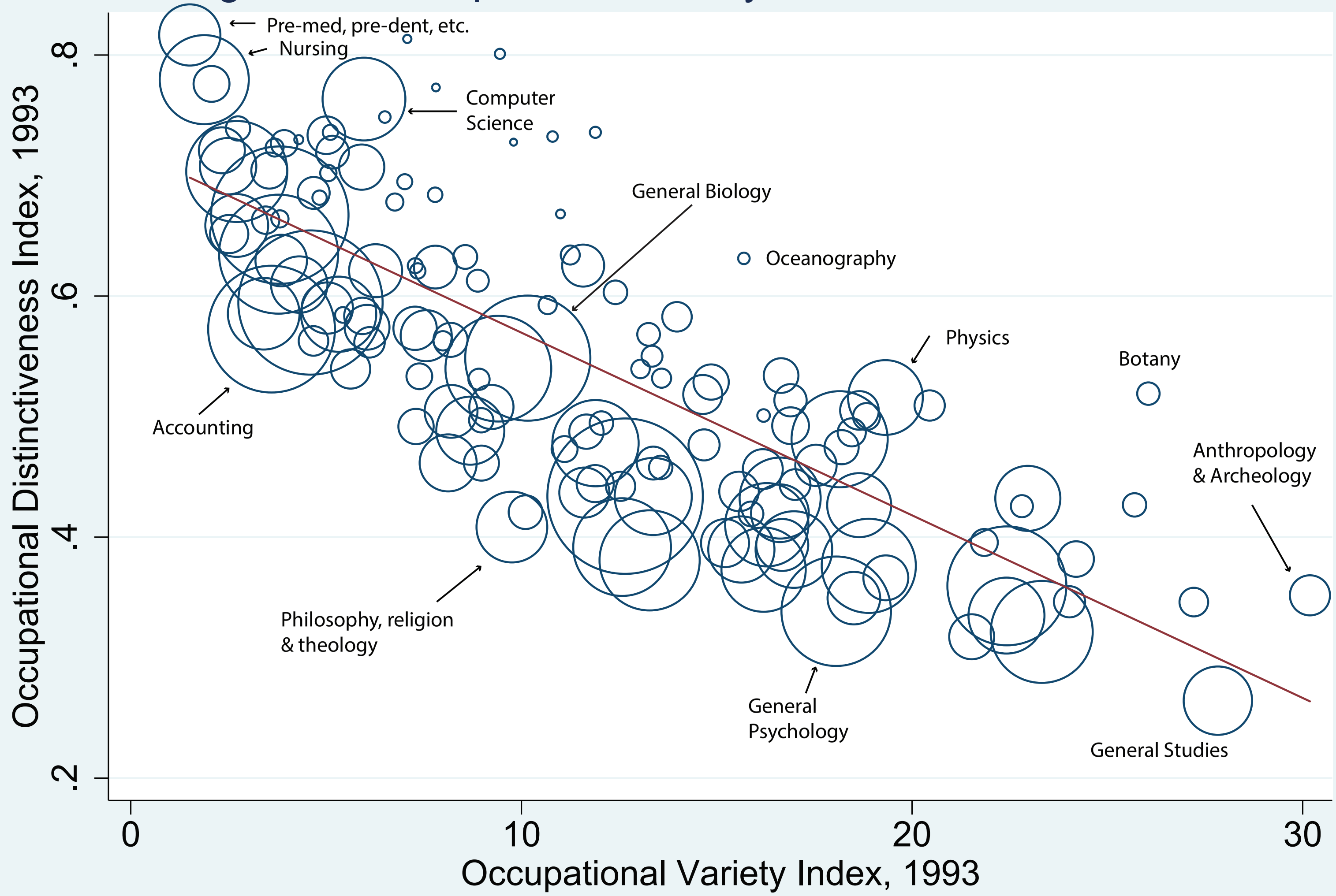

Figure 5: Changes in Occupational Variety for Popular Majors

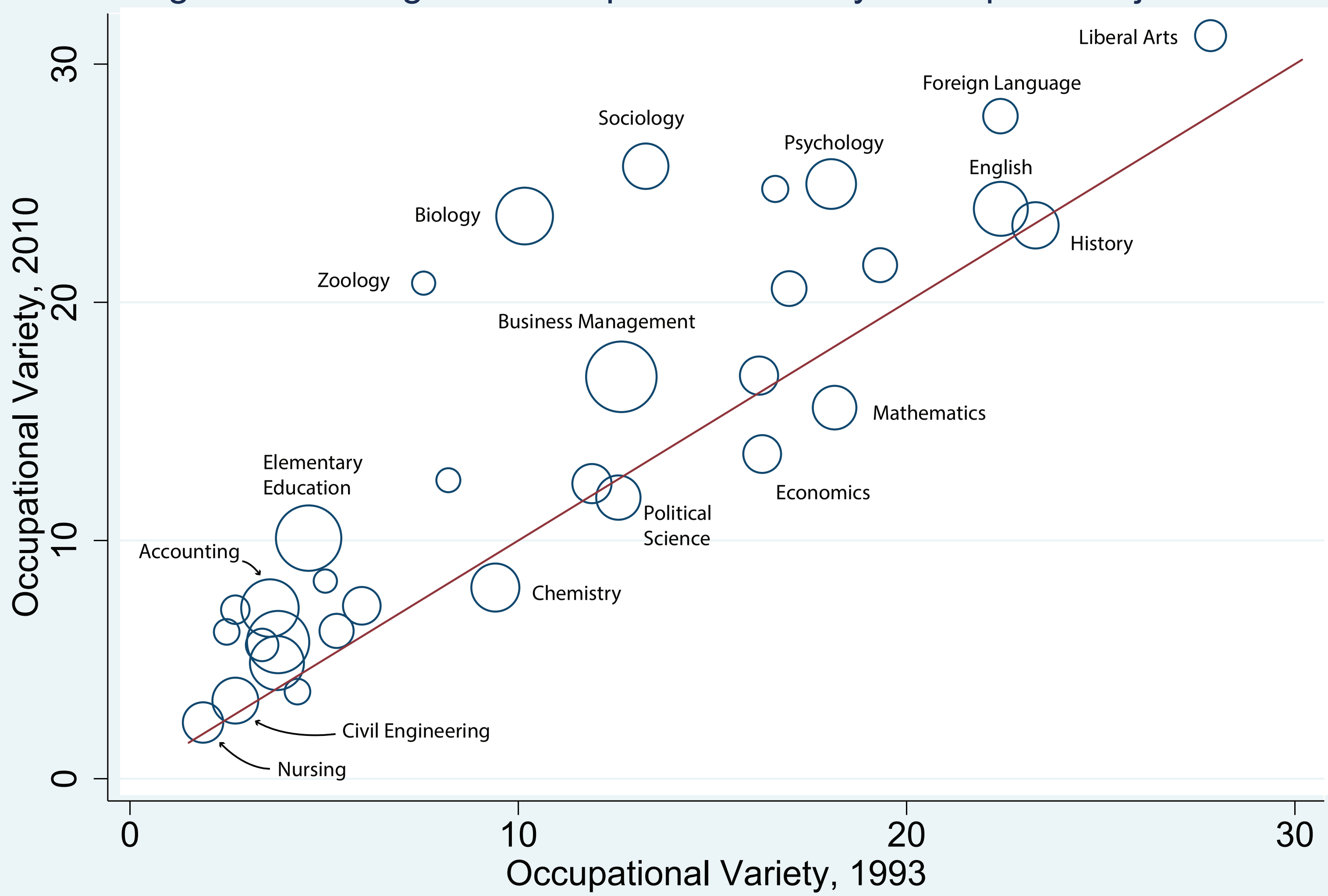

Figure 6: Changes in Occupational Variety for All Majors

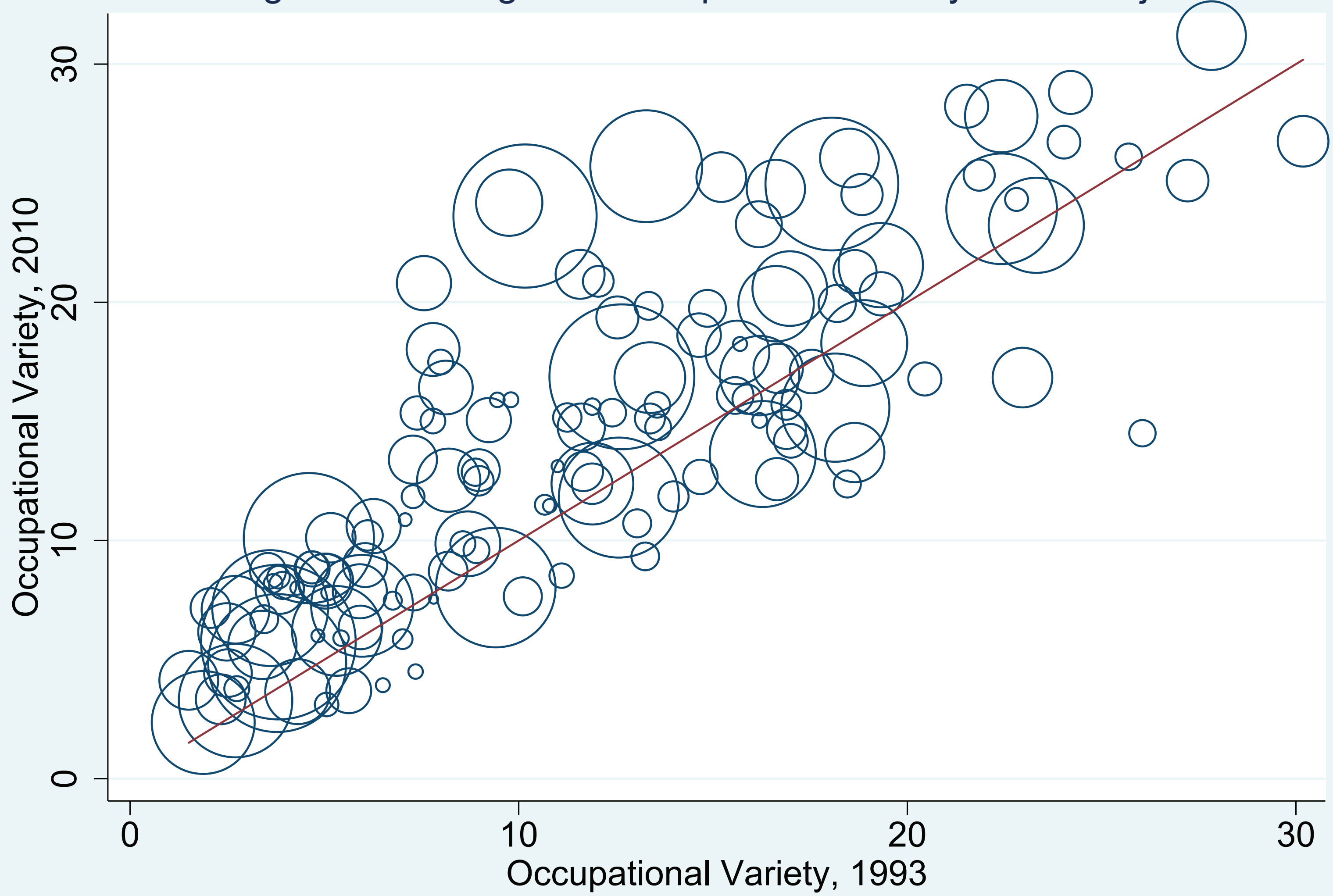

Figure 7: Changes in Occupational Variety Across Sample Years

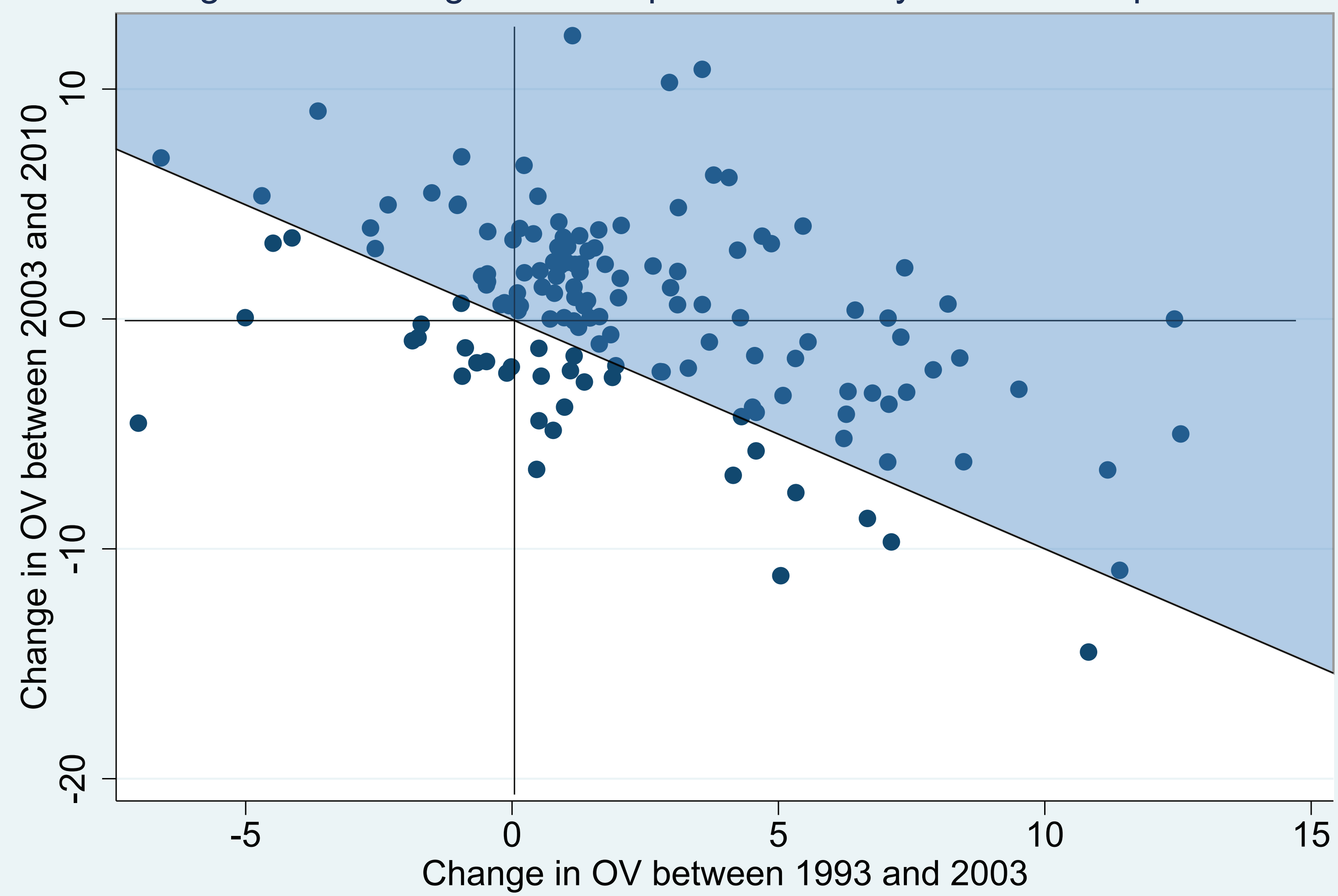

Table 1
Summary Demographic Statistics

	Sample Year					
	1993		2003		2010	
Variable	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Age	42.699	10.225	45.206	10.605	44.688	12.172
Female	0.393	0.488	0.412	0.492	0.424	0.494
Highest Degree:						
Bachelor	0.611	0.487	0.542	0.498	0.535	0.499
Masters	0.271	0.445	0.307	0.461	0.339	0.473
Doctorate	0.055	0.228	0.087	0.282	0.066	0.249
Professional	0.062	0.242	0.064	0.244	0.060	0.237
Race:						
Native American	0.009	0.094	0.005	0.072	0.008	0.091
Asian	0.097	0.296	0.119	0.323	0.161	0.367
Black	0.091	0.287	0.074	0.262	0.095	0.294
White	0.740	0.439	0.712	0.453	0.613	0.487
Ethnicity:						
Hispanic (all races)	0.063	0.243	0.070	0.256	0.102	0.302
Unemployed	0.032	0.175	0.037	0.188	0.050	0.218
Sample Size	123,837		83,350		63,553	

Table 2
Occupational Variety for Popular Majors

	1993		2003		2010	
Math and Sciences	OV	St Err	OV	St Err	OV	St Err
Computer science	5.97	0.14	5.40	0.16	7.26	0.27
Mathematics, general	18.15	0.50	17.49	0.60	15.58	0.65
Biology, general	10.16	0.35	11.30	0.46	23.62	0.68
Zoology, general	7.56	0.61	10.52	1.14	20.81	1.72
Chemistry, except biochemistry	9.41	0.33	10.77	0.51	8.03	0.39
Geology	4.31	0.28	6.20	0.58	3.66	0.24
Physics	19.32	0.91	19.55	0.94	21.56	1.28
Social Sciences						
Economics	16.28	0.69	20.43	0.80	13.63	0.45
Political science and government	12.58	0.47	13.08	0.66	11.80	0.46
General psychology	18.06	0.56	18.28	0.72	24.97	0.63
Sociology	13.28	0.53	25.72	1.28	25.71	0.91
Social Work	3.40	0.15	4.82	0.33	5.62	0.63
Engineering						
Aerospace & related engineering	5.03	0.34	5.81	0.55	8.30	0.86
Chemical engineering	5.32	0.26	6.57	0.41	6.21	0.32
Civil engineering	2.71	0.07	2.57	0.08	3.28	0.11
Electrical, electronics & related engineering	3.82	0.09	5.17	0.15	5.74	0.17
Industrial and manufacturing engineering	8.20	0.56	11.17	0.94	12.53	0.80
Mechanical engineering	3.79	0.10	4.94	0.17	4.86	0.16
Health Related						
Health/medical technologies	2.49	0.12	3.78	0.32	6.17	0.69
Nursing	1.88	0.05	2.00	0.06	2.36	0.08
Business						
Accounting	3.60	0.08	4.79	0.17	7.16	0.57
Business administration and management	12.65	0.30	20.06	0.44	16.87	0.94
Business, general	16.97	0.68	22.29	0.89	20.58	1.48
Business marketing/marketing management	11.90	0.37	14.68	0.62	12.39	1.02
Education						
Elementary teacher education	4.60	0.11	6.23	0.25	10.10	0.99
Secondary teacher education	16.20	0.77	16.35	1.12	16.92	1.76
Humanities & Other Fields						
English Language, literature and letters	22.43	0.56	21.97	0.71	23.93	1.85
Foreign languages and literature	22.42	0.99	18.77	1.15	27.82	2.37
Liberal Arts/General Studies	27.83	1.21	34.90	1.69	31.20	2.56
History	23.32	0.78	25.27	1.03	23.23	1.98
Architecture/Environmental Design	2.71	0.12	4.14	0.30	7.10	0.55
Communications, general	16.62	0.90	21.48	1.16	24.76	2.17

Table 3
Occupational Distinctiveness for Popular Majors

	1993		2003		2010	
Math and Sciences	OD	St Err	OD	St Err	OD	St Err
Computer science	0.763	0.008	0.693	0.008	0.577	0.010
Mathematics, general	0.481	0.010	0.485	0.011	0.455	0.011
Biology, general	0.549	0.007	0.550	0.008	0.423	0.009
Zoology, general	0.567	0.017	0.520	0.022	0.427	0.025
Chemistry, except biochemistry	0.540	0.008	0.531	0.010	0.511	0.010
Geology	0.610	0.016	0.598	0.020	0.620	0.018
Physics	0.516	0.011	0.509	0.012	0.416	0.014
Social Sciences						
Economics	0.410	0.008	0.408	0.010	0.466	0.008
Political science and government	0.392	0.008	0.433	0.010	0.457	0.007
General psychology	0.338	0.008	0.386	0.010	0.413	0.008
Sociology	0.381	0.008	0.368	0.012	0.412	0.009
Engineering						
Aerospace & related engineering	0.590	0.017	0.563	0.019	0.525	0.023
Chemical engineering	0.585	0.011	0.563	0.014	0.537	0.011
Civil engineering	0.703	0.007	0.716	0.008	0.682	0.009
Electrical & related engineering	0.667	0.006	0.624	0.007	0.589	0.006
Industrial and manufacturing engineering	0.504	0.015	0.469	0.016	0.466	0.015
Mechanical engineering	0.635	0.006	0.605	0.007	0.575	0.008
Health Related						
Health/medical technologies	0.708	0.014	0.656	0.020	0.579	0.024
Nursing	0.780	0.008	0.764	0.010	0.709	0.010
Business						
Accounting	0.573	0.006	0.536	0.008	0.478	0.016
Business administration and management	0.434	0.005	0.429	0.006	0.368	0.012
Business, general	0.390	0.008	0.391	0.011	0.371	0.018
Education						
Elementary teacher education	0.595	0.006	0.589	0.008	0.579	0.017
Secondary teacher education	0.373	0.011	0.427	0.013	0.496	0.024
Social Work	0.585	0.012	0.592	0.016	0.559	0.023
Business marketing/marketing management	0.478	0.008	0.487	0.011	0.432	0.018
Humanities & Other Fields						
English Language, literature and letters	0.360	0.008	0.405	0.010	0.426	0.019
Foreign languages and literature	0.335	0.012	0.407	0.015	0.398	0.024
Liberal Arts/General Studies	0.264	0.012	0.287	0.017	0.268	0.020
History	0.321	0.008	0.364	0.011	0.410	0.020
Communications, general	0.420	0.012	0.375	0.015	0.390	0.024
Architecture/Environmental Design	0.659	0.013	0.599	0.015	0.524	0.015

Table 4
Summary of Statistical Significance of Changes between Survey Waves

	Change 2003-2010			
Change, 1993-2003	Significant Decline	No Significant Change	Significant Increase	Total
Significant Decline	0	2	4	6
No Significant Change	5	47	20	72
Significant Increase	15	31	17	63
Total	20	80	41	141

Table 5

Occupational Variety Index Values
All Majors and All Workers

NSCG RESULTS		CENSUS RESULTS		
Year	All College Grads	Year	All Workers	All College Grads
1993	33.29	1990	76.59	36.63
2003	43.06	2000	89.31	46.51
2010	35.66	2010	83.70	45.42

Table 6
Effects of Influential Occupations for Selected Majors

Biology

	1993		2010		Difference
O_v	10.163		23.622		13.46
H	0.098		0.044		-0.055

Occupation	Share(S)	S^2	Share(S)	S^2	$S^2_{10} - S^2_{93}$
Health practitioners	0.278	0.077	0.115	0.013	-0.064
Health technologists & etc.	0.068	0.005	0.026	0.001	-0.004
Operators & related	0.018	0.000	0.004	0.000	-0.000
Biological scientists	0.045	0.002	0.061	0.004	0.002
Mid & Upper Management	0.070	0.005	0.084	0.007	0.002
Secondary school teachers	0.050	0.002	0.069	0.005	0.002

Sociology

	1993		2010		Difference
O_v	13.282		25.714		12.432
H	0.075		0.039		-0.036

Occupation	Share(S)	S^2	Share(S)	S^2	$S^2_{10} - S^2_{93}$
Social worker	0.210	0.044	0.073	0.005	-0.039
Mid & Upper Management	0.132	0.017	0.106	0.011	-0.006
”Other” occupation	0.038	0.001	0.016	0.000	-0.001
Judges & Lawyers	0.026	0.001	0.042	0.002	0.001
Other Management	0.045	0.002	0.061	0004	0.002
“Other” Service Occupation	0.021	0.000	0.051	0.003	0.002

Elementary Teacher Education

	1993		2010		Difference
O_v	4.600		10.101		5.501
H	0.217		0.099		-0.117

Occupation	Share(S)	S^2	Share(S)	S^2	$S^2_{10} - S^2_{93}$
Elementary school teacher	0.446	0.199	0.279	0.078	-0.122
Pre-Kindergarten teacher	0.072	0.005	0.046	0.002	-0.003
Mid & Upper Management	0.073	0.005	0.011	0.000	-0.003
Counselors	0.009	0.000	0.031	0.001	0.001
Post-Secondary Teacher (Education Field)	0.007	0.000	0.046	0.002	0.002
Other Teachers (Pre college)	0.010	0.000	0.053	0.003	0.003

Table 7
Proportion of Respondents whose Current Job is
Related to Field of Highest Degree
(Currently Employed Only)

	1993	2010
All Types of Highest Degree	N=123,873	N=63,553
Closely Related	0.558	0.581
Somewhat Related	0.241	0.230
Closely or Somewhat Related	0.799	0.811
Highest Degree Bachelors	N=75,719	N=33,986
Closely Related	0.462	0.476
Somewhat Related	0.280	0.270
Closely or Somewhat Related	0.742	0.746
Highest Degree: Masters	N=33,605	N=21,552
Closely Related	0.648	0.653
Somewhat Related	0.220	0.216
Closely or Somewhat Related	0.868	0.869
Highest Degree: Doctorate	N=6,788	N=4,203
Closely Related	0.788	0.802
Somewhat Related	0.139	0.134
Closely or Somewhat Related	0.927	0.936
Highest Degree: Professional	N=7,725	N=3,812
Closely Related	0.901	0.863
Somewhat Related	0.048	0.062
Closely or Somewhat Related	0.948	0.925

Appendix Table A1
Occupational Variety by College Major

	1993		2003		2010	
Mathematics and Sciences	OV	St Err	OV	St Err	OV	St Err
Computer and information sciences	5.91	0.28	6.48	0.37	7.87	0.65
Computer science	5.97	0.14	5.40	0.16	7.26	0.27
Computer systems analysis	3.93	0.41	4.97	0.70	8.12	1.28
Information services and systems	5.17	0.30	7.81	0.46	10.12	0.67
Other computer and information sciences	7.28	1.04	12.84	1.77	11.84	2.07
Applied mathematics	18.65	1.42	16.33	1.22	21.29	1.86
Mathematics, general	18.15	0.50	17.49	0.60	15.58	0.65
Operations research	10.67	1.63	17.72	2.78	11.50	2.32
Statistics	13.26	1.93	13.76	1.45	9.33	1.38
Other mathematics	16.89	1.51	12.40	2.77	15.70	2.79
Animal sciences	16.18	1.43	23.24	2.50	23.28	1.85
Food sciences and technology	8.91	1.52	13.43	3.01	9.59	1.50
Plant sciences	16.65	1.76	17.42	2.59	12.58	1.38
Other agricultural sciences	20.45	2.48	31.27	4.02	16.78	2.68
Biochemistry and biophysics	7.80	0.70	11.87	0.95	18.02	1.23
Biology, general	10.16	0.35	11.30	0.46	23.62	0.68
Botany	26.05	3.05	19.04	3.09	14.51	2.54
Cell and molecular biology	11.25	1.83	10.22	1.52	15.17	1.31
Ecology	13.05	2.89	12.57	2.43	10.72	1.66
Genetics, animal and plant	11.89	2.28	15.00	2.37	15.62	2.63
Microbiological sciences and immunology	11.58	0.83	18.95	1.27	21.18	1.37
Nutritional sciences	4.68	0.52	8.25	1.74	8.88	1.66
Pharmacology, human and animal	10.80	2.63	6.10	1.84	11.46	1.82
Physiology and pathology, human and animal	7.99	1.59	13.45	2.49	17.49	2.23
Zoology, general	7.56	0.61	10.52	1.14	20.81	1.72
Other biological sciences	14.64	1.50	13.63	1.69	18.62	1.70
Environmental science or studies	18.83	2.43	26.74	2.89	24.53	1.95
Forestry sciences	8.19	0.87	8.13	1.15	8.71	1.01
Chemistry, except biochemistry	9.41	0.33	10.77	0.51	8.03	0.39
Atmospheric sciences and meteorology	5.06	1.12	5.61	1.23	3.12	0.44
Earth sciences	13.59	3.42	16.90	2.58	14.76	2.42
Geology	4.31	0.28	6.20	0.58	3.66	0.24
Other Geological sciences,	7.01	1.80	8.11	2.24	5.86	1.34
Oceanography	15.70	3.47	16.86	4.74	18.25	3.12
Astronomy and astrophysics	9.45	2.34	18.96	3.05	15.91	3.27
Physics	19.32	0.91	19.55	0.94	21.56	1.28
Other physical sciences	24.03	3.03	24.86	3.85	26.72	3.67

Social Sciences						
Agricultural economics	17.00	1.97	15.13	1.83	14.19	1.69
Economics	16.28	0.69	20.43	0.80	13.63	0.45
Public policy studies	9.80	1.81	8.85	2.03	15.91	2.87
International relations	12.54	1.58	18.98	2.27	19.36	1.37
Political science and government	12.58	0.47	13.08	0.66	11.80	0.46
Educational psychology	15.88	1.98	20.18	2.56	15.94	1.83
Clinical psychology	8.98	0.89	7.47	0.81	12.96	1.30
Counseling psychology	11.66	1.00	11.76	1.34	12.90	1.34
Experimental psychology	21.85	2.35	22.88	2.68	25.34	3.27
General psychology	18.06	0.56	18.28	0.72	24.97	0.63
Industrial/Organizational psychology	13.57	2.12	19.84	3.07	15.70	2.46
Social psychology	12.05	1.73	20.23	2.77	20.88	2.20
Other psychology	15.21	1.02	19.00	1.95	25.26	2.18
Anthropology and archaeology	30.18	2.33	29.25	2.66	26.76	2.10
Criminology	8.97	1.17	15.74	2.61	12.51	1.54
Sociology	13.28	0.53	25.72	1.28	25.71	0.91
Area and Ethnic Studies	27.21	2.58	27.20	3.14	25.11	1.82
Linguistics	25.70	3.00	19.11	3.02	26.11	2.96
Philosophy of science	22.81	2.73	24.27	3.21	24.32	4.42
Geography	24.20	2.49	35.38	2.78	28.81	2.88
History of science	16.20	2.67	20.78	3.45	15.04	3.43
Social Work	3.40	0.15	4.82	0.33	5.62	0.63
Other social sciences	18.51	1.24	31.06	2.17	26.06	1.74
Engineering						
Aerospace & related engineering	5.03	0.34	5.81	0.55	8.30	0.86
Chemical engineering	5.32	0.26	6.57	0.41	6.21	0.32
Architectural engineering	3.55	0.28	6.66	0.85	8.72	1.12
Civil engineering	2.71	0.07	2.57	0.08	3.28	0.11
Computer and systems engineering	5.01	0.42	4.55	0.30	8.35	0.50
Electrical & related engineering	3.82	0.09	5.17	0.15	5.74	0.17
Industrial and manufacturing engineering	8.20	0.56	11.17	0.94	12.53	0.80
Mechanical engineering	3.79	0.10	4.94	0.17	4.86	0.16
Agricultural engineering	12.41	1.58	16.96	2.50	15.37	2.13
Bioengineering and biomedical engineering	7.79	1.47	12.03	2.03	15.02	1.99
Engineering sciences, mechanics and physics	14.86	1.29	16.13	1.87	19.75	2.53
Environmental engineering	3.82	0.71	5.37	0.88	8.46	1.24
Engineering, general	14.68	1.60	21.35	2.38	12.67	1.92
Geophysical and geological engineering	7.08	1.84	9.11	1.72	10.88	2.04
Materials engineering (inc. ceramics & textiles)	8.88	1.34	9.74	1.69	12.87	2.06
Metallurgical engineering	3.45	0.40	4.36	0.70	6.70	1.27
Mining and minerals engineering	6.76	1.21	7.48	1.52	7.48	2.05

Naval architecture and marine engineering	8.56	1.05	5.91	1.23	9.87	1.91
Nuclear engineering	3.68	0.65	4.65	1.01	8.20	2.38
Petroleum engineering	2.75	0.32	3.72	0.66	3.78	0.65
Other engineering	16.89	1.58	22.22	2.49	14.66	2.07
Health Related Majors						
Audiology and speech pathology	5.93	0.51	5.72	0.70	6.35	0.62
Health services administration	7.39	0.82	10.51	0.88	15.36	1.41
Health/medical assistants	6.50	1.23	4.74	1.51	3.93	1.07
Health/medical technologies	2.49	0.12	3.78	0.32	6.17	0.69
Medical preparatory programs [e.g. pre-dentistry,-me...	1.51	0.04	2.04	0.12	4.13	0.47
Medicine	2.07	0.14	2.95	0.24	7.17	0.87
Nursing [4 years or longer program]	1.88	0.05	2.00	0.06	2.36	0.08
Pharmacy	2.33	0.13	1.85	0.09	3.33	0.30
Physical therapy and rehabilitation	2.52	0.18	3.31	0.30	4.44	0.38
Public health	13.34	1.99	20.64	3.32	19.85	2.69
Other health/medical sciences	7.28	0.58	9.33	0.83	13.40	1.39
Technology						
Computer programming	4.68	0.43	6.43	0.51	8.81	1.17
Data processing	5.11	0.84	8.81	1.20	7.81	2.17
Electrical and electronic technologies	6.27	0.44	10.55	1.13	10.61	0.96
Industrial production technologies	17.54	1.36	18.71	1.83	17.10	2.05
Mechanical engineering-related technologies	6.05	0.51	8.05	1.33	8.97	1.41
Other engineering-related technologies	18.20	1.95	23.28	2.12	19.95	2.92
Architecture/Environmental Design	2.71	0.12	4.14	0.30	7.10	0.55
Business						
Actuarial science	4.30	1.38	5.23	1.72	8.01	1.84
Other agricultural business and production	18.46	1.93	18.92	2.51	12.37	2.29
Accounting	3.60	0.08	4.79	0.17	7.16	0.57
Business administration and management	12.65	0.30	20.06	0.44	16.87	0.94
Business, general	16.97	0.68	22.29	0.89	20.58	1.48
Business and managerial economics	11.61	0.83	17.92	1.47	14.76	1.75
Business marketing/marketing management	11.90	0.37	14.68	0.62	12.39	1.02
Marketing research	13.38	1.14	15.02	1.88	15.12	3.25
Financial management	8.69	0.38	10.54	0.63	9.86	1.20
Other business management/administrative	15.63	0.85	24.11	1.01	17.90	1.70
Education						
Education administration	5.43	1.30	16.84	2.74	5.90	2.19
Counselor education and guidance services	7.35	1.61	8.33	2.50	4.50	1.15
Elementary teacher education	4.60	0.11	6.23	0.25	10.10	0.99
Physical education and coaching	13.37	0.61	13.39	0.99	16.84	2.36
Pre-school/early childhood education	6.11	0.69	6.51	0.68	10.22	1.67
Secondary teacher education	16.20	0.77	16.35	1.12	16.92	1.76

Computer teacher education	7.81	1.91	6.86	1.26	7.54	1.61
Mathematics teacher education	5.63	0.55	3.92	0.38	3.69	0.35
Science teacher education	10.11	1.26	10.01	1.54	7.66	1.14
Social science teacher education	11.89	1.06	9.32	1.15	12.38	1.41
Special education	3.85	0.24	4.00	0.33	7.93	1.36
Other education	18.89	0.68	14.76	0.79	18.29	1.97
Arts & Humanities						
Other philosophy, religion, theology	9.76	0.60	13.33	1.06	24.18	2.80
English Language, literature and letters	22.43	0.56	21.97	0.71	23.93	1.85
Other foreign languages and literature	22.42	0.99	18.77	1.15	27.82	2.37
Liberal Arts/General Studies	27.83	1.21	34.90	1.69	31.20	2.56
History, other	23.32	0.78	25.27	1.03	23.23	1.98
Dramatic arts	15.57	1.49	18.39	1.95	16.09	3.11
Fine arts, all fields	16.62	0.86	17.90	1.13	19.94	2.04
Music, all fields	18.65	0.80	13.64	0.85	13.69	2.29
Other visual and performing arts	9.23	0.88	9.72	0.99	15.06	2.17
Other Majors						
Communications, general	16.62	0.90	21.48	1.16	24.76	2.17
Journalism	8.13	0.53	12.82	1.20	16.42	2.47
Other communications	16.68	1.04	18.31	1.46	17.23	2.22
Other natural resources and conservation	13.98	1.40	13.11	1.84	11.85	2.01
Home Economics	22.96	0.92	28.01	1.79	16.84	2.39
Law/Prelaw/Legal Studies	7.30	0.79	11.88	1.76	7.82	1.29
Library Science	4.83	1.20	4.37	1.38	6.00	0.00
Parks, Recreation, Leisure, and Fitness Studies	19.33	1.37	25.56	2.18	20.36	3.01
Public administration	11.11	1.46	18.23	2.42	8.53	2.06
Other public affairs	11.00	1.73	12.18	2.67	13.12	3.26
Other FIELDS	21.53	1.67	29.93	2.66	28.23	3.91

Appendix Table A2
Occupational Distinctiveness by College Major

	1993		2003		2010	
Mathematics and Sciences	OD	St Err	OD	St Err	OD	St Err
Computer and information sciences	0.707	0.017	0.656	0.018	0.520	0.018
Computer science	0.763	0.008	0.693	0.008	0.577	0.010
Computer systems analysis	0.727	0.027	0.727	0.030	0.609	0.034
Information services and systems	0.719	0.021	0.612	0.017	0.501	0.014
Other computer and information sciences	0.625	0.042	0.505	0.030	0.511	0.033
Applied mathematics	0.505	0.023	0.506	0.020	0.419	0.028
Mathematics, general	0.481	0.010	0.485	0.011	0.455	0.011
Operations research	0.593	0.039	0.561	0.029	0.587	0.039
Statistics	0.568	0.037	0.615	0.032	0.571	0.031
Other mathematics	0.514	0.027	0.579	0.043	0.598	0.047
Animal sciences	0.456	0.021	0.474	0.027	0.469	0.022
Food sciences and technology	0.531	0.029	0.565	0.041	0.511	0.028
Plant sciences	0.534	0.025	0.571	0.028	0.542	0.025
Other agricultural sciences	0.509	0.027	0.489	0.038	0.540	0.028
Biochemistry and biophysics	0.624	0.019	0.606	0.020	0.481	0.020
Biology, general	0.549	0.007	0.550	0.008	0.423	0.009
Botany	0.519	0.036	0.517	0.041	0.581	0.038
Cell and molecular biology	0.634	0.037	0.656	0.032	0.612	0.029
Ecology	0.540	0.039	0.553	0.037	0.572	0.031
Genetics, animal and plant	0.736	0.054	0.679	0.039	0.564	0.045
Microbiological sciences and immunology	0.625	0.019	0.545	0.022	0.492	0.023
Nutritional sciences	0.563	0.024	0.537	0.040	0.528	0.032
Pharmacology, human and animal	0.732	0.044	0.689	0.053	0.637	0.036
Physiology and pathology, human and animal	0.563	0.044	0.511	0.040	0.481	0.040
Zoology, general	0.567	0.017	0.520	0.022	0.427	0.025
Other biological sciences	0.518	0.021	0.572	0.025	0.510	0.027
Environmental science or studies	0.500	0.032	0.497	0.030	0.467	0.022
Forestry sciences	0.564	0.022	0.634	0.028	0.545	0.029
Chemistry, except biochemistry	0.540	0.008	0.531	0.010	0.511	0.010
Atmospheric sciences and meteorology	0.702	0.037	0.680	0.036	0.691	0.032
Earth sciences	0.532	0.044	0.618	0.024	0.513	0.029
Geology	0.610	0.016	0.598	0.020	0.620	0.018
Other Geological sciences,	0.695	0.041	0.729	0.039	0.691	0.042
Oceanography	0.631	0.044	0.613	0.060	0.652	0.056
Astronomy and astrophysics	0.801	0.034	0.676	0.058	0.583	0.044
Physics	0.516	0.011	0.509	0.012	0.416	0.014
Other physical sciences	0.346	0.029	0.386	0.039	0.352	0.038

Social Sciences						
Agricultural economics	0.444	0.023	0.559	0.027	0.568	0.024
Economics	0.410	0.008	0.408	0.010	0.466	0.008
Public policy studies	0.728	0.001	0.668	0.042	0.617	0.038
International relations	0.442	0.024	0.437	0.024	0.463	0.020
Political science and government	0.392	0.008	0.433	0.010	0.457	0.007
Educational psychology	0.419	0.031	0.496	0.035	0.550	0.036
Clinical psychology	0.461	0.025	0.531	0.024	0.459	0.027
Counseling psychology	0.488	0.025	0.506	0.029	0.517	0.022
Experimental psychology	0.396	0.025	0.444	0.031	0.395	0.032
General psychology	0.338	0.008	0.386	0.010	0.413	0.008
Industrial/Organizational psychology	0.458	0.027	0.502	0.041	0.492	0.031
Social psychology	0.495	0.026	0.448	0.036	0.419	0.025
Other psychology	0.395	0.017	0.437	0.028	0.410	0.027
Anthropology and archaeology	0.352	0.023	0.372	0.024	0.422	0.020
Criminology	0.497	0.032	0.521	0.039	0.542	0.029
Sociology	0.381	0.008	0.368	0.012	0.412	0.009
Area and Ethnic Studies	0.346	0.027	0.393	0.027	0.463	0.019
Linguistics	0.427	0.036	0.544	0.039	0.509	0.039
Philosophy of science	0.426	0.038	0.479	0.039	0.463	0.016
Geography	0.382	0.020	0.371	0.027	0.355	0.022
History of science	0.501	0.022	0.486	0.042	0.612	0.059
Other social sciences	0.349	0.014	0.387	0.023	0.430	0.017
Engineering						
Aerospace & related engineering	0.590	0.017	0.563	0.019	0.525	0.023
Chemical engineering	0.585	0.011	0.563	0.014	0.537	0.011
Architectural engineering	0.704	0.022	0.669	0.028	0.604	0.024
Civil engineering	0.703	0.007	0.716	0.008	0.682	0.009
Computer and systems engineering	0.733	0.017	0.683	0.014	0.550	0.016
Electrical & related engineering	0.667	0.006	0.624	0.007	0.589	0.006
Industrial and manufacturing engineering	0.504	0.015	0.469	0.016	0.466	0.015
Mechanical engineering	0.635	0.006	0.605	0.007	0.575	0.008
Agricultural engineering	0.603	0.035	0.581	0.033	0.523	0.032
Bioengineering and biomedical engineering	0.684	0.046	0.630	0.039	0.513	0.034
Engineering sciences, mechanics and physics	0.529	0.019	0.537	0.030	0.427	0.026
Environmental engineering	0.664	0.041	0.661	0.033	0.597	0.030
Engineering, general	0.477	0.023	0.474	0.027	0.464	0.029
Geophysical and geological engineering	0.813	0.070	0.789	0.039	0.717	0.031
Materials engineering (inc. ceramics & textiles)	0.613	0.027	0.571	0.032	0.517	0.029
Metallurgical engineering	0.663	0.029	0.656	0.027	0.600	0.035
Mining and minerals engineering	0.678	0.032	0.698	0.039	0.651	0.042
Naval architecture and marine engineering	0.632	0.023	0.613	0.042	0.600	0.033
Nuclear engineering	0.723	0.036	0.707	0.043	0.631	0.041
Petroleum engineering	0.739	0.029	0.659	0.040	0.669	0.038

Other engineering	0.492	0.021	0.476	0.030	0.430	0.031
Health Related Majors						
Audiology and speech pathology	0.584	0.023	0.571	0.026	0.643	0.021
Health services administration	0.533	0.031	0.573	0.026	0.444	0.020
Health/medical assistants	0.749	0.050	0.858	0.001	0.692	0.052
Health/medical technologies	0.708	0.014	0.656	0.020	0.579	0.024
Medical preparatory programs (pre-med, etc.)	0.817	0.010	0.741	0.018	0.604	0.028
Medicine	0.776	0.017	0.759	0.019	0.661	0.027
Nursing	0.780	0.008	0.764	0.010	0.709	0.010
Pharmacy	0.721	0.015	0.759	0.015	0.597	0.024
Physical therapy and other rehabilitation	0.651	0.021	0.635	0.024	0.566	0.021
Public health incl. epidemiology	0.550	0.035	0.428	0.036	0.436	0.034
Other health/medical sciences	0.573	0.020	0.562	0.023	0.508	0.023
Technology						
Computer programming	0.686	0.022	0.701	0.023	0.608	0.030
Data processing	0.736	0.038	0.651	0.028	0.696	0.002
Electrical and electronic technologies	0.621	0.014	0.589	0.022	0.545	0.025
Industrial production technologies	0.460	0.018	0.476	0.025	0.442	0.025
Mechanical engineering-related technologies	0.574	0.017	0.546	0.030	0.575	0.029
Other engineering-related technologies	0.475	0.023	0.456	0.024	0.411	0.024
Architecture/Environmental Design	0.659	0.013	0.599	0.015	0.524	0.015
Business						
Actuarial science	0.730	0.059	0.681	0.068	0.642	0.038
Other agricultural business and production	0.487	0.030	0.506	0.028	0.644	0.049
Accounting	0.573	0.006	0.536	0.008	0.478	0.016
Business administration and management	0.434	0.005	0.429	0.006	0.368	0.012
Business, general	0.390	0.008	0.391	0.011	0.371	0.018
Business and managerial economics	0.437	0.012	0.429	0.018	0.493	0.020
Financial management	0.488	0.010	0.460	0.012	0.443	0.022
Other business management/administration	0.390	0.010	0.402	0.013	0.405	0.020
Business marketing/marketing management	0.478	0.008	0.487	0.011	0.432	0.018
Marketing research	0.461	0.020	0.504	0.031	0.644	0.054
Education						
Computer teacher education	0.773	0.001	0.771	0.001	0.761	0.002
Mathematics teacher education	0.540	0.022	0.601	0.023	0.688	0.022
Science teacher education	0.421	0.024	0.469	0.030	0.494	0.031
Social science teacher education	0.444	0.019	0.533	0.024	0.571	0.022

Education administration	0.584	0.031	0.485	0.038	0.703	0.044
Counselor education and guidance services	0.621	0.042	0.747	0.047	0.791	0.002
Elementary teacher education	0.595	0.006	0.589	0.008	0.579	0.017
Physical education and coaching	0.434	0.009	0.492	0.016	0.508	0.027
Pre-school/kindergarten/early childhood	0.562	0.027	0.633	0.025	0.665	0.031
Secondary teacher education	0.373	0.011	0.427	0.013	0.496	0.024
Special education	0.629	0.016	0.633	0.020	0.631	0.038
Other education	0.376	0.009	0.455	0.012	0.529	0.026
Arts, Humanities						
English Language, literature and letters	0.360	0.008	0.405	0.010	0.426	0.019
Other foreign languages and literature	0.335	0.012	0.407	0.015	0.398	0.024
Liberal Arts/General Studies	0.264	0.012	0.287	0.017	0.268	0.020
History, other	0.321	0.008	0.364	0.011	0.410	0.020
Dramatic arts	0.438	0.022	0.472	0.025	0.590	0.040
Fine arts, all fields	0.432	0.011	0.454	0.014	0.462	0.026
Music, all fields	0.427	0.014	0.524	0.017	0.457	0.034
Other visual and performing arts	0.508	0.018	0.489	0.019	0.489	0.032
Other Majors						
Communications, general	0.420	0.012	0.375	0.015	0.390	0.024
Journalism	0.462	0.013	0.433	0.019	0.475	0.034
Other communications	0.393	0.017	0.423	0.020	0.457	0.028
Other natural resources and conservation	0.583	0.028	0.616	0.033	0.628	0.042
Home Economics	0.432	0.012	0.397	0.017	0.467	0.029
Law/Prelaw/Legal Studies	0.492	0.023	0.450	0.028	0.536	0.025
Library Science	0.682	0.040	0.736	0.062	0.900	0.001
Parks, Recreation, Leisure, and Fitness Studies	0.366	0.014	0.405	0.024	0.489	0.032
Public administration	0.473	0.026	0.466	0.034	0.682	0.046
Other public affairs	0.668	0.001	0.593	0.041	0.646	0.062
Other philosophy, religion, theology	0.408	0.013	0.420	0.016	0.406	0.028
Social Work	0.585	0.012	0.592	0.016	0.559	0.023
Other fields not elsewhere listed	0.317	0.019	0.345	0.025	0.389	0.040

Appendix B

Harmonization of Occupations Across Waves of
The National Survey of College Graduates

Because new occupations were added to later waves of the National Survey of College Graduates, and because some older occupations were eliminated (or aggregated with similar fields) in earlier waves, it was necessary for us to harmonize the occupation definition. These are the changes that we implemented:

The following occupations were combined into code 110610 "Other computer information science occupations:"

From 2010:

Code	Description
110570	Information security analysts
110610	OTHER computer information science occupations
110560	Database administrators
110580	Network and computer systems administrators
110520	Computer network architect
110590	Software developers - applications and systems software
110600	Web developers
110510	Computer & information scientists, research

From 2003

110580	OTHER computer information science occupations
110550	Database administrators
110560	Network and computer systems administrators
110570	Network systems and data communications analysts
110510	Computer and information scientists, research

From 1993

110540	Information Systems Scientists and Analysts
110550	OTHER Computer and Information Science Occupations

The following occupations that appeared in the 1993 wave NSCG were combined into code 742990 "Postsecondary Teachers: Other" which appears in the 2003 and 2010 waves

Codes	Description
632840 Through 642990	Postsecondary Teachers (in various listed fields)

The following occupations merged to form the broad occupation of "Management"	
From 2003 and 2010 surveys:	
Codes	Description
711410	Top-level managers, executives, administrators
621420	Computer and information systems managers
621430	Engineering managers
621440	Medical and health services managers
621450	Natural sciences managers
711460	Education administrators (e.g. registrar, dean, principal)
711470	OTHER mid-level managers
From 1993 Survey:	
611410	Top and Mid-Level Managers, Executives, Administrators

Appendix Figure C1: Changes in OV 2009-2014
from American Community Survey