Green for All?

Gender Segregation and Green Fields of Study in American Higher Education

Abstract

Using the example of green fields of study in higher education, which emerged largely in response to growing prevalence of the environmental movement over recent decades, this paper posits that new and emerging fields of study can be an important source of change in gender segregation across fields of study. Specifically, we suggest that new and emerging fields of study, when framed outside of existing gender divisions or are lacking clear norms of participation, may transcend traditional gender divisions and be characterized by greater gender integration in both STEM and non-STEM discipline. Patterns of gender segregation among all bachelor degree recipients between 2009 and 2011 show that green fields of study are systematically characterized by greater gender equality relative to non-green fields, regardless of whether a given field falls within the STEM paradigm. As a result, green fields of study are promoting greater gender integration overall in higher education, especially in STEM disciplines. These results suggest that changes in the organizational structure of higher education, and changes in the available curriculum in particular, can have important consequences for gender segregation by field of study.
INTRODUCTION

Despite dramatic improvements in the representation of women in higher education over the last three decades, men and women at four-year colleges are still highly segregated across fields of study (Buchmann and DiPrete 2006; Mann and DiPrete 2013; Morgan et al. 2013). Today, men are still more likely than women to earn a degree in science, technology, engineering and math fields (hereafter, STEM fields), and women are more likely to earn a degree in humanities and social science fields (England and Li 2006; Jacobs 1996; Mann and DiPrete 2013; Morgan et al. 2013; Legewie and DiPrete 2014; Xie and Shauman 2003; Gerber and Cheung 2008). Given the labor market benefits associated with the attainment of STEM degrees (e.g. Melguizo and Wolniak 2012; Shauman 2006), the persistent underrepresentation of women among bachelor degree recipients in STEM fields is an important issue for scholars and policymakers concerned with gender equality (England and Li 2006; Jacobs 1996; Mann and DiPrete 2013; Morgan et al. 2013; Legewie and DiPrete 2014; Xie and Shauman 2003).

Various explanations have been put forth to account for the persistence of gender segregation by field of study. Prominent explanations focus primarily on earlier stages of the life course and include gender-role socialization and widely shared cultural beliefs about gender (Eccles 2011; Correll 2001; 2004), differences in attitudes towards work and family (e.g., Ceci and Williams 2010), differences in self-assessment in mathematics and dispositions towards science fields (e.g. Corell 2001; 2004; Legewie and DiPrete 2014), as well as differences in occupational plans prior to college enrollment (Morgan et al. 2013; Eccels 1991; Xie and Shauman 2003). These explanations indicate that men and women arrive to college with certain gendered aspirations, beliefs and goals, which manifest themselves in students’ selection of
fields of study. Thus, as long as these gender differences persist, gender segregation is not expected to disappear (Charles and Bradley 2002; 2009; Barone 2011).

Yet, while existing theories account for much of the persistence of gender segregation by field of study, they are nonetheless limited in their ability to conceptualize changes in this regime. And although gender segregation persists, it is changing in pattern and magnitude over time (Mann and DiPrete 2013; England and Lee 2006; Jacobs 1995). We posit that one promising direction for theorizing the sources of change in gender segregation is to look at changes in the curricular structure of higher education. Higher education has a long history of adapting to changes in the social and technological landscape with new courses and degree programs emerging to address student and market demand (Karraj and Zajac 1996; Jacobs 1996; England and Li 2006). The result is a higher education landscape that is constantly in flux, creating new offerings that appeal to different constituencies (Kamenetz 2010). We argue that these new fields may be a key to understanding change in the gender segregation regime in higher education, as well as its stability. New fields may lack established stereotypes and norms, which could level the playing field and attract a broad distribution of students – and norms within existing fields could adapt to external force. Furthermore, if new fields of study are not framed within an existing gendered paradigm, or fail to evoke strong gendered identities, they may depart from traditional segregation patterns and be characterized by more gender-equal student bodies. Thus, new fields can disrupt the academic curriculum in ways that change traditional patterns of enrollment, opening the potential for a more equal distribution of students across fields.

In this paper we extend the literature on gender segregation in higher education by considering the role of new fields of study in promoting change in the gender segregation regime
in higher education. We do so by focusing on the example of the “green” movement in American higher education, which has become increasingly prevalent over the first decade of the 21st century (Clark et al 2011). Green programs provide an ideal opportunity to examine the impact of new fields of study since they emerge both in STEM and in non-STEM disciplines, and were institutionalized in higher education fairly quickly. We argue that green fields of study emerge largely outside of existing gender divisions and thus are characterized by greater gender equality. Using data on all U.S bachelor degree recipients between 2009 and 2012, we show that both STEM and non-STEM fields of study associated with the green movement are characterized by greater gender equality relative to non-green fields of study. The finding that green fields of study differ from what we would otherwise expect for fields on both sides of the STEM divide suggest that the organizational structure of higher education is important for understanding change and stability in the gender segregation regime. We discuss the theoretical and policy implication of our results.

GENDER SEGREGATION AT FOUR-YEAR COLLEGES AND NEW FIELDS OF STUDY

Inequality scholars have long sought to understand the sources and persistence of gender segregation across fields of study, and especially women’s underrepresentation in STEM fields (e.g. Mann and DiPrete 2013; England and Li 2006). Traditionally, most explanations for gender disparities in field of study selection focus on stages of the life course prior to college enrollment. These explanations include gender differences in math preparation and ability (Arcidiancono et al 2012; Jonsson 1999; Turner and Bowen 1999; Porter and Umbach 2006; Margolis et al. 2008; Ayalon 2003), biased self-assessment of mathematical ability (e.g. Corell...
2001; 2004), widely shared cultural beliefs and stereotypes (e.g. Eccles and Jacobs 1986; Steele and Aronson 1995), and differences in family-work values and expected labor market attachment (Xie and Shauman 2003; Ceci and Williams 2010), as well as differences in the social penalty associated with choosing a STEM field and occupation (Simpson 2001; Seymour and Hewett 1998). These gender differences in preparation, socialization, and perception inform students’ social identities and beliefs about gender-suitable careers, and subsequently impact field of study selection in college (Morgan et al. 2013; Mann and DiPrete 2013; Eccels 1991).

Students’ dispositions and aspirations, however, are only part of the process of field of study selection. Once in college, students look at the course catalog, consult with their friends, families, academic advisors and classmates about the different programs, and eventually choose a field of study from the available set of options at their respective institution. During this process, students learn about the content of fields, the social and academic climate within them, the way the different fields and the students within them are perceived, and how compatible they are with their (gendered) aspirations and dispositions (e.g. Morgan 1992; Steele and Barnett 2002; Xie and Shauman 2003). As a result, fields have an important role to play in shaping gender difference as they evoke certain degrees of gender identity/

The idea that fields themselves evoke gendered identities is present both implicitly and explicitly in research on gender segregation by fields of study. Since widely shared cultural beliefs about gender (and gender-appropriate fields and occupations) structure the curricular choices men and women make in college, the way fields of study themselves are perceived by students feeds into the curricular choices men and women make (e.g. Barone 2011; Charles and Bradley 2002; 2009; Bradley 2000). Charles and Bradley (2009), for instance, suggest that the curricular choices men and women make can largely be viewed as an expression of students’
gendered social identities, in which “gender-essentialist stereotypes and dispositions combine with norms of self-expression to intensify gender typing of curricular choice…” (Charles and Bradley 2009: 928). Consistent with this argument, Barone (2011) shows that much of the association between gender and field of study selection can be understood by two independent gender divides: humanistic vs. scientific fields, and care-oriented vs. technical fields. Per this line of research, we can expect fields that are framed within these existing gendered paradigms to evoke strong gender identities and have a disproportionately high representation of either men or women.

The influence of fields’ framing on the gender composition of fields may shed light on the high persistence of gender segregation by field of study despite dramatic improvements in women’s math achievement in high school and growing labor market opportunities for women (e.g. Charles and Bradley 2002; 2009; Correll 2001; 2004; Barone 2011; Mann and DiPrete 2013; Turner and Bowen 1999; England and Li 2006). But it can also point to an important source of change in the pattern and magnitude of gender segregation by field of study over time. Just as social changes have affected the pool of students entering higher education, they also have some effect on how academic disciplines are perceived and framed. As Charles and Bradley (2009:928) note: “The content of gender-essentialist stereotypes shows much consistency across time and space….but historical and comparative case studies also reveal significant fluidity. For example, different versions of masculinity (emphasizing muscularity or abstract logic) have been more or less salient in different fields, depending in part upon the demographic and social pressures operative at the time of each field’s development or expansion.” Thus, the higher education curriculum does not emerge in a vacuum, but rather reflects the needs, concerns, and demands of society at large.
Although existing theories leave the door open to changes in the social context of academic fields affecting perceptions and stereotypes, they stop short of making predictions about the impact of entirely new movements and disciplines. Most existing research suggest that diversification of curricular offerings will enhance gender segregation because they assume new fields emerge largely within existing gender paradigms (e.g. Bradley 2000; Charles and Bradley 2002; 2009). This unidirectional view of organizational change, we argue, may overlook important variation in the ways in which new fields emerge, and how that variation may affect gender distributions across fields. Most important, what happens when a new social and technological movement emerges and disrupts established assumptions and stereotypes about disciplines, and even creates entirely new fields?

We submit that new fields may lack established stereotypes and norms, which could level the playing field and attract a broad distribution of students – and norms within existing fields could adapt to external forces. Furthermore, new fields can emerge outside of existing gender paradigms, for example being simultaneously care-oriented and technical, or both humanistic and scientific, and therefore transcend traditional gender divisions. In other words, the gender characteristics of fields (e.g. care-technical/humanistic-scientific) may not be orthogonal in new and emerging fields, consequently transcending traditional gender divisions. Focusing on responses to changes in the curriculum shed light on the role of the organization in promoting change in gender segregation by field of study. This is the point of departure for the current investigation. Our goal is to both to expand existing theories by explicitly conceptualizing change in the segregation regime, as well as to highlight the role of changes in the organizational structure of higher education in shaping this change. We do so by focusing on a set of clearly defined new and emerging fields of study in higher education—green fields of study. As we will
explain in the next section, we believe that the green movement in higher education provides an ideal opportunity to examine changes in the curricular offerings in higher education, both in STEM and in non-STEM fields.

HIGHER EDUCATION AND THE EMERGENCE OF GREEN FIELDS OF STUDY

The American higher education curriculum is far from static – rather, it is constantly evolving in response to a variety of interrelated factors such as student demand, technological innovation, and institutional resources. Research in organizational behavior has established that the activity of organizations such as colleges and universities are highly influenced by changes in their technical and normative environments, such as material resources, workforces, customer bases and tastes, and market demands (Selznick 1957; Kraatz, and Zajac 1996; Meyer and Rowan 1977; DiMaggio and Powell1983; Pfeffer and Salancik 1978). Changes in the environment require organizations to improvise, deviate from their original goals, or to adopt new organizational structures in order to expand and survive. Thus, new opportunities that may appeal to different demographic groups are continuously created.

Perhaps the greatest change in American liberal arts education in the 20th century was the encroachment of professional and business-related education (Kraatz and Zajac 1996). The emergence of such fields significantly altered the distribution of gender across fields of study (England and Li 2006; Jacobs 1995), leading to overall gender desegregation as these newly popular fields approached gender parity (Mann and DiPrete 2013). Such changes underscore the importance of student demand in shaping the curriculum and the manifestation of such changes in the gender distribution of students. The response of higher education to students’ demands, changing social norms and technologies can be seen in the changes to the course catalogs of most
research universities over the course of the 20th century with the addition or decline of various fields, including home economics, women’s studies, labor relations and epidemiology (Jacobs 1996; Kerr 2001; Geiger 2004).

The increasing presence of the green movement in higher education over the 21st century stems from similar pressures in colleges’ normative and technical environments. The first decade of the twenty-first century was characterized by record levels of public awareness of and concern for environmental issues (Dunlap and Mertig 1991; Wolf and Moser 2011). Public concern about climate change in the U.S. reached an all-time high in 2008, followed by a modest decline in subsequent years (Scruggs and Bengal 2012; Ratter, Philipp, and von Strach 2012; Marquart-Pryatt et al 2011). Scholars have documented the increasing prevalence of the “green” movement, which has undergone a process of institutionalization from an outside activist movement to a mainstream phenomenon (Bosso 2005; Kolk 2004; Rondinelli and Vastag 2000). And, at the individual level, green lifestyle choices have become more commonplace as consumers prioritize and internalize environmental concerns (Berger 1997; Haanpää 2007).

Colleges and universities responded to these pressures through the creation of programs specialized in conveying green knowledge. The environmental movement in higher education has been characterized as “hyper-differentiated” in its theoretical and methodological approaches and a “curricular smorgasbord” (Clark et al 2011: 718). The number of distinct green fields of study offered by US four-year colleges increased from 47 in 2002 to 59 in 2011—an increase of 26 percent relative to a 6 percent increase in the number of distinct non-green fields (IPEDS, Authors’ calculations). And, while the focus of this paper is on the bachelor’s degree level, the green movement is becoming institutionalized at all levels of the educational system ranging
from middle school science courses to new PhD programs, offering a logical progression through higher education for individuals inclined toward studying green topics.

The green movement in higher education provides a unique opportunity to document the effects of new and emerging fields of study in higher education on gender segregation by fields of study. New programs representing emerging fields of study, such as queer studies and quantitative biology, are often hard to track—they are small and experimental by nature, and thus usually disappear after a short period of time, or get grouped together with more traditional fields in both micro- and macro-level data on higher education. And, as is the nature of any change in a highly institutionalized organizational field like higher education, they emerge slowly and unevenly across different parts of the system before they become institutionalized (Scott 1995).

This is not necessarily the case for green fields of study. Since green fields of study evolved largely in response to a powerful social movement, they expanded and institutionalized across the higher education system quickly over a relatively short period of time. Even though green fields tend to be smaller than more established fields, the institutionalization of these fields can be seen in the addition of distinctly green fields of study to the 2010 Department of Education Classification of Instructional Programs (CIP), including “Environmental Education”, “Energy, Environment, and Natural Resources Law”, “Environmental Psychology” and Sustainability Studies” (US Department of Education 2010). Insofar as officially-updated classifications can tell us something about the organizational landscape of higher education, the changes between the 2000 and 2010 CIP classification schemes suggest that green fields of study are becoming more institutionalized in the organizational landscape of higher education.

What makes the case of green fields especially useful for understanding gender segregation in fields of study is that green programs emerge in both STEM and non-STEM
fields. Growing demand for more sustainable products and production processes coupled with increasing governmental investment in green energy provide a direct incentive for higher education to create STEM programs that specialize in conveying and developing “green” products, including environmental engineering and environmental sciences. At the same time, in response to students’ growing demands for programs with an environmental orientation, institutions began to offer programs that focus on humanistic and social aspects of the environment (Vincent 2010; Clark et al. 2011). Examples of such programs include environmental studies and sustainability studies, which are green in nature but situated outside the STEM paradigm. Therefore, we can examine whether the distribution of men and women across STEM disciplines differs in green and non-green fields.

And indeed, there are good reasons to expect that green fields will be characterized by greater gender equality than non-green fields, both in STEM and in non-STEM fields. First, most green fields are relatively small and new and thus they may not have clear norms of participation, which may leave room for change. For example, it may be well known among students that electrical engineering enrolls relatively few women - thereby deterring young women from entering these fields. Yet, the gender composition of a new field like environmental engineering may not be common knowledge, and therefore be less likely to deter women from entering these fields. Second, green fields may be simultaneously perceived as care- and technical-oriented, and as humanistic and scientific fields, thereby transcending traditional gender divisions (e.g. Barone 2011). For instance, STEM green fields such as environmental engineering may be considered both care for the environment and the natural world, as well as conveying technical skills and knowledge, thereby compatible with the gendered preferences of both men and women. Similarly, environmental studies can be seen as having both a humanistic
focus (i.e. human-environment relationships) and a field informed by scientific evidence, and thus may be equally appealing to men and women in theory. Consequently, we can expect the gender composition of both STEM and non-STEM green fields to be more balanced than non-green fields.

In the following sections, we set out to empirically examine trends in the expansion and proliferation of green fields of study in higher education, and patterns of gender segregation in these programs over the last decade.

DATA, VARIABLES AND METHOD

Data and sample
The empirical investigation of this paper is based on data from the Integrated Post-Secondary Data System (IPEDS). The IPEDS is a set of publicly available data files collected by the U.S Department of Education that contains detailed information on all Title-IV eligible institutions in the U.S. We use information drawn from IPEDS’ institutional characteristics, enrollment and completion files collected between 2009 and 2011. These files contain detailed and consistent information on the demographic and organizational characteristics of each Title IV institution offering four year courses of study. The files also contain detailed information about all undergraduate academic programs (majors) at each eligible institution, including the detailed classification of instructional programs (CIP) code and the number of degrees awarded in each program by gender.

The analyses focus on all instructional programs (6-digit CIP codes) offered at the bachelor’s level in all Title IV-eligible 4-year institutions between 2009 and 2011 that awarded at least one degree over that period. Our analytic sample consists of 70,931 degree-granting
programs nested in 2,629 four-year postsecondary institutions (hereafter “program-institution”), and are classified into 1,097 unique CIP categories. We supplement these analyses with information collected between 2002 and 2008 to track the progression of green fields of study in higher education, although we are fully aware that the inclusion of new fields of study may not have precisely corresponded to the date that the first degree program was launched (e.g. sustainability studies) and thus we interpret these results cautiously.\textsuperscript{ii}

The main advantage of using IPEDS data to study gender segregation by field of study is that it contains information on the entire universe of Title IV institutions in higher education and thus circumvents the need to infer from a sample of students or institutions. Simply put, the IPEDS provides an accurate snapshot of gender segregation within fields of study. Yet, because the IPEDS does not contain micro-level information on students’ behaviors, preparation, or choices, we cannot assess the micro-level processes that channel men and women to different fields of study.

**Main Variables**

**Outcome variable:** gender composition of degrees awarded in program-institution is measured as the percentage of degrees in each program-institution that were awarded to women.

**Main predictors:** fields of study classifications. We collapsed the detailed codes for all instructional programs (6-digit CIP codes) in the IPEDS dataset into four quadrants: green and non-green STEM fields, and green and non-green non-STEM fields. To distinguish between green and non-green fields, we use the broad categories defined by the U.S. Economics and Statistics Administration’s 2010 report on green jobs, “Measuring the Green Economy,” which identifies five major types of economic activity that could be considered green (pp. 8): (1)
Pollution control, (2) Renewable and alternate sources of energy, (3) Energy conservation, (4) Resource conservation, including recreation, and (5) Environmental assessment, including nonprofit environmental advocacy. Using the descriptions of fields of study provided in the CIP codebook (US Department of Education 2010), we determined if each instructional program is explicitly and directly related to in one of these five economic areas. In classifying instructional programs to STEM and non-STEM fields we utilize the National Science Foundation definitions of STEM fields (US National Science Foundation 2005), excluding some fields that focused on policy and management that are clearly non-technical in nature.

Overall, we identify 61 programs as green, of which 23 are in non-STEM disciplines and 38 are in STEM disciplines. A full list of the instructional programs categorized as green, their STEM status, and CIP codes are provided in Appendix A.

Adjustment variables: In addition to field classification, our models adjust for several characteristics that vary across both majors and institutions. Major-level adjustments include the size of program-institution, % of R1 institution offering degrees in major; % all 4-year institution offering degrees in major. Institution-level adjustments include the size of the institution, control of institution, and whether the institution is categorized as an R1 university.

Analytic approach

We assess differences in the gender composition of green fields of study by estimating several multi-level models predicting the share of degrees awarded in a given program-institution unit that were awarded to women. At the core of the analyses are two main predictors and their interaction term: (1) a dummy variable indicating whether or not the program conveys green knowledge; and (2) a dummy variable indicating whether or not the program is in a STEM
discipline. As we will discuss further later, the interaction term allows us to compare green and non-green programs across STEM and non-STEM fields. To account for differences between institutions, and their effect on the gender composition of programs within them, we estimate the intercept and the effect of green as random effects. Finally, we build on these models to calculate several predictive scenarios that illustrate the significance of green fields in promoting gender integration.

RESULTS

Gender segregation by fields of study in higher education

We begin our empirical investigation by describing patterns of gender segregation by field of study among recent bachelor’s degree recipients between 2009 and 2011 (Table 1). The trends in Table 1 pose no surprise—women are overrepresented in psychology (68%) education (79%) and health professions (85%), and are underrepresented among degree recipients in engineering (17 percent) and computer and information sciences (18%). Other fields on the both sides of the STEM divide have more balanced gender composition, such as biological sciences and agricultural fields (58% women), reflecting well-known trends of gender integration in these fields. Similarly, while math and physical science fields still have relatively low percentage of women graduates (43 and 41 percent, respectively), the proportion of degrees awarded to women is substantially higher than in engineering and computer science fields.

[Table 1 about here]

The general patterns of gender segregation by field of study observed in Table 1 suggest we are still far from gender integration, especially in STEM fields. Yet, while this may be the case when we consider broad categories of fields, these aggregated categories of fields mask a
substantial degree of variation in the gender composition of more refined field categories that can reveal possible changes in higher education. For instance, while only 17 percent of engineering degrees were awarded to women, 39 percent of degrees in biochemical engineering and 66 percent of degrees in textile sciences and engineering were awarded to women.

Of course, focusing on more refined major categories has many methodological issues that have no doubt curtail previous efforts to examine changes in gender segregation at the program-level, especially in the absence of strong theoretical need to do so. Yet, it is exactly this variation within the aggregate field categories that is of interest here. We analyze the most detailed level of fields available to assess whether and how majors that offer green knowledge—both in STEM and non-STEM fields—differ systematically in their patterns of segregation than non-green fields. Before we take on this question, however, we first examine the emergence and prominence of green fields of study in higher education over the past decade.

**Green fields of study in higher education**

How widespread is the green movement in higher education and how did it changed over time? Table 2 charts trends in the prevalence of green programs in higher education between 2002 and 2011. The proportion of 4-year institutions that offer any green field of study increased only slightly over the last decade, from about a third of all institutions in 2002 to about 37 percent in 2003 and then remaining roughly stable through 2011. However, the average number of green programs offered in each institution increased steadily throughout the period, from an average of about 1.58 in 2002 to an average of 1.98 green programs by 2011. This suggests although the spread of green undergraduate degree programs throughout the system stagnated, their density within institutions increased.
The growing prevalence of green programs is also visible in the steady increase in the number of green programs available to American undergraduate students, as well as in the number of bachelor’s degrees awarded in green programs. The number of degree-awarding green programs increased from 47 in 2002 to 59 in 2011—a 26 percent increase. The total number of degrees awarded in green programs increased by about 58 percent, from 19,527 in 2002 to 30,980 in 2011. For comparison, the growth rate of green programs, both in size and in number, far exceeded that of non-green fields: the number of non-green programs increased by less than 6 percent during this time (from 857 to 905 programs), and the overall number of degrees awarded in non-green programs increased by 32 percent (from 1,351,246 to 1,782,543). The dramatic increase in the number of undergraduate degree recipients in green programs accompanied by a steady increase in the number of green programs offered within institutions strongly suggest that green fields of study are becoming more and more institutionalized in American higher education.

[Table 2 about here]

What are the institutional characteristics of these new green fields of study and how do they differ from non-green fields of study? Table 3 examines this question by comparing several characteristics of green and non-green programs, including the average number of graduates in each program, the average gender composition of their graduates, the prevalence of these programs across institutions, and the proportion of colleges and universities offering a given field of study that are R1 institutions. While this is certainly not an exhaustive list of all factors that may differ between green and non-green fields, it nonetheless provides a snapshot of the landscape of higher education.
We find that green programs are smaller on average than non-green programs (averaging just 37 bachelor’s degree recipients in program between 2009 and 2011, relative to 76 for the average non-green program), and their undergraduate populations tend to be more gender equal: on average, 46 percent of bachelor’s recipients in green programs are women in comparison to 56 percent in non-green fields. Since women receive about 57 percent of all bachelor’s degrees in the United States, women are slightly underrepresented, on average, among graduates of green programs.

Green programs also differ in the institutional characteristics of their host colleges and universities relative to non-green programs. As expected, the typical green field is offered by a smaller share of all institutions relative to the typical non-green field – while nearly all liberal arts colleges and research universities have English departments, forestry will naturally appear in a smaller subset of institutions. Yet, green programs are offered in larger institutions, including a disproportionately high number of R1 universities. These trends are consistent with the organizational literature, which suggest that institutional change often originates from the most established organizations (e.g. R1 universities) and later spread out throughout the organizational field (i.e. Scott 1995; Tolbert and Zucker 1983). Given that R1 and large universities tend to have more resources and face fewer risks, they may be better positioned to adapt to labor market changes and innovate in their curricular offerings (Geiger 2004).

[Table 3 about here]

In sum, two conclusions can be drawn from the previous sections: (1) gender segregation by field of study, especially along STEM and non-STEM lines, is still strong among recent bachelor degree recipients; (2) green programs in higher education, represent a small fraction of
all degrees awarded and programs offered, though they have become more prevalent over the past decade.

But are these new and emerging fields systematically different from more traditional and established fields? In what ways do traditional gender divisions, especially those across STEM and non-STEM lines differ in green and non-green fields? We address these questions in the next section.

**Gender segregation and green fields of study**

We examine whether green fields of study differ systematically in their gender composition from non-green fields of study by estimating a series of nested multilevel linear models predicting the proportion of degrees awarded in each program (within each university) that were awarded to women (Table 4). The first model is the baseline unconditional model which includes only an intercept that is allowed to vary between institutions (Model 1). According to this model, the average share of degrees awarded to women in programs is 56 percent. The variance components from the unconditional model suggest that 71 percent of the variability of gender composition of programs is related to program-level factors, and 29 percent of the variability is related to differences between institutions.

Model 2 in Table 4 includes a dummy variable indicating whether the program is green or not. The effect of being a green program in this model is also allowed to vary across institutions, although the results suggest that the effect of being green on the gender composition of degree recipients in each program does not significantly vary from institution to institution. The results from this model suggest that the share of degrees awarded to women in green programs is about 10 percentage points lower than in non-green programs. Model 3 adds a
dummy variable indicating whether the program is in a STEM discipline to the model. As anticipated, STEM field has a strong negative effect on the gender composition of fields: the share of degrees awarded to women in STEM programs is about 24 percentage points lower than that in non-STEM fields, netting out the effect of green fields. However, this procedure neutralized the effect of being a green field on the gender composition of programs. Given that green programs are more common in STEM fields than in non-STEM fields, the negative effect of being a green program captured in Model 2 can be related to the overall lower representation of women in STEM fields rather than an effect of green field per-se.

To further examine this possibility, Model 4 adds an interaction term between being a green field and being a STEM field. The main advantage of this interaction is that it allows for direct comparisons between green and non-green fields across STEM and non-STEM disciplines. According to the model, the share of degrees awarded to women in green fields that are non-STEM is, on average, 13 percentage points lower than in non-STEM non-green fields. The share of degrees awarded to women in STEM fields that are not green is about 25 percentage points lower than non-STEM fields that are not green. Finally, the positive interaction term suggests that green fields of study are characterized by greater gender equality, both in STEM and in non-STEM. For example, the average share of degrees awarded to women in non-STEM programs that are not green is about 61 percent (intercept), while the average share of degrees awarded to women in non-STEM green fields is about 48 percent (61-13=48). Similarly, the average share of degrees awarded to women in STEM fields that are not green is about 36 percent (61-25=36). In comparison, the average share of degrees awarded to women in STEM programs that are green is 43 (61-13-25+20=43)—about 7 percentage points higher than in STEM non-green
fields. In other words, green programs have on average more balanced gender composition of their graduates than non-green programs, both in STEM and in non-STEM disciplines.

To account for the potential effect of differences between the institutions that offer green and non-green programs, or the characteristics of the programs themselves, Models 5 and 6 add adjustment variables for both level of the model. The inclusion of these controls did not impact the size of the effect for green and STEM or their standard errors. It appears, then, that the differences between green and non-green fields both in STEM and non-STEM fields are above and beyond the major-level or institutional-level differences discussed in Table 3.

[Table 4 about here]

These results, although not indicative of any direct causal effect of green fields on gender composition, support the argument advanced here—that new and emerging fields in higher education can systematically depart from traditional patterns of gender segregation by field of study and promote greater gender integration. Of course, it is possible that other small or new programs will also depart from traditional gender divisions. However, since small fields tend to be new and experimental in nature, it is hard to assess this possibility without making ad-hoc assumptions about differences between programs. In this sense, the case of the green movement in higher education provides a unique opportunity to assess whether and how new fields of study—especially when tied to a social movement—may depart from well-known patterns of gender divisions. The results presented here suggest that change is indeed occurring, but it is limited in scope because it occurs in new and rather small segment of higher education. The majority of fields—the ones that are more established—are much more resistant to change.
Are green fields diversifying STEM?

The argument advanced in this paper is that new fields of study can be an important source for change in the gender segregation regime in higher education. Indeed, the results presented in Table 4 support that argument and suggest that trends towards gender integration are slowly occurring in green fields. But what is the scope of this change, and what are the implications for the diversification of STEM fields? As a final step of our empirical investigation we calculate several predictive simulations that assess the scope and magnitude of the trends described above. Our goal is both to assess the current contribution of green fields of study to gender integration, as well as to explore the scope the possible contribution of green fields assuming that the green movement in higher education will continue to expand. To this end we asked what would be the percent of degrees in STEM or non-STEM fields that would be awarded to women if the percentage of programs that are green would change, but everything else would stay the same? We used Model 6 in Table 5 to calculate these predictive simulations and estimated several different scenarios. The predicted probabilities from these scenarios are presented in Table 5.

As of 2011, about 10 percent of programs in STEM fields and about 2 percent of programs in non-STEM fields are categorized as green (labeled as “Current” in Table 5, Panels A and B). To gauge the contribution of green fields of study to gender integration in STEM and non-STEM fields we asked what would be the percentage of degrees awarded to women in these fields if no green programs were offered at all in STEM and non-STEM fields (“No green programs” row). Under this scenario, the share of degrees awarded to women in STEM would decrease by about 2 percent (from 36.6 to 35.7 percent), and the share of degrees awarded to women in non-STEM fields would increase by about 1 percent (from 60.8 to 61.3). In other words, the impact of green fields of study on gender integration is small, but stronger in STEM
disciplines than in non-STEM. Given that the share of programs that are green in STEM fields is higher than in non-STEM, this asymmetry is expected.

Yet, even if the impact of green programs on gender integration is currently small, it may change over time. As the green movement continues to gain prevalence in higher education, it is likely that more green programs will be offered. We calculated two additional scenarios to address this trend. First, we present a scenario in which the current share of green programs in STEM and non-STEM doubles. Under this scenario, which we believe is fairly realistic, the share of STEM degrees awarded to women would increase by about 2.2 percent from the current share, but the share of non-STEM degrees awarded to women would stay basically the same. Here again, the larger impact of green fields on gender integration in STEM fields is again related to the fact that green programs are much more prominent in STEM fields. Under the assumption that the growth of green programs will be proportional to their current share, green programs are expected to have a positive impact on diversifying STEM fields, but not on diversifying non-STEM fields. Second, we calculated a scenario in which half the programs in both STEM and in non-STEM are green. While we regard this scenario as highly unlikely, we see it as a conceptual exercise that can help us understand the scope of the impact the green movement can have on gender integration. This scenario yields bitter-sweet results: although the representation of women among degree recipients in STEM would increase by about 9 percent, women would still receive only about 40 percent of degrees in STEM fields. In non-STEM fields we can expect a decrease of about 9 percent in the representation of women as women would receive about 55 percent of degrees awarded in non-STEM fields.

In sum, the predictive simulations suggest that green programs in higher education are indeed promoting greater gender integration, especially in STEM fields. However, the impact is
still quite limited in scope. We show that if the green movement will continue to expand at its current direction, it is likely to further diversify STEM fields. For those concerned with increasing the representation of women in STEM fields, these findings should be quite encouraging.

CONCLUSIONS

Exiting theories of gender segregation by field of study focus on explaining the persistence of gender segregation, but are limited in their ability to explain change. This study set out to examine one possible source for changes in gender segregation by fields of study: new and emerging fields of study. We argue that new and emerging fields of study can depart from traditional gender divisions and be a force leading to greater equality in higher education. New fields arrive on the scene without a set of historically-shaped norms, allowing them to attract a more balanced population of students to begin with. Therefore, we suggest that far from permanently settled, the distribution of students across fields is highly malleable and subject to change over time. The case of green fields of study, which has been the focus of this paper, is a clear example of these processes in action.

Higher education has taken substantial steps to respond to the green movement through the creation of new disciplines and programs as well as the expansion of existing ones. Universities are creating new programs and, indeed, entirely new fields of study at an impressive rate. Though the response to changing student demand and broader social currents has taken different forms across institutions, with R1 universities being fastest to adapt to demand, it nonetheless represents a disruption in the higher education curriculum. We find that green fields of study are indeed more gender-balanced than other fields of study, both within the STEM and
non-STEM spheres. STEM green fields are more likely to attract women than other STEM fields, and non-STEM green fields are more likely to attract men – converging on gender parity in both cases. And, as the green movement expands, our models suggest that we will continue to see changes in the direction of gender equality. While the green movement will never lead to a perfectly equal gender distribution across fields, it is clearly an equalizing force.

The impact of the green movement is not isolated to those academic disciplines with a clear connection to the green movement, however. The green movement in higher education has demonstrated its potential to shape the overall demographics of the STEM sector in favor of a more gender-balanced distribution of students, potentially permitting a wider array of individuals to reap the economic rewards typically associated with completing a STEM degree. And, green fields of study have managed to achieve this task without forcing painstaking cultural changes in such constantly male-dominated fields as computer science and mathematics. While some coursework may be new, many of the general skillsets and intellectual paradigms they fall under are not. Thus, fields like environmental engineering not only enroll students directly, but also promote an overall diversification of STEM fields.

The broader implication of this study is that changing the framing of academic fields can lead to different demographic outcomes. We argue that one possible reason for the more balanced gender distribution in green fields is that they emerge outside of existing gender dichotomies. Fields of study can be framed as both caring and technical, in addition to being both humanistic and scientific. As a result, they may transcend traditional gender divisions. Therefore, one promising way in which postsecondary institutions can actively change the framing of fields to make them appeal to different demographic groups is to add coursework and extracurricular opportunities that defy traditional expectations of what a field is supposed to encompass. For
example, we could see changes in economics or statistics disciplines that better align their curricula with the anti-poverty and economic justice movements, potentially combining technical skills with care.

Furthermore, institutions aiming for greater equality across fields can think about how a green framing can be applied beyond what we traditionally think of as green programs. The green sector requires electrical engineers, chemical engineers, physicists, educators and other scientists and professionals that can advance the sector’s goals and mission. By highlighting the connection between traditional disciplines and the green economy, existing fields may be able to diversify their student bodies. We can think of ways in which these changes will also have implications for the broader labor market and emergent green economy. Bringing green topics into the curriculum may not only help individuals who might not otherwise see themselves in STEM fields select such majors, but also lead them to consider related careers – increasing the pool of talent in the green workforce and facilitating the broader aims of the green movement. We have shown that the demographics of higher education are shaped by broader forces affecting the outside world, and in turn we expect that such changes in higher education will contribute to social change.
REFERENCES


According to Barone (2011), “we could anticipate a female preference also for fields like psychology or medicine that give access quite often to jobs characterized by their symbolic affinity with traditional caring roles, given their specific orientation toward the well-being and personal development of customers” (2011: 159). Although care orientation has traditionally been associated with care for people, there is no reason to assume that “care” for the natural world. Indeed, research suggests that women exhibit higher levels of environmental concern than men, and that concern results in the adoption of environmentally-friendly behaviors and attitudes at higher rates (Luchs and Mooradian 2012; Diamantopolous et al 2003; Matthies and Klockner 2002).

Since the CIP classification changed in 2010, some fields from the 2000 classification were removed, or changed in the 2010 classification that is the base for our primary sample.

As a sensitivity analyses, we estimated a series of fixed effects models (not shown, available from authors), and the results were virtually the same.