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DOI
10.1086/691327

Publication date
2017

Document Version
Final published version

Published in
American Journal of Sociology

School-to-Work Linkages in the United States, Germany, and France[1]

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A new research agenda is proposed for assessing the strength of linkages between educational credentials, including fields of study, and occupational positions. The authors argue that a theoretically fruitful conception of linkage strength requires a focus on granular structure as well as the macroinstitutional characteristics of pathways between education and the labor market. Building on recent advances in the study of multigroup segregation, the authors find that Germany has stronger overall linkage strength than France or the United States. However, the extent to which the three countries differ varies substantially across educational levels and fields of study. The authors illustrate the substantive importance of the new approach by showing, first, that the standard organization space/qualification space distinction poorly describes the contemporary difference between Germany and France and, second, that relative mean occupational wages in Germany and the United States vary directly with the relative linkage strength for occupations in the two countries.

INTRODUCTION

A long-established literature in sociology, political science, and economics attests to the importance of national educational systems for the quality of adult lives along a host of dimensions. For several decades, much of this lit-

[1] The research in this article has been supported in part by National Science Foundation grant SES-1423828, a Veni grant from the Netherlands' Organization for Scientific Research (451-15-001), a small grant from the Spencer Foundation, the Amsterdam Centre for Inequal-

0002-9602/2017/12206-0006$10.00

erature also has paid systematic attention to the different ways that educational systems allocate school leavers in the labor market. It is frequently asserted that institutional characteristics of educational systems affect the distribution of skills and the employment and occupational "returns" to education of school leavers (Shavit and Müller 1998; Müller and Gangl 2003*a*; van de Werfhorst 2004; Wolbers 2007; Reimer, Noelke, and Kucel 2008; Andersen and van de Werfhorst 2010; Altonji, Blom, and Meghir 2012). It is further argued (e.g., Hall and Soskice 2001) that the institutional configurations that link education, training, and the labor market constitute different "varieties of capitalism" and have developed over the specific histories of countries from efforts by firms to solve coordination problems in the market (Thelen 2004; Streeck 2005; Busemeyer and Trampusch 2012; Anderson and Hassel 2013). The configuration of educational programs and outcomes, the impact of this configuration for the matching of workers to labor market positions, and the influence of these institutional linkages for productivity and the organization of work are seen as having broad consequences not only for skill distributions of workers but also for the national economy, the distribution of wages and earnings, and the level of inequality.

The comparative stratification literature in sociology made significant progress in the 1980s and 1990s by identifying a set of institutional dimensions along which national educational systems were thought to differ, such as the vocational specificity of educational programs. This classificatory effort examined whether countries could be classified along these institutional dimensions, as well as the impact of these dimensions on employment and occupational outcomes. Meanwhile, the comparative political economy literature identified the historical factors that create path dependence in institutional development in the face of common technical forces. But even though both literatures acknowledge that "training regimes" (Busemeyer and Trampusch 2012) differ across nations, research too often has treated these regimes as undifferentiated "country-level" variables. The possibility that institutional effects vary within countries—meaning that they produce more tightly coupled outcomes in some parts of the "training space" than others—remains largely unexamined. Similarly, the possibility that broad institutional accounts

ity Studies, and a grant from the Programme Council for Educational Research of the Netherlands' Organisation for Scientific Research (411-10-920). Previous versions of this article were presented at the University of Amsterdam; the Sociology of Education Association annual meeting at Asilomar, California; the Sørensen Conference at the University of Oxford; the RC28 meeting at the Central European University in Budapest; the Population Association of America annual meeting in San Diego, California; the University of Bielefeld; and Princeton University. We thank Silke Schneider, Markus Klein, Felix Weiss, Louis-Andre Vallet, Milan Bouchet-Valat, Benjamin Elbers, Luciana de Souza Leão, the participants at these presentations, and the *AJS* reviewers for their helpful comments and suggestions. Direct correspondence to Professor Thomas A. DiPrete, 610B Knox Hall, Columbia University, New York, New York 10027. E-mail: tad61@columbia.edu

fail to capture accurately the pathways that link school outcomes with workforce placement also remains largely unexamined. We argue that these gaps stem from insufficient appreciation of the importance of the granular structure of the pattern of linkages between detailed educational outcomes and labor market positions. A theoretically adequate account of a country's training regime cannot rest solely on broad institutional generalizations; instead, the granular structure of linkages is an essential characteristic of the macrostructure, and (as we will show) it is a characteristic that cannot be simply (or accurately) deduced from broad institutional generalizations.

In this article we advance the literature by developing a research agenda for understanding the granular structure of linkages between educational outcomes and occupational categories, and we show how the well-known macrostructure of training regimes emerges from the granular structure that underlies it. We demonstrate the theoretical importance of taking both fields of study and level of education into account in order to accurately characterize the national structure of linkages between educational outcomes and the labor market. Attention to the actual structure of school-work linkages goes beyond the essential task of "establishing the phenomenon" before we attempt to explain it (Merton 1987), although this is an important component of what we propose. We argue that standard abstract characterizations of institutional facts in this arena (e.g., that a nation's educational system is standardized and vocationally specific) lack an adequate grounding in the granular structure of these institutions as they actually affect the training and placement of people.

Relying on statistical methods to assess multigroup segregation (Theil and Finizza 1971; Theil 1972; Reardon and Firebaugh 2002; Mora and Ruiz-Castillo 2011), we study whether people who have obtained a specific level of education and specific field of study within this level are employed in many different kinds of occupations (weak linkage) or a more restricted set of occupations (strong linkage). We compare the school-to-work linkages in the United States with those in two other countries that are the standard examples of different types of training regimes, namely, Germany and France (Maurice, Sellier, and Silvestre 1986; Shavit and Müller 1998). The educational systems and labor market regulations are known to differ substantially across Germany, France, and the United States, plausibly leading to strongly divergent linkages between educational qualifications and occupational positioning. We use country-specific labor force surveys with a large number of observations to estimate the strength of linkages in the three countries at a level of resolution that is considerably greater than anything currently available in the comparative literature.

We outline a broad research agenda of important questions that potentially can be answered with the linkage structure approach. We then illustrate the value of the approach by demonstrating important new insights into the nature of the training regimes in France, Germany, and the United States. First, linkage strength is not homogeneous within countries but varies greatly across educational credentials and across occupations. Second, country differences in aggregate linkage strength mask considerable variation in the size of country differences at the level of educational categories or occupations. Third, the long-argued structural difference between the effects of training on occupational placement in France and Germany is considerably smaller than commonly presumed since the work of Maurice et al. (1986), and the United States is further from France and Germany in terms of total linkage strength than France and Germany are from each other. We further find that the greater total linkage strength in Germany than in France arises at least partly from compositional differences (e.g., national differences in the proportion of workers with educational outcomes that have relatively strong links to specific occupations) between the two countries and that many specific educational outcomes link as strongly or more strongly to occupations in France than in Germany. Fourth, differences in linkage strength between Germany and the United States are related to differences in the wage distribution of the two countries. Net of occupational status, full-time mean occupational earnings differences between Germany and the United States are found to be positively related to the relative linkage strength of occupations in the two countries. Taken together, these results illustrate the power of the new approach for addressing many important questions about the articulation of national educational systems with the labor market and the consequences of this articulation for both micro- and macro-outcomes.

TRAINING REGIMES AND THEIR CONSEQUENCES

Strengths and Limitations of Existing Research

In the past quarter century, a large literature has emerged on the question of how institutional and organizational characteristics of countries, schools, and firms are related to accessing positions in the labor market. Studies conducted in the 1980s found that the structure of training regimes affects the matching of school leavers to jobs, and through this mechanism, it also affects a country's distribution of school-leaving credentials (Maurice et al. 1986; Allmendinger 1989; Rosenbaum et al. 1990; Rosenbaum and Kariya 1991). Institutional linkages between school and work are, along with macroeconomic conditions, associated with national patterns of early career job search, unemployment risk and duration, and the rate and outcomes of job mobility. One aspect of educational systems that has appeared particularly relevant in many studies is the vocational education and training sector, with Germany's dual system as the prime example. Scholars have argued that in countries with extensive vocational education and training systems, the transition from school to work runs more smoothly than in countries where educational systems focus more on general education at the secondary and lower tertiary level (e.g., Shavit and Müller 1998). School-to-work linkages, moreover, are generally stronger when employers are connected to schools in one sense or another (Allmendinger 1989; Rosenbaum et al. 1990; Shavit and Müller 1998, 2000; Müller and Gangl 2003*a*; Wolbers 2007; Mayer and Solga 2008; Andersen and van de Werfhorst 2010). The evidence in favor of the German apprenticeship system has aroused debates in the United States about strengthening vocational education and training by increasing employers' involvement in community colleges (e.g., Hoffman 2011), even as other scholars argue that vocational education is detrimental because it lowers the odds of employment as workers progress through their career (Hanushek, Woessmann, and Zhang 2011; Forster, Bol, and van de Werfhorst 2016).

Various aspects of training regimes have been studied extensively in sociology (Allmendinger 1989; Blossfeld 1992; Kerckhoff 1996; Shavit and Müller 2006; Bol and van de Werfhorst 2013). Shavit and Müller (1998) summarized the important cross-national differences into four core characteristics of educational systems: (1) whether they provide general or specific vocational education,[2] (2) whether the educational curriculum is nationally standardized,[3] (3) the extent to which the system is stratified via early tracking into different curricula with little mobility among tracks (vs. later tracking with more similar curricula and more mobility among tracks), and (4) the extent of credential inflation. These distinctions incorporate an understanding of what Maurice et al. (1986) referred to as the contrast between "qualification" spaces, which are training regimes where vocational qualifications are used to allocate persons to jobs, and "organizational" spaces, which are training regimes where education provides general skills, with vocational skills then typically learned after the onset of the work career via on-the-job training. In their book, Germany was the model of a "qualification" space, and France was the model of an "organizational" space. Shavit and Müller (1998) argued that credential inflation is a particular problem in organizational spaces where job queues consist of generally educated applicants. In such systems, they contended, young people feel pressure to acquire more education in order to maintain a favorable position in the job queue. In contrast, the value of a credential in qualification spaces does not consist primarily in its position in the hierarchy of credentials but instead is derived from the specific skill it represents.

[2] General educational systems emphasize the teaching of general skills—literacy, arithmetic, general cognitive skills, basic cultural and communication skills—while specific vocational education systems focus on the teaching of particular functional tasks, e.g., the mastery of specific tools or machinery or crafts.

[3] Using Allmendinger's (1989, p. 233) formulation, "the degree to which the quality of education meets that same standards nationwide."

Meanwhile, the political economy literature has concentrated more intensively on studying the evolution and coevolution of market economies and education and training institutions. For example, it is argued that coordinated market economies, such as Germany or the Netherlands, have developed vocational educational and training (VET) systems that provide the range of specific skills required by firms in the production process. These institutions are maintained in coordinated market economies via the collaboration between state educational institutions and firms and are backed by state-sanctioned licensing requirements (Estevez-Abe, Iversen, and Soskice 2001; Iversen and Soskice 2001; Culpepper and Thelen 2008). The baseline argument of this literature is that vocational education can only be an attractive option for students if workers are protected against dismissal. Employment protection legislation, although not in the interest of employers, is traded for specific skills formation in the educational system. Thelen (2004) argued that vocational training systems were in fact fairly similar in Britain and Germany up to the first half of the 20th century. However, the vocational system was successfully maintained in Germany but not in Britain because relevant German stakeholders (unlike their British counterparts) were able to use these coordination mechanisms to modify the vocational training system to the changing environments. As a consequence, Germany successfully has maintained a high-skill, high-wage, manufacturing-centered economy (Soskice 1991; Streeck 1991; Hall and Soskice 2001; Thelen 2004).

Cross-national variation in the structure of market coordination can also be seen in the cross-national variation in licensing and credential requirements. Many occupations have licensing requirements even in liberal market economies such as the United States and the United Kingdom (Weeden [2002] found that 33% of U.S. workers in the middle 1990s were in occupations that require licenses).[4] In contrast, while the German labor market makes relatively little use of formal licensing requirements, it does extensively employ credentialing requirements, apprenticeships, and unionization, particularly for occupations that require high levels of technical skills.[5] Bol and Weeden (2015) estimate that 69% of jobs in the United Kingdom require either an intermediate certificate or a tertiary degree as compared with the 84% of jobs in Germany that require a vocational certificate or tertiary degree. The authors argue that the weaker reliance on collective bargaining (especially in the United States) and the stronger reliance on a relatively uncoordinated educational system with regard to the specific skill requirements of

[4] More recent estimates from the 2006 Gallup survey put the proportion of workers in a licensed occupation at 29% (Kleiner and Krueger 2010).

[5] Bol and Weeden (2015) estimate that only 5% of German workers are licensed, while Haput (2014) estimates that 14.5% of workers are licensed.

firms leads to an American workforce with greater inequality in both skills and earnings and a smaller manufacturing sector.[6]

These cross-national studies recognize that training regimes have an internal, differentiated structure. This recognition notwithstanding, studies of training regimes tend toward at least de facto treatment of countries as relatively homogeneous units of analysis, whose features can be described in terms of a few overarching dimensions. This approach fits readily with the idea of institutional coupling between education and the economy. Hall and Soskice (2001), to take a notable example, view this coupling as central to the enduring institutional continuities that produce country-specific responses to global challenges (e.g., the growing importance of the service sector even in countries like Germany) and that create system evolution without convergence (Müller and Gangl 2003*a*; Hillmert 2008).

However, this approach runs the risk of overemphasizing internal institutional uniformity and underappreciating the extent to which convergence, or the lack of convergence, varies across educational outcomes or across occupations. The upper tertiary education systems of Western European countries, for example, have been changing in partial synchrony in response to the ministerial agreements that are collectively known as the Bologna Process. Another example is the development in Germany of broader and more theoretical elite vocational programs that link a bachelor's degree with an apprenticeship in training in a workplace setting (Bosch and Charest 2012), even as the share of firms offering apprenticeships (especially among small firms) has dropped and the differentiation of apprenticeship options has widened (Thelen and Busemeyer 2012). A third example is the continuing development in the United States of new professional and technical jobs, for example, in information technology (e.g., network analyst or data communications analyst), in health fields (e.g., physicians assistant or skin care specialist), or in business (e.g., convention and meeting planners, cost estimators). Sometimes these new or growing labor market opportunities are accompanied by new licensing requirements (e.g., for skin care specialist), and in other cases not (e.g., for cost estimators). Patterns of hiring in the United States and perhaps also in other countries evolve through institutional forces other than licensing (e.g., the preference by employers for MBAs for certain jobs), which may function similarly to the set of explicitly professional degrees for these university-level jobs that are used in Germany or the Netherlands (van de Werfhorst 2004).

As a consequence of technological, market, and institutional change, the overall average difference between specific education-occupation linkages across countries will mask substantial variation in the size of country differ-

[6] Kleiner and Krueger (2010) found that U.S. licensing requirements had a weaker impact on within-occupation wage inequality than did unionization.

ences for specific educational levels, specific fields of study, and specific occupations. In addition, in most cases, employers will be more strongly incentivized by either technical imperatives or institutional pressure—including the legal force of licensing—to hire specifically trained individuals for highly technical occupations regardless of the overall structure of the "qualification" or "organizational" space. Understanding how cross-national educational differences affect cross-national differences in inequality requires theory construction and empirical measurement at the level of specific educational levels, fields of study, and occupations, as well as at the more macrolevel of countries, varieties of capitalism, and training regimes. This understanding is not yet well developed in the comparative literature on educational systems and school-to-work linkages and on their stratification consequences.

Arguments and research about these relationships typically have been carried out at highly aggregated levels of analysis. The economists Goldin and Katz (1998), for example, argued that rising inequality in the United States is explained by the failure of educational supply to keep up with the growing demand for high-skilled labor, but their test for the United States was based on an aggregate analysis with a crude two-skill (college and noncollege) operationalization. The political scientists Bradley et al. (2003) and Busemeyer and Iversen (2012) analyze the impact on inequality of national-level institutional features, such as union density, the centralization of collective bargaining, firm involvement in training, or public investment in vocational education. Comparative sociological approaches typically treat national institutions in terms of a few dimensions assayed through an examination of a country's institutional features. They then use country-specific regressions or multilevel regressions to examine the outcomes of these country-level institutional variables on individual-level outcomes such as occupational prestige, wages, the number of job shifts in the early career, or youth unemployment (Allmendinger 1989; Müller and Gangl 2003*b*). These literatures have been very productive, but at the same time they have abstracted away from the actual linkages between educational outcomes and occupational positions that—at a theoretical level—they contend are a central attribute of the education–labor market institutional complex. This abstraction has created empirical paradoxes that the literature has not satisfactorily resolved.

As one important example, in a large comparative project on 13 countries, Shavit and Müller (1998) concluded that the vocational specificity of educational systems was conducive to a smooth transition from school to work. However, while their study found support for this proposition at the country level, the expected microlevel association between educational track and labor market outcomes has been empirically elusive. The studies able to directly test this proposition at the individual level have not found strong evidence that the VET sector is particularly good for those who had been enrolled in vocational education (Iannelli and Raffe 2007; Wolbers 2007).

In short, the evidence is ambiguous on the microlevel foundation of more efficient transitions from school to work in countries with strong vocational training systems. To address these ambiguities, the literature needs to recognize that considerable heterogeneity may exist in the strength of linkages between qualifications and occupations within a specific country. Even in weakly linked societies, such as the United States is asserted to be, strong linkages will exist between fields of study that lead to regulated occupations such as professional positions in health, education, or engineering. An adequate framework for comparative and historical analysis must provide information about the granular structure of both strong and weak linkages so that we can understand how aggregate differences in employment, earnings, and mobility outcomes arise from structures as complicated as educational systems and labor markets.

The Theoretical Relevance of Linkage

When linkage is treated as a conceptual tool for theorizing and conducting empirical research, it becomes apparent that the granular as well as the macrostructure of linkage are salient for several important research programs in the social sciences. These programs can be stated in terms of both the causes and the consequences of a country's linkage structure.

Our approach, when applied to data, should provide insights into the question of how linkages emerge. Two research lines on these "causes" of linkage are as follows:

First, the political economy literature has mainly interpreted the German system as a "skills machine" (Culpepper and Finegold 1999) and largely assumed that it is the human capital generated in education that makes for strong linkages between education and occupation (van de Werfhorst 2011). However, as has been recently addressed, VET systems also involve strong regulation of access to occupations, which implies that mechanisms of occupational closure also shape the strength of linkages (Bol 2014; Di Stasio and van de Werfhorst 2016). Further comparative research can investigate the extent to which qualifications are strongly linked to occupations because of the skills they entail as opposed to institutionalized closure mechanisms that arise from broader political, economic, and cultural forces. Our conceptualization of linkage may also inspire research on the presumed coevolution of employment protection and the specificity of human capital laid out in the comparative political economy literature (Hall and Soskice 2001). From our approach, one could deduce the hypothesis that stronger linkage at the national level covaries with higher levels of employment protection or that weaker linkage at the group level coincides with higher levels of labor market flexibility.

Second, our approach additionally may encourage further research on the impact of educational standardization on the school-to-work transition (Allmendinger 1989). One question that emerges is whether we see stronger linkages in countries and fields where more nationwide standardization of curricula, examinations, and school resources takes place.

More generally, the linkage approach provides a more accurate and comprehensive measure of the precise ways that the educational system does or does not articulate well with the labor market. Consequently, it enhances the capability of scholarship to test theories of why and how occupational placement works differently in different societies.

Moreover, we expect that the linkage structure has many important consequences that intersect with existing research programs and yet are not well understood. Some of the most obvious intersections are as follows:

Outcomes.—The granularity of the linkage structure is likely to have an impact on the distribution of educational outcomes. The utility of particular levels of education and fields of study and their institutional availability strongly influences their rate of expansion and cross-national variation in the distribution of credentials. Weak linkage for specific educational pathways may, in turn, raise uncertainty about the value of these educational routes and diminish the rates of persistence in these fields.

Job access.—The structure of linkage may provide important insights into access to and exit from part-time and contingent jobs, including temporary jobs, jobs on fixed term contracts, and jobs that are irregular in terms of work schedules. We expect the linkage strength for workers in part-time and irregular jobs to be weaker than for full-time workers in regular jobs, but the extent of this difference may vary by country as a consequence of the extent of institutionalization of part-time or various forms of irregular work. Inequalities between irregular and more regular forms of employment may be partly related to linkage strength (and accompanying economic benefits) in some occupations rather than from the type of contract per se.

Within-occupation wage inequality.—Linkage structure may be an important component of the level of wage inequality within occupations. We generally expect that wage inequality within occupations would vary inversely with the strength of occupational linkage to the educational system. To the extent that workers within a single occupation have similar educational credentials, one might expect that their wages would be more similar both because their skills would be more similar and because they might more readily see themselves as similar and thereby deserving of comparable treatment in the labor market.

Between-occupation wage inequality.—Linkage structure may also affect the amount of inequality of wages between occupations. To the extent that greater occupational linkage implies a more uniformly trained workforce within a given occupation, linkage might improve the productivity and hence the typical pay of workers in that occupation. If greater occupational linkage implies greater solidarity among the workers within a given occupation, this solidarity might increase their ability to organize collectively and increase wages through collective bargaining and other mechanisms of occupational closure.

Gender and race.—Wage and earnings inequality by gender and by race/ethnicity may be expressed partly through gender and race differences in the linkage structure of educational outcomes and occupations. For example, the comparatively high gender inequality in Germany, which is often explained in terms of its conservative "familial" welfare state policies (DiPrete and McManus 2000; Aisenbrey, Evertsson, and Grunow 2009), may manifest occupationally if German women are less able to find employment in well-linked occupations or avoid educational fields of study that link strongly to occupational destinations. Such an explanation would illuminate processes by which welfare states and gender cultures create structural barriers to achieving gender equality. In a similar fashion, immigrants and their descendants may find it difficult to find employment in well-paying, strongly linked occupations and may therefore opt for more open, but also more disadvantaged, educational and occupational careers.

Career mobility.—Linkage structure is an important aspect of career mobility. Those with a credential from a strongly linked educational program may have less mobility over their career, given their specific degree and specific skill set. Furthermore, one might expect that the strength of linkages varies over the career and that the pattern of variation differs by country. Part of this variation may arise from economic and technological change that produces trends in the industrial and occupational structure and distribution of jobs. Part of the variation may arise from institutional flexibility or barriers to occupational mobility that would affect the relationship between years of labor force experience and the structure of linkage.

Positional goods.—Another broad research area served by our linkage approach concerns the positional character of educational qualifications. It has recently been argued that education works more as a positional good in environments with weak ties between education and occupation (Di Stasio, Bol, and van de Werfhorst 2016). From this it would follow that the positional character of education would be more evident in societies and labor market segments with weak linkages between education and occupation, leading, for instance, to higher levels of overschooling.

Microclass approach.—Finally, the structure of linkages may be relevant to scholarship on occupational "microclasses" (Grusky and Sørensen 1998; Weeden and Grusky 2005). The microclass approach emphasizes that important forms of within-group homogenization take place at the level of (detailed) occupations, rather than at the level of broad social classes as was previously assumed in class theories. Three such homogeneity-inducing mechanisms are allocation (who enters which class), social conditioning (with which group does one identify with), and the institutionalization of conditions (processes along which work is organized and rewarded; Weeden and Grusky 2005). It is evident that linkages between educational qualifications and occupations are key to all three mechanisms of class formation. In other words, if one believes that class formation occurs through these three processes, and that occupations are the level of disaggregation at which researchers should then focus, it is important to understand clearly how education and occupation, in detailed ways, are linked (van de Werfhorst and Luijkx 2010). As such, the study of linkages may address criticisms of the occupation-oriented study of stratification made by proponents of "big class" research (Goldthorpe 2002) by using the occupational level of analysis to better understand how educational outcomes are linked to placement in "big classes."

We develop an analytical framework for measuring both the granular structure and the macrostructure of linkage in the next section. In the process, we demonstrate its value for institutional analysis by using it to address two specific substantive questions. First, we revisit the differences in linkage structure between France and Germany that are predicted (but rarely studied empirically) from the "organizational space" versus "qualificational space" distinction of Maurice et al. (1986). Maurice et al.'s evidence was largely taken from only a portion of the industrial distribution (metal and petrochemical manufacturing). Moreover, their research is now over three decades old and does not reflect changes that have taken place in the French educational system (Goux and Maurin 1998; Ichou and Vallet 2013). It is important, therefore, to investigate the comparative linkage structure of these two countries to determine whether the observations of Maurice et al. adequately describe the current reality. In addition, we include the United States in the analysis because of its institutional differences from both France and Germany. The United States is a country that generally lacks a differentiated vocational education and training system at the secondary level, and it is known to have diffuse pathways from many of its postsecondary programs into the labor market (Rosenbaum, Deil-Amen, and Person 2007).[7] Both of these characteristics would be expected to give the United States a distinctive linkage structure.

[7] Most American high schools differentiate between a college preparatory and a general or vocational track, and we take this into account later in the article. American high schools often offer courses with specific vocational content, but these courses do not typically amount to a formal program or specialized diploma.

Second, we demonstrate how an understanding of the differences between the linkage structure of the United States and Germany provide insights into the earnings distributions of the two countries that go far beyond the insights provided by the country-level characteristics approach of the comparative stratification literature. We have two specific theoretical expectations. The first is that within-occupation earnings inequality will vary inversely with the strength of occupational linkages. Greater linkage means less educational variation, which should imply lower earnings inequality. Beyond this expectation, however, we address the question whether country differences in relative occupational earnings vary systematically with country differences in occupational linkage strength. If tighter matches between credentials and occupations either produce a more productive occupational workforce or enhance the ability of occupational incumbents to bargain collectively, the result would be higher mean earnings in that occupation than would be the case otherwise.

ANALYTICAL STRATEGY

We describe in detail the computation of linkage strength in appendix A. Here we provide a nontechnical understanding of the basic concepts and results.

We conceptualize the strength of linkages in terms of the association between school-leaving credentials and labor market position. For any given school-leaving credential, a strong linkage occurs when school leavers with that credential cluster in a relatively small number of labor market positions. When field of study is taken into account, the clustering should be even stronger. When this pattern occurs across the distribution of qualifications and fields of study, then education is tightly linked to the labor market. The linkage measure is inherently relational. It measures an association between educational and occupational outcomes that is simultaneously *granular*—it provides information about the strength of linkage for specific and in principle highly detailed educational or occupational categories—and *macrostructural*, in that it characterizes linkage strength for particular levels of education, particular sectors of the labor market, or for the country as a whole. As we argue above, the linkage structure of a country arises from institutional characteristics of both its educational system and its labor market, and the causal effects of these two systems are entangled because they develop and change in reaction to each other. In this section, we focus on the linkage measure itself.

The theoretically most appealing measure of association for this phenomenon comes from the generalized entropy family of segregation measures (see Mora and Ruiz-Castillo 2011; see also Theil and Finizza 1971; Theil

1972; Reardon and Firebaugh 2002). These measures are based on the concept of entropy. We refer to them as "linkage" measures below, although it should be kept in mind that they are formally identical to multigroup segregation measures. It is also important to keep in mind that segregation in our context implies a tighter coupling between educational credentials and the occupational structure of the labor market. In other words, a labor market that is relatively highly segregated by educational credentials is one in which linkage between education and occupation is strong. We begin with a formal discussion, and then later we provide a more intuitive and substantive interpretation that gives substantive meaning to linkage scores of a given strength.

Entropy measures are based on the amount of additional information one gains about an outcome by knowing a particular characteristic of the individual. For example, entropy-based segregation measures for a city reflect the gain in one's ability to predict the neighborhood someone lives in if one knows that person's race. Entropy-based measures of education-occupation linkage strength reflect the gain in our ability to predict an occupation if we know the person's educational category or, correspondingly, the gain in our ability to predict a person's educational level and field of study if we know that person's occupation. We specifically use the Mutual information index (M index, represented formally by M) to measure linkage strength (Mora and Ruiz-Castillo 2011). We start with the concept of the entropy of a distribution of workers over education categories or, correspondingly, over occupation categories; if P_g is the distribution of workers across education categories indexed by g, then we write $T(P_g)$ as the entropy (see app. A for more detail). The M index measures the average reduction in entropy in P_g between its overall value and its value within a specific occupation, averaged over all occupations:

$$M = \sum_{j=1}^{J} p_j (T(P_g) - T(P_{g|j})),$$

where $j = 1, \ldots, J$ indexes occupations. Intuitively, M is a measure of the increase in the ability to predict what educational outcome a worker had if we know his occupation, averaged over all occupations. Equivalently, M can be written as a sum over all educational categories and described as a measure of the increase in the ability to predict what occupation a worker is in if we know his educational outcome, averaged over all educational outcomes.

We will refer to M as the linkage strength in a country for some specific set of education and occupation categories. As with segregation measures, M depends on the categories used (e.g., neighborhood-level segregation is different from and typically greater than city-level segregation). We are typically interested in education categories that differentiate both educational level and field of study with as much detail as is practical. We are also interested in detailed occupational categories that are nested within a set of major occupational groups. For comparative analysis, we are interested in harmonized categories that make use of as much detail as possible concerning educational levels, fields of study, and occupations, while at the same time maintaining comparability across either countries, historical time, or both.

The M is an attractive measure of linkage strength at the level of detailed education-occupation categories because we can decompose it in three different ways that provide substantive insights into both the macrostructure and the granular structure of linkage strength. The first decomposition allows us to determine the extent to which linkage between detailed educational and occupational categories occurs primarily at the major occupational group level or at the level of detailed occupations within major groups. This first decomposition, which is enabled by a nested structure of fine-grained subgroups within major groupings, also allows us to compare the relative importance of educational levels and of fields of study within educational levels in constituting the overall structure of linkage between detailed education-occupation categories in a country. Decomposing total linkage into components derived from major occupational groups versus detailed occupations or from educational levels versus fields of study can provide important analytical insights into the granular structure of total linkage strength.[8]

The second decomposition resolves the total M into "local" linkage components for every specific occupation or educational category. As can be seen in equation (1), total linkage is the weighted average of local linkage scores, where the weights are the respective proportions of the categories. Notably, M can be expressed as a weighted average of the educational outcome linkage scores (M(ed) indexed by g in eq. [1]), or as the weighted average of the occupation linkage scores (M(occ) indexed by j in eq. [1]). This second decomposition is important because it allows the researcher to assess the contribution of each occupation and educational category to a country's overall structure of linkage. Local linkage scores are useful because they allow researchers to assess how variation in the linkage scores for specific educational or occupational categories across countries or over time are related to variation in employment, earnings, and career outcomes.

[8] An earlier approach to the dispersion of educational fields of study across occupations used the Gini-Hirschman index (Allen et al. 2000) with Dutch data on graduates from universities and vocational colleges (HBOs) and lacked the decompositions that illuminate comparisons across countries and over time. For a related contemporary approach using the Gini concentration index applied to a sample of 4,898 respondents from the Austrian Labour Force Survey, see Vogtenhuber (2014).

$$M = \sum_{g}^{G} p_g M(\text{ed})_g = \sum_{j}^{J} p_j M(\text{occ})_j. \quad (1)$$

Country differences in M will be influenced by country differences in the marginal distribution of educational categories and by the marginal distribution of occupations. However, M allows a third type of decomposition to isolate that part of the country difference in M that is composition invariant by education categories, separating this distinct structural element from that part of the country difference in M arising solely from differences in the marginal distribution of education in the two countries, as well as that part of the country differences in M emerging from country-specific entropy of the occupational distribution (Mora and Ruiz-Castillo 2011). This third decomposition alternatively can be expressed as a term that is composition invariant by occupations, a term that arises solely from differences in the marginal distribution of occupations, and a term that arises from country differences in the entropy of the educational distribution.

The linkage measures defined above have statistical distributions that are described in Mora and Ruiz-Castillo (2009*b*). Because our sample sizes are large, sampling error is generally not large enough to be of substantive importance. For results where sampling error is of interest, we estimate standard errors using bootstrapping.

A fair question to raise is about the substantive meaning of a total linkage score for a country. Mora and Ruiz-Castillo (2011) note that M obtains its maximum value for any given educational distribution at the value of occupational entropy for that specific country or time point, but this does not provide useful intuition. It does not, for example, provide a substantive interpretation about the difference between an M of 1.0 and an M of 0.5. Because the total M is a weighted average of local linkage scores, the question about the meaning of M can be reframed as the meaning of a specific level of local linkage for an educational outcome or for an occupation. Measures of local linkage provide information about the extent to which workers with a given educational outcome are clustered in a relatively small number of occupations or about the extent to which workers in a given occupation mostly have one of a small number of specific educational outcomes. We will use this principle later in the article to provide a more intuitive interpretation of the size of linkage strength.

CLASSIFICATION SCHEMES AND DATA

We analyze large-N labor force microdata for France, Germany, and the United States. In the first instance, we focus our analysis on a comparison of the entire workforce, operationalized as employed persons who are not full-time or part-time students. In order to get a more contemporary comparison of linkage strength across the three countries, we then restrict the analysis to workers who are no more than 10 years past the normal school-leaving age for someone with their educational level. As we show below, country differences using the full workforce are very similar to country differences using workers who left school within 10 years of the date of data collection.

For France, we use the Enquête Emploi, which is a quarterly labor force survey of 60–80,000 household members. The Enquête Emploi uses a rotating format, where all respondents in principle participate in six quarters (1.5 years). We use all unique observations matching our schooling restrictions from the years 2005–12 in order to increase sample size. Our analytical sample for the entire workforce is 221,082.

For Germany, we use the Mikrozensus of 2006. The Mikrozensus is a random sample of roughly 1% of German households with about 70% of these cases available for analysis in the anonymized scientific use file. All household members who are 15 years or older are interviewed. The analytical sample for the entire German workforce is 200,401.

For the United States, we use a combination of U.S. Census data, specifically the 2009 American Community Survey (ACS) and the Survey of Income and Program Participation (SIPP) Topical Modules on Education and Training (plus core SIPP data) for the 2004 and 2008 panels. The ACS is a survey of roughly 1% of the American population that contains information about field of study for the bachelor's degree for respondents who have graduated from a four-year college. We supplement the ACS with the SIPP because the ACS does not contain information of field of study for lower tertiary educational credentials or for postgraduate degrees. The SIPP provides information about fields of study for those who attained two-year degrees, including both occupational and academic degrees. It also provides information about fields of study for those who obtained high school diplomas or certificates from vocational, technical, trade, or business schools. Finally, the SIPP provides information about fields of study for those who obtain postgraduate degrees.

The SIPP panels have realized sample sizes of 35,000 or more households for each of the two panels (i.e., 70,000 for the combined SIPP samples). Because of the desirability of employing the large sample size of the ACS whenever possible, we also adopted a second imputation strategy using ACS data alone for measuring the contribution to linkage strength of workers with graduate degrees. This alternative strategy produced almost identical results as with the SIPP for the overlapping educational categories, and it has the virtue of retaining a larger number of educational categories for the comparative analysis. We describe this alternative strategy below. Using the same sample restrictions for the United States as for Germany and France gives an analytical sample of 1,449,070 for the United States. Since the SIPP contributes many fewer observations to the total sample size than does the ACS, the SIPP weights are rescaled to align with the weights in the ACS.[9] Although the years covered by the data vary somewhat (from 2004 to 2012, depending on the country), we do not believe that the structure of linkages has changed so rapidly over this period as to introduce major problems for the analysis.

Education provides not only access to specific occupations but also favorable chances to be employed at all, which matters more during periods of economic contraction than during economic expansion. In 2006, the unemployment rate in Germany was 11%. The French unemployment rate averaged 8.9% over the years for our data. The U.S. unemployment rate in 2009 (when our ACS data were collected) was 9.3%. Limiting the analysis to those with an occupation produces approximately the same rate of selection in all three countries, although it should be kept in mind that we are studying linkage strength by educational categories, conditional on having a job. A next task, obviously, is to examine country variation in the impact of educational levels and fields of study on the probability of having a job, or of having a secure job, as well as country variation in the interaction between educational levels and fields of study and macroeconomic conditions on the probability of having a job or a secure job. Similarly, there are important distinctions between having a full-time job or a part-time job. There are also important distinctions between having a relatively secure job or an insecure job that is institutionalized in terms of fixed or indefinite term labor contracts in the European context, or jobs understood to be temporary in the American context (Kalleberg, Reskin, and Hudson 2000; Maurin and Postel-Vinay 2005). It is highly desirable to analyze the variations in the structure of linkage strength with aspects of the employment contract (just as it is desirable to analyze variations in linkage strength by age or gender), but these analyses are necessarily out of scope for the current article and are included in the broader future research agenda discussed above. Our first objective is to understand the aggregate linkage structure for the employed workforce in the three countries, and that is where we focus the initial analytical effort.

Occupation

The United States, Germany, and France each have their own occupational coding schemes that are based on country-specific logics and idiosyncrasies (Levine, Salmon, and Weinberg 1999; Brousse 2009; Paulus and Matthes

[9] We used the 2009 ACS because its use of the census 2000 coding allowed a more direct conversion to ISCO-88. Because 2009 was the depth of the recent recession, we also estimated the U.S. linkage structure with 2011 ACS data. The results using 2011 data are very similar to the results using 2009 data.

2013). ISCO (the International Standard Classification of Occupations) is a skill-based occupational classification system developed at the International Labour Office to provide the basis for comparing countries. The major international class and status schemes (e.g., EGP, International Socioeconomic Index [ISEI], Standard International Occupational Prestige Scale) are based at least in part on ISCO (Ganzeboom, De Graaf, and Treiman 1992).[10] The European Union (EU), moreover, requires the national statistical agencies of the member countries to include ISCO coding for occupations in the national labor force surveys. ISCO has been regularly included in data sets produced by the National Opinion Research Center and has been adopted as the standard for occupational classification by ZUMA (Ganzeboom and Treiman 1996). At the same time, each of the countries under study in this article has maintained its own national systems that deviate in various respects from ISCO, with the consequence that greater occupational detail can be reliably obtained from the national classification systems even as ISCO remains the best option for comparative analysis at a reasonable level of detail.

In this article, we primarily use three-digit ISCO for cross-national comparisons because it is the international standard and, by EU regulations, is already coded into the German and French data by the national statistical agencies. We converted U.S. Census 2000 codes into ISCO-88 codes using an existing crosswalk (Elliott and Gerova 2005). In our analyses we nest detailed three-digit occupations (e.g., police inspectors, health professionals, primary school teachers) within 10 major occupational groups, which are defined as the first digit of this classification. A listing of the major occupational groups as well as the detailed occupations in our study can be found in tables D3 and D4. We harmonized the ISCO-88 three-digit groups so that the same 90 occupational categories were used in all three countries.

In addition, we employ a sensitivity check on our results by redoing our analyses using native occupational classifications for each country, specifically the French National Classification of Occupations and Socio-Occupational Categories 2003 (PCS-2003), the Klassifizierung der Berufe 1992 (KldB-1992) for Germany, and the 2000 census occupational codes for the United States. The native classifications are considerably more detailed than are the three-digit ISCO categories, and therefore they enable a more finely resolved measure of linkage. Even though results using native categories are not directly comparable across countries, they allow us to determine whether the conclusions that we draw using ISCO are robust to the differences between international standard coding schemes and native coding schemes for occupa-

[10] The Erikson and Goldthorpe (EGP) class schema also use information on employment status (especially employee vs. self-employed) and on the supervisory responsibilities of the job. ZUMA = Zeutrum für Umfragen, Methoden, und Analysen (Center for Survey Research and Methodology).

tions. The use of native occupational codes raised the number of occupational categories to 486 in France, 337 in Germany, and 471 in the United States.

Education

All comparative studies on education face the difficulty of measuring education in consistent ways cross-nationally. A substantial literature has evolved on how one can achieve maximum comparability of educational qualifications with a minimum loss of information (e.g., Müller and Karle 1993; Ishida, Müller, and Ridge 1995; Kerckhoff, Ezell, and Brown 2002; Schneider 2010). In this article we rely on the International Standard Classification of Education 1997 (ISCED), which distinguishes vocational and general/academic forms of secondary and tertiary education (UNESCO 2006). This variable, which we denote as "educational level," is rather similar to the CASMIN (Comparative Assessment of Social Mobility in Industrial Nations) classification of educational attainment that is used in much of the comparative work to date. However, we prefer ISCED over CASMIN as the CASMIN project did not include the United States and hence is less suitable for comparisons including that country (Kerckhoff et al. 2002). ISCED has been used in major international surveys such as the European Social Survey, the European Union Statistics on Income and Living Conditions , and the Program for International Student Assessment studies. Our ISCED measure consists of 12 levels of education, which ranges from no education (ISCED level 0) to post BA (bachelor of arts) degrees (ISCED level 6). Not all levels are available in all countries, but the number of available levels is 9 in Germany, France, and the United States. The ISCED codes for France and Germany are assigned by the national statistical agencies, and for the United States we performed a conversion of U.S. categories into ISCED categories. Because of the importance of the distinction between a master and a doctoral level postgraduate degree in the United States, we separate these into levels 6A and 6B. The educational information available in the German and French data do not allow a separation between bachelor's and master's degrees, which did not exist as separate degrees before the Bologna Process that harmonized European higher education systems gradually since 1999. The equivalent of the standard university degrees in France and Germany is coded 5A by the national statistical agencies.[11] In the analyses below, we present results based on the full set of ISCED distinctions available in the data as well as some additional collapsing of ISCED levels to achieve greater harmonization (and later in the article we consider distinctive American highest level of schooling completed features

[11] In this article, we employ the convention of placing level 6 German and French workers into level 6A in charts and tables that include U.S. data that make use of the 6A and 6B distinction.

such as the GED [general educational diploma] and "some college" without a credential). A summary of the ISCED levels can be found in table D1.

Fields of study within levels of education are also harmonized using the ISCED. We use the two-digit fields of study measure, which distinguishes a maximum of 24 fields within levels, and we code the field of study information in the data for the three countries into these fields. Examples of the two-digit ISCED fields include "health," "personal services," and "business and administration." A complete list of all the two-digit ISCED fields of study is in table D2. Our coding system includes an "other" code for those respondents who had a field of study that was not classifiable into one of the 24 explicit fields. Individuals whose field was "general" are included in a "general" field (for some educational levels in some countries, everyone at this level is in "general"). A very small fraction of the respondents had a missing field (these individuals had a field, the field was not "other," but it was not recorded because of refusal or some other reason). This very small number of individuals with missing fields were dropped from the analysis.

Our final educational measure is a combination of a specific educational level and field of study (we sometimes refer to this combination as "level field"). In each country, fields of education are nested within levels of education. If all levels had all fields, we would have 216 (9×24) different categories in our educational variable, but of course many of these combinations are nonexistent (e.g., there are no fields in primary education). More generally, the number of level-field combinations that are available, as well as the content of these combinations, differs across the countries under study. To give an example, in Germany one can obtain a business and administration qualification at the upper secondary level, whereas such a qualification is not available in the United States. In general, we do not have information about fields of study at the secondary level in the United States because, for the most part, they do not exist as distinct school-leaving credentials. Later in the article, we examine both the difference in linkage strength across the three countries that stems from their entire (harmonized) set of school-leaving outcomes and also the difference that exists between the United States and the European countries if we suppress secondary fields of study in France and Germany to artificially match the lack of field differentiation in American secondary school-leaving credentials.[12]

We only include level-field combinations with at least 100 observations in order to mitigate sparseness bias that would otherwise inflate the calculated value of M. Given the size of the samples we employ, the excluded

[12] Later in the article, we also address the implications of distinguishing between American workers whose highest educational attainment is high school completion who studied in a "vocational/business" high school program vs. an "academic/general" high school program.

categories contain a very small portion of the working population in each country (.77% in Germany, .73% in France, and .0001% in the United States using the "ACS-boost" imputation described below). Using the 100 observation threshold along with the obvious condition that the category must exist in a country in order to be included results in 73 educational categories in France and 82 categories in Germany.

When using the SIPP data for graduate degrees as well as for community college and occupational certificate degrees, we obtain 58 educational categories in the United States using the 100 observation threshold. In appendix C, we examine the impact of lowering the observation threshold for the SIPP from 100 to 50, and we also employ two alternative strategies for imputing fields of study for graduate degrees using the ACS. All four of these methods produce very similar results and create high confidence in our imputation method of choice. We describe the approach employed in the article's main tables as the "ACS-boost" imputation. We identified a set of occupations (entirely professional and managerial) for which graduate degrees are common and would (for licensing or other reasons) very frequently be in the same field as the occupation itself (this list is in app. C). We then used the ACS data to determine the proportion of workers in these occupations that had a bachelor's and also a postgraduate degree. We next selected at random the fraction of workers in this occupation from the BA + ACS sample and assigned their field of study to the field that most closely matched their occupation. For the remaining workers, we retained the BA field of study recorded in the ACS. For example, if 30% of civil engineers had a postgraduate degree, we chose 30% of the BA + civil engineers in the ACS at random, and we changed the field of study for that 30% to engineering while leaving the BA field of study from the ACS in place for the other 70% of civil engineers. Even though we are forcing tight linkage for a (varying) fraction of the postsecondary degrees in this imputation, the M computed is almost identical to the M computed using the actual graduate degrees reported in the SIPP, which is reassuring given that graduate degree holders make a greater contribution to total linkage strength than their relatively small share of workers might suggest (see fig. 3 and app. C). Using the imputation method allowed us to expand the number of education categories in the United States from 58 to 81. We therefore focus our analysis of the U.S. data on the ACS-boost imputation for graduate degree holders while continuing to employ the SIPP data for community college graduates and postsecondary occupational certificate holders.

For any given category scheme, M is sensitive to sample size, which means (as we verified through simulation studies) that the calculated value of M is larger when cells are only sparsely filled. To make sure that our analyses are not affected by this, we ran our analysis on smaller randomly drawn subsamples of the original sample and examined how this affected M. These sensitivity analyses showed that total linkage strength only increased when the sample size was smaller than 200,000 observations with our operationalization of occupations, educational levels, and educational fields, and the "sparseness" bias only became notable (greater than 3%) when the sample was around 30,000 or less. The sample size in each of our three countries was so large as to make sparseness bias unimportant.

As described above, we also did a sensitivity check by using native coding in place of harmonized coding for each of the three countries. In the case of education, we focused on the native field of study codes in the Enquête Emploi for France and the Mikrozensus for Germany, which we combined with CASMIN educational levels in order to obtain level-field combinations. This substitution increased the number of educational categories in France from 73 to 216 and in Germany from 82 to 205. For the United States we used the full set of fields of study in the SIPP and in the ACS, which was not much larger than the number of harmonized fields. We also created additional educational levels for GED and for some college with no degree. This elaboration raised the number of educational categories in the United States from 82 to 90. Then, in a separate analysis (which only uses SIPP data for respondents whose maximum education was high school), we differentiated between high school graduates (but no college) who studied in a vocational or business-oriented high school program and high school graduates who studied in an academic or general high school program. This elaboration had only a very minor impact on the American results, and so we do not report these elaborated results here.

To repeat, we first focus our analysis on a comparison using harmonized categories because they are directly comparable across the three countries. We then determine whether the conclusions we reach using the harmonized categories appear consistent with the picture obtained using native categories.

RESULTS

Table 1 shows the differences in the distribution across educational levels in the three countries. The main differences can be readily summarized. First, while the American lead in rates of college graduation in recent cohorts has been eroded (DiPrete and Buchmann 2013), the United States continues to have a higher fraction of workers who have an upper-level tertiary degree or higher. At the lower tertiary level, however, France and Germany have more degree holders than does the United States. Secondary school graduates are organized differently across the three countries. In the United States, 2B and 2A correspond to high school dropouts, while those with no more than a high school diploma or a GED are in 3A. Germany has 7% of its workforce coded into 4A, which are one-year programs in specialized vocational high schools concluding with a vocational credential and a school-

TABLE 1
DISTRIBUTION BY EDUCATIONAL LEVEL IN FRANCE, GERMANY, AND THE UNITED STATES (%)

Level	Description	France	Germany	United States
0	Preprimary education	.5	...	.8
1	Primary education	6.6	2.1	3.5
2B	Lower secondary, direct access to 3C	...	8.3	3.6
2A	Lower secondary, access to 3A/3B	17.3	3.4	4.1
3C	Upper secondary, labor market access	28.0	...	...
3B	Upper secondary, access to 5B	4.0	49.8	...
3A	Upper secondary, access to 5A	12.3	2.2	51.6
4A	Preparation for entry to level 5	...	7.3	...
5B	Tertiary education, occupation specific	13.0	9.8	6.8
5A	Tertiary education, theoretical	17.8	15.9	18.9
6	Tertiary education, advanced (Germany and France)	.6	1.3	...
6B	Tertiary education (U.S. master's)	...	...	7.5
6A	Tertiary education (U.S. Ph.D.)	...	...	3.4
Total		100	100	100

NOTE.—Percentages are based on the weighted analytical samples for each country.

leaving certificate that typically qualifies the holder for higher education (e.g., a *Fachhochschulreife*). In some of the analyses below, we collapse the sublevel categories at levels 2 and 3, and we group 4A with lower tertiary (5B) in order to create greater comparability across countries.

We start with a baseline analysis of linkage strength by focusing solely on the linkage characteristics of educational levels without any consideration of fields of study. We do this because almost all the comparative literature has restricted attention to the study of educational levels, and so it is important to know how much of a difference it makes when fields of study are included in the analysis. Table 2 shows that the overall strength of linkage between educational levels and detailed harmonized occupations (as measured by M) is roughly the same size for France and Germany, and both of these countries have somewhat higher linkage strength than the United States. Moreover, the contribution of specific ISCED levels to overall linkage strength differs considerably by country; as we will see below, these differences stem from a combination of country differences in the distribution of workers across educational levels and country differences in the linkage strength of specific educational levels.

We then examine the extent to which level-field combinations matter for total linkage strength. To do so, we use equation (A1) to decompose total linkage strength—measured using detailed harmonized occupations, ISCED educational levels, and harmonized fields of study—into four terms:

TABLE 2
LINKAGE STRENGTH FROM ISCED EDUCATION LEVELS ONLY (Ignoring Field of Study) IN FRANCE, GERMANY, AND THE UNITED STATES

Level	Description	France	Germany	United States
0.	Preprimary education	.004	. . .	.004
1.	Primary education	.034	.017	.024
2B	Lower secondary, direct access to 3C	. . .	.040	.016
2A	Lower secondary, access to 3A/3B	.031	.006	.014
3C	Upper secondary, labor market access	.053	. . .	. . .
3B	Upper secondary, access to 5B	.010	.061	. . .
3A	Upper secondary, access to 5A	.016	.006	.047
4A	Preparation for entry to level 5	. . .	.020	. . .
5B	Tertiary education, occupation specific	.056	.028	.007
5A	Tertiary education, theoretical	.122	.129	.056
6.	Tertiary education, advanced (Germany and France)	.012	.028	. . .
6B	Tertiary education (U.S. master's)	. . .	. . .	.054
6A	Tertiary education (U.S. Ph.D.)	. . .	. . .	.052
Total . . .		.340	.335	.274

A. Linkage across occupational major groups by educational levels.
B. Linkage across detailed occupations within major occupational groups by educational levels.
C. Linkage across occupational major groups by educational fields within levels.
D. Linkage across detailed occupations within major occupational groups by educational fields within levels.

Decomposition term A resembles most strongly the focus of the current school-to-work literature; it analyzes the extent to which total linkage strength—measured at the level of detailed education and occupation categories—arises from the process by which educational levels sort workers into major occupational groups (e.g., managers vs. clerical workers or skilled manual workers vs. low-skill manual workers). Term B of the decomposition brings more detail into the occupational structure, while keeping the focus on educational levels. This term will increase if there are educational levels that sort clearly into specific occupations within major occupational groups. The magnitude of decomposition term C measures the extent to which specific fields of study within levels of education sort people into particular major occupational groups, for instance, when lower tertiary graduates from engineering programs are more likely to be employed in the group of "lower professionals, technicians" while lower tertiary graduates in personal services are more likely to be "service/sales workers." The fourth and last term (term D) measures the contribution of specific linkages between detailed occupations within major groups and educational fields of study within educational levels. The magnitude of this term depends on whether there is clear sorting from specific fields of study to specific occupations within major occupational groups, for instance, when graduates from medical school enter the occupation of medical doctor as opposed to engineer (both being professions). The relative contribution of these four terms to a country's total linkage strength is shown in figure 1.

Figure 1 shows that a sole focus on educational levels (see table 2) greatly understates both the total linkage strength and the difference in linkage strength across these three countries. Fields of study contribute substantially to total linkage, accounting for 67% of total linkage strength in Germany, 56% in France, and 41% in the United States. When these field of study contributions are taken into account, it is evident that Germany has a greater total linkage strength than France, and the United States has relatively weak total linkage

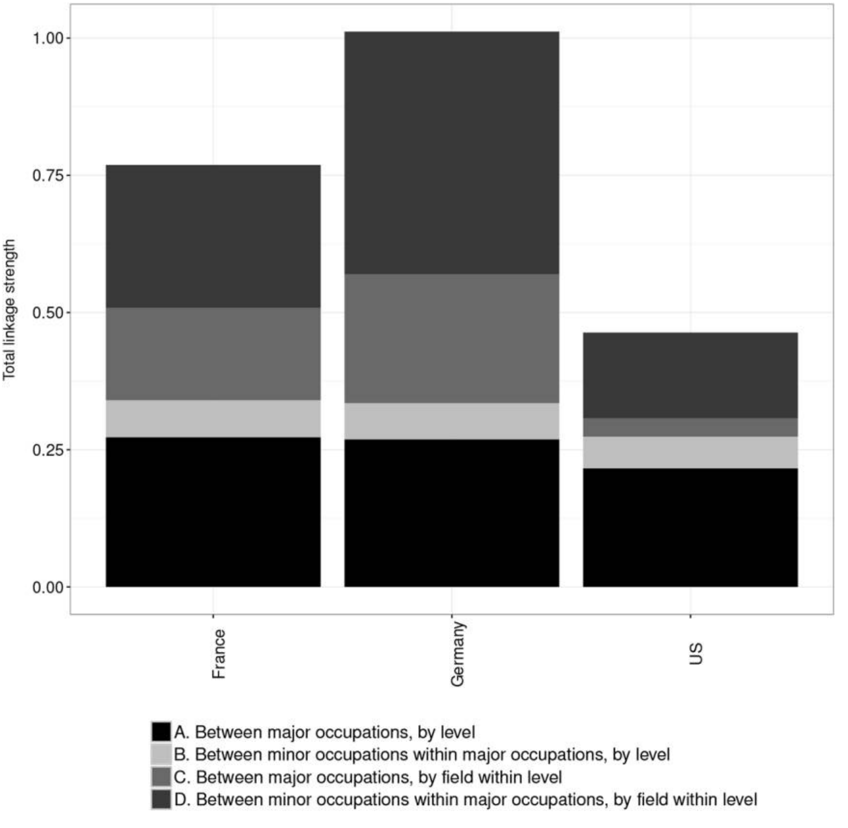

FIG. 1.—Total linkage strength of educational levels and fields of study in France, Germany, and the United States. Color version available as an online enhancement.

strength. We see that the ability of specific fields of study within educational levels to sort workers across occupational major groups is an important reason why M is higher in Germany and France than it is in the United States. The specific sorting consequences of fields of study, moreover, differ between Germany and France. While the sorting of fields of study into major groups contributes more to total linkage in Germany than in France, we see in figure 1 that much of the larger harmonized detailed linkage strength in Germany relative to France comes from the linkage of specific fields of study within educational levels to specific occupations within major occupational groups.

The contributions to the total linkage strength of a country come from the size of the linkage scores for each educational category weighted by the relative size of the educational category, or equivalently from the size of the linkage scores for each occupation weighted by the relative size of the occupation (see eq. [1]). The local linkage scores themselves are precisely defined in appendix A in terms of the average of (a function of) the ratio of the proportion of the workforce in specific occupation-education categories compared with what the proportions would be if education and occupational outcomes were independent. More concretely, they indicate how much clustering there is in terms of occupational destinations, conditional on education, or in terms of educational origins, conditional on occupation. The higher the local linkage score, the greater is the proportion of workers with that educational outcome who are located in the most common occupational destinations for that particular educational outcome. This fact provides a simple way of obtaining useful intuition about what local linkage scores mean in substantive terms.

As we show in table D8, we can accurately predict the proportion of workers in, for example, the three most common occupational destinations, or the five most common occupational destinations, or the 10 most common occupational destinations, as a function of the educational linkage score. Importantly, these prediction equations are very similar for all three countries. In rough terms, one gets a pretty good prediction of the proportion of workers with a given educational outcome in the three most common occupations as one-fifth of the linkage score plus 0.2. In other words, if the local linkage score is 0.4, roughly $.2 + .2 \times .4 = .28$ (i.e., 28% of the workers with that educational outcome) are predicted to be in one of the three most common occupational destinations for that educational outcome. If instead, the local linkage score is 2.0, then roughly $.2 + .2 \times 2 = .6$ (i.e., 60% of the workers with that educational outcome) are predicted to be in one of the three most common occupational outcomes for that educational category. A similar calculation can be done if we are focusing on occupational linkage scores instead of educational linkage scores; in the case of occupational scores, the prediction concerns the proportion of workers in the occupation who have one of the three most common educational outcomes for workers in that occupation.

Figure 2 demonstrates the connection between local linkage scores and clustering for three educational outcomes in Germany. A health degree at ISCED 5AB/6 in Germany has a very high local linkage score of 3.42: 90.5% of the workers with this outcome are in the three most common occupations for that educational outcome, with almost all of these workers being in the health professionals occupational category. Math and statistics (ISCED 5AB/6) has a local linkage score of 2.07. Most of these workers (64.6%) are in the three most common occupational destinations for this educational outcome, with about 4 in 10 being in mathematics and statistics. Graduating in health

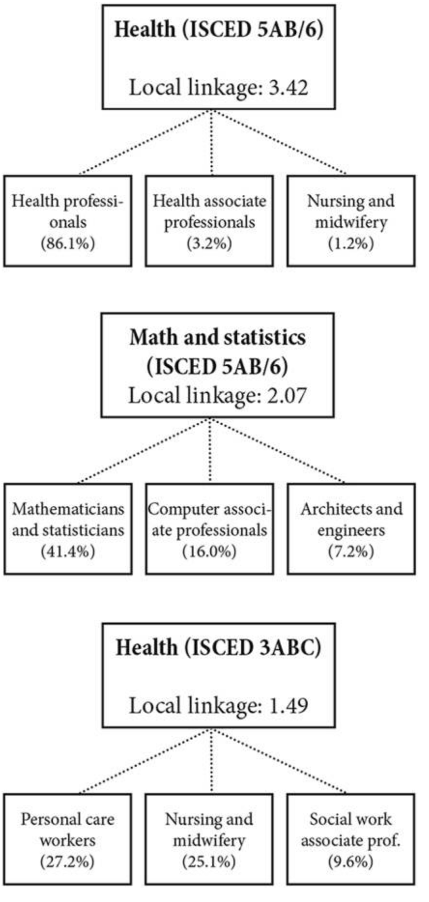

FIG. 2.—Proportion of workers in the three most common occupational destinations, for three illustrative educational outcomes in Germany. Percentages for each of the three educational outcomes sum to less than 100% because some workers with each of these educational outcomes are in occupations other than the three shown. Occupations shown are the three most common occupational destinations for workers with the indicated educational outcome.

at ISCED 3ABC has a local linkage score of 1.49. For this educational outcome, 61.9% of these workers are in the three most common occupations, with only 27.2% being located in the most common occupation (personal care workers) but another 25.1% being in nursing and midwifery. These three educational outcomes reveal very clearly the connection between the size of the local linkage score and the extent of occupational clustering for workers with any given educational outcome.

Moreover, because total M is the weighted average of the local linkage scores (using either the educational or the occupational scores), we can readily interpret the difference between the total M for Germany relative to the United States. In Germany (with a total linkage score of 1.01), roughly 40% of workers are in one of the three most common occupational destinations for their educational outcome. In the United States (with a total linkage score of 0.463), only about 29% of workers are in one of the three most common occupational destinations for their educational category. Of course, these approximate averages encompass considerable heterogeneity in both countries: workers with some educational outcomes are tightly clustered in only one or two occupations, while workers with other educational outcomes are scattered across many occupations. But, on average, workers are more tightly clustered in the modal occupational destinations in Germany or France compared with the United States.

The contribution to M of specific educational levels and fields of study is—as shown in equation (1)—the product of the strength of local linkage and the relative size of the category. These contributions can be summed within educational levels to show the total contribution to M of all the specific fields of study for each educational level. These total contributions, which are graphed in figure 3, demonstrate important cross-national differences in the strength and pattern of education-occupation linkage. Fields within level 3C contribute most strongly to overall linkage strength in France at the secondary school level, whereas 3B matters most in Germany. In the ISCED scheme, 3C represents upper secondary education not designed to lead directly to other tertiary education, and 3B represents upper secondary education designed to provide direct access to vocational education at the tertiary level. Accordingly, our results seem to reflect national differences in secondary school-level vocational education systems, which is consistent with Shavit and Müller (1998).

However, even though the school-to-work literature has in the past emphasized the importance of linkage at the secondary school level, it is clear from figure 3 that linkage matters substantially at the tertiary level. We see strong linkages between fields of study and occupations within the lower tertiary 5B category in both Germany and France, which confirms that linkage remains relevant beyond the space of secondary school level VET and into tertiary education. This finding would not be visible without examining fields of study within levels of education. Figure 3 makes clear that the

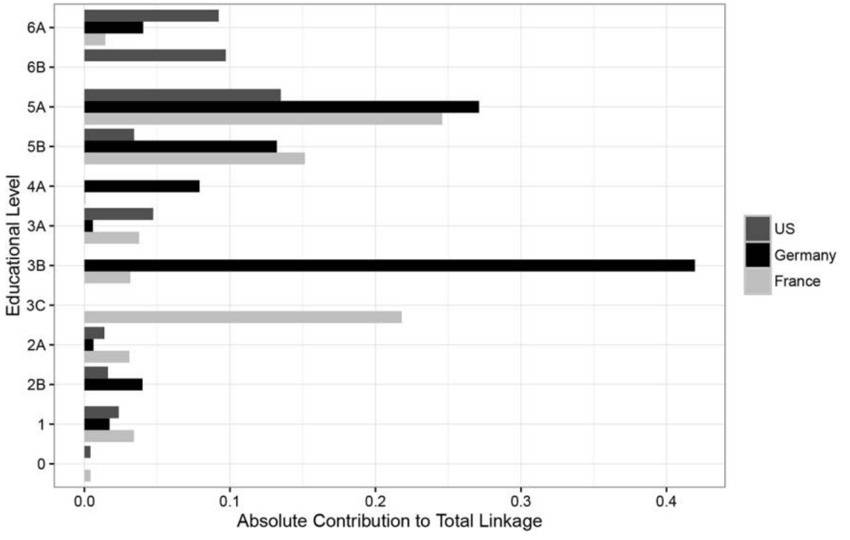

FIG. 3.—Sum of contributions of fields of study to total linkage strength, by educational level and country. Color version available as an online enhancement.

big difference between the United States and either France or Germany is at the secondary and lower tertiary educational levels. At the upper tertiary level (5A/6B) and at the doctoral level (6A), the educational categories are contributing as much to total linkage in the United States as they are in France and in Germany. This difference, as we will see below, is driven not by greater linkage strength at specific tertiary educational levels and fields of study in the United States but rather by the greater fraction of the workforce at these educational levels in the United States than in Germany or France.

We emphasize again that the contribution of specific fields within levels to overall M is driven partly by linkage strength within a category and partly by the share of all workers in that category. In appendix tables D5, D6, and D7, we report the linkage strength for fields of study within a condensed set of educational levels for France, Germany, and the United States. These three tables show considerable variation in linkage strength across educational categories both within and between countries. As we predicted, categories that correspond well to specific occupational licensing requirements and categories at the upper tertiary level generally have rather strong linkage scores. Computing, engineering, law, architecture, business and administration, health, mathematics and statistics, and the physical sciences are all examples of fields that correspond to various professional occupations and that in almost every case have stronger linkage at the upper tertiary than at lower tertiary educational level in all three countries. At the same time, the relative linkage strength of these and other fields clearly varies across France, Germany, and the United States.

We report the relative linkage strength and category share in figures 4–6. Figure 4 shows the relative strength of linkages in France and Germany in educational levels 3ABC; the United States is absent from this figure because the American educational system does not for the most part differentiate fields of study at this level. Figure 5 shows the relative strength of linkages for lower tertiary education (including level 4A in Germany). Figure 6 shows the relative strength of linkages for upper tertiary education, including post-graduate degrees. In each of these figures, the left-side graph shows the ratio of linkage strength in each category (i.e., the scores in tables D5–D7) for Germany relative to the indicated country (i.e., either France or the United States). A ratio greater than 1 means that the German category has stronger linkage strength than does the category of the indicated country. Statistically significant differences from unity (at the .05 level) are shown with filled circles (for Germany-France ratios) and squares (for Germany–United States ratios), while nonsignificant differences are shown with white circles and squares.

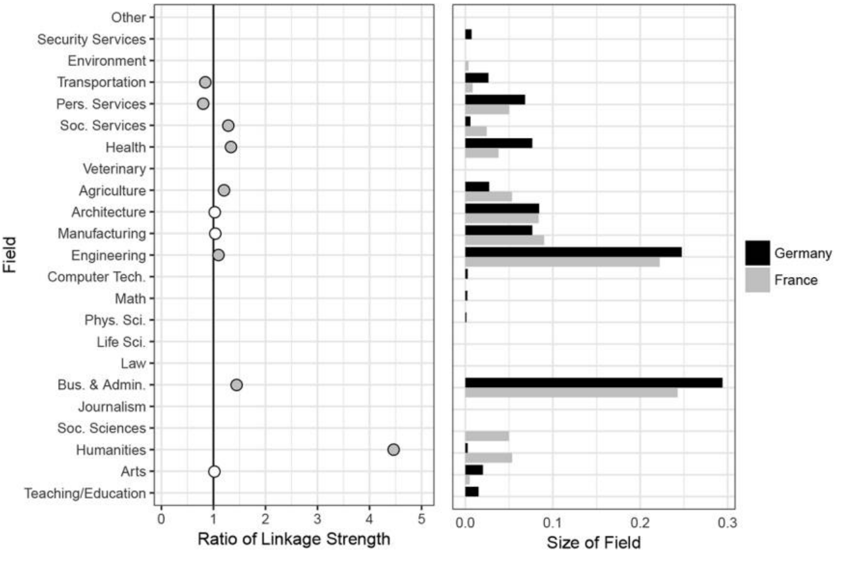

Fig. 4.—Ratio of linkage strength of Germany to France for fields of study in secondary school and proportion in fields. A ratio of less than 1 means that France has stronger linkage strength between this field and the occupational structure than does Germany. A ratio of greater than 1 means that the German linkage strength exceeds the linkage strength in the comparison country by the indicated amount. White circles are not significantly different from a ratio of unity (SEs were calculated using bootstrapping). Linkage strength measures that make up the ratios in the left panel are not functions of the share of the population in the educational category, which is displayed (as a proportion of the educational level) in the right panel. Color version available as an online enhancement.

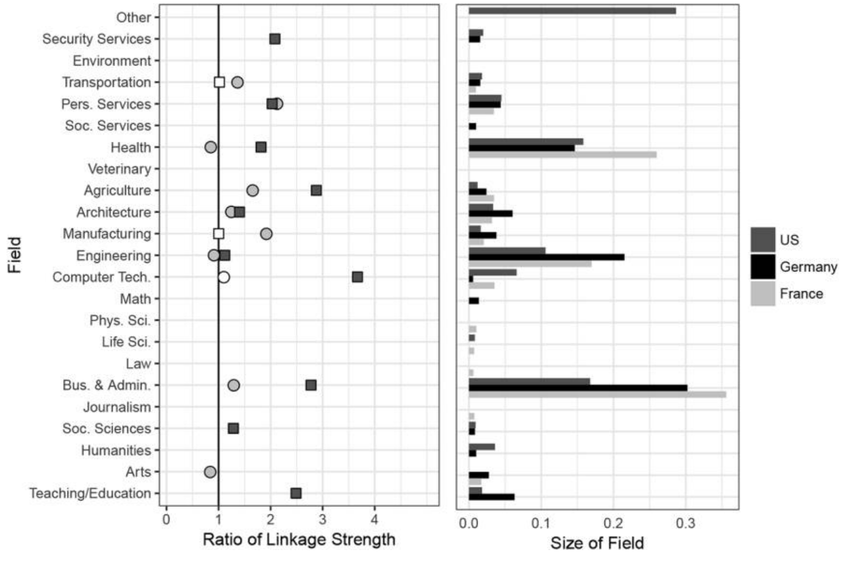

FIG. 5.—Ratio of linkage strength of Germany to both France (circles) and the United States (squares) for fields in lower tertiary (ISCED level 5B, including also 4A in Germany) and proportion in fields. A ratio of less than 1 means that the country (France or the United States) has stronger linkage strength between this field and the occupational structure than does Germany. A ratio of greater than 1 means that the German linkage strength exceeds the linkage strength in the comparison country by the indicated amount. White circles and squares are not significantly different from a ratio of unity (SEs were calculated using bootstrapping). Linkage strength measures that make up the ratios in the left panel are not functions of the share of the population in the educational category, which is displayed (as a proportion of the educational level) in the right panel. No ratio is shown for the “other” category, which is only present in the U.S. data. Color version available as an online enhancement.

The right-side graph in each case shows the distribution of workers at that educational level across the indicated level-field categories.

Figure 4 shows important shared characteristics of the distribution of fields of study in France and Germany at the secondary level. In both countries, business and administration and engineering are the most common fields. Among the smaller categories some differences appear; France has more secondary graduates whose field of study was in the humanities or social sciences, while relatively more of Germany’s graduates were in health or personal services. In general, the linkage score for a field in Germany is slightly greater than for the corresponding field in France, although France has tighter linkage for transportation and personal services, and the two countries are statistically equivalent in architecture, manufacturing, and the arts and rather similar also in engineering. Overall, the difference between France and Germany in linkage strength at the 3ABC level is smaller than our expectations based on Maurice et al. (1986) and Shavit and Müller (1998).

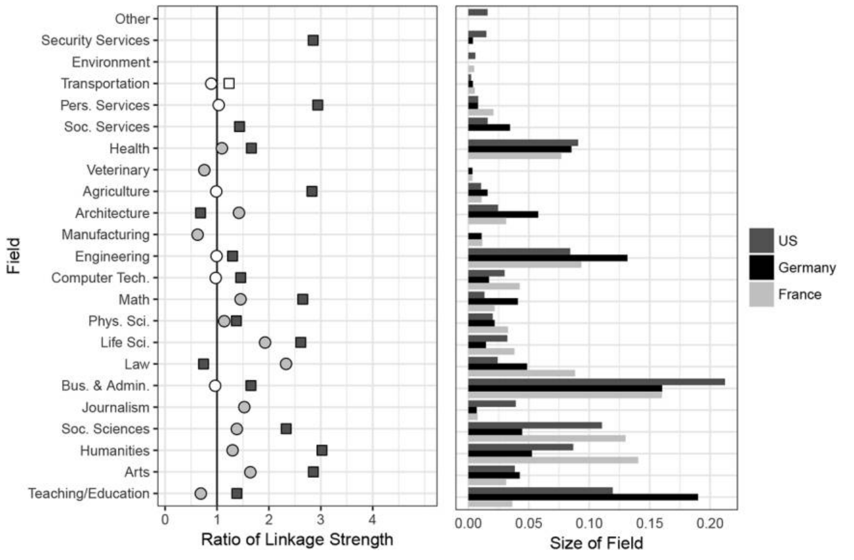

FIG. 6.—Ratio of linkage strength of Germany to both France (circles) and the United States (squares) for fields in upper tertiary (ISCED 5A, 6A, and 6B) and proportion in fields. A ratio of less than 1 means that the country (France or the United States) has stronger linkage strength between this field and the occupational structure than does Germany. A ratio of greater than 1 means that the German linkage strength exceeds the linkage strength in the comparison country by the indicated amount. White circles and squares are not significantly different from a ratio of unity (SEs were calculated using bootstrapping). Linkage strength measures that make up the ratios in the left panel are not functions of the share of the population in the educational category, which is displayed (as a proportion of the educational level) in the right panel. No ratio is shown for the "other" category, which is only present in the U.S. data. Color version available as an online enhancement.

Figure 5 shows linkage strength for lower tertiary fields of study, and this figure includes the United States, where—unlike the typical secondary school situation—students can specialize in different fields of study.[13] For some fields, notably engineering, the linkage strength is comparably tight in all three countries. In health and engineering—two of the most populous fields—France actually has tighter linkage than does Germany. Germany has a clear lead in the strength of linkage involving business and administration—another very populous field—over France and especially over the United States, where linkage from this field is rather weak. The U.S. pattern is notably heterogeneous, with linkages being about as strong as in France and Germany in en-

[13] The SIPP—which is the source of fields of study information for lower tertiary degrees in the United States—provides respondents with the option of choosing "other" as their field of study, which we carry over into our analysis because of the relatively high proportion of respondents in this category.

gineering, manufacturing, and transportation and being notably weaker in health, computer technology, and business and administration.

Figure 6 shows linkage strength for upper tertiary fields of study. The picture is one of considerable heterogeneity. Sometimes linkages in France are stronger than in Germany and sometimes they are weaker. Linkages in the United States are generally weaker than in either Germany or France, although the magnitude of the difference varies considerably. The U.S. shortfall is relatively small in engineering, physical science, computer science, or education and is much larger in social sciences, the humanities, or the arts, while the United States has stronger linkage than either France or Germany in architecture or law.[14]

Comparing figures 5 and 6, one can also see that the comparative strength of linkages involving specific fields can vary across educational levels. If one compares the United States with either France or Germany, it is notable that the linkage gap for students with computer science degrees is much smaller at the upper tertiary level than at the lower tertiary level. The linkage gap in business and administration between the United States and either France or Germany similarly shrinks at the higher tertiary level. Clearly, linkage differences across these three countries vary considerably depending on the specific level-field category that is the focus of attention.

Country Comparisons Using Native Categories

The results above show that Germany has the highest linkage strength, France is the intermediate case, and the United States has relatively weak linkages between educational and occupational outcomes.[15] Table 3 repeats the earlier analysis using native educational and occupational categories. As expected, the use of a greater number of educational and occupational categories increases linkage strength in all three countries. However, the results based on native categories do not alter our conclusions above. In the case of the United States, the use of native categories raised linkage strength 28%, from .463 to .593. This larger value for the United States, however, remains far short of the .769 computed value of M for France and the 1.012 value of M for Germany using the harmonized categories. It confirms that weak

[14] Architects and lawyers in the United States frequently have advanced degrees, and if one imputes architecture or law as their fields of study—an imputation that is confirmed by the SIPP data as largely correct—one gets the result shown in fig. 6.

[15] The German native occupational coding scheme (Klassifizierung der Berufe 1992) uses only five major groups, with about 90% of all workers located in two of these groups (*Dienstleistungsberufe* and *Fertigungsberufe*). This high level of clustering results in relatively little of the overall linkage strength in Germany coming from the occupational groups by educational levels component. The particular form of the occupational major groups classification has no impact on the overall amount of linkage strength in a country.

TABLE 3
COMPARISON OF LINKAGE STRENGTH USING BOTH NATIVE AND HARMONIZED EDUCATIONAL AND OCCUPATIONAL CATEGORIES

	NATIVE CODES			HARMONIZED CODES		
	France	Germany	United States	France	Germany	United States
Number of educational categories	216	205	90	73	82	82
Number of occupations	486	337	471	90	90	90
	Linkage Strength Components					
Occupational groups by educational levels	.330	.082	.210	.273	.269	.216
Fields of study within levels by occupational groups	.216	.317	.151	.067	.066	.058
Detailed occupations within groups by educational levels	.159	.212	.082	.168	.235	.033
Fields of study within levels by detailed occupations within groups	.491	.917	.150	.261	.442	.156
Total linkage strength	1.196	1.529	.593	.769	1.012	.463
Native/harmonized ratios	1.56	1.51	1.28	. . .	. . .	. . .

linkage is a true characteristic of the American educational system and of its labor market and not an artifact of internationally comparable measures. Meanwhile, Germany and France have much greater linkage strength when native instead of harmonized categories are used, but the ratio of German to French linkage strength using native codes is revealed to be very similar to the ratio of German to French linkage strength using harmonized codes. We conclude that harmonized codes allow a revealing and generally accurate comparison of the structure of linkage across all three of the countries in our study.[16]

[16] As noted earlier, the approximate formula for relating local or global linkage to clustering will vary with the level of detail of the classification being used. With 82 educational categories and 90 occupations, the proportion of workers with a given educational outcome that were in the three most common occupations for that educational outcome is approximately $0.2 + 0.2 \times$ (local linkage strength). With 205 educational categories and 337 occupations, the approximate formula for the three most common occupations for Germany shifts to $.16 + .11 \times$ (local linkage strength). For predicting the proportion of workers in the five most common occupations using the more detailed education and occupation categories, the formula for Germany becomes $.15 + .22 \times$ (local linkage strength).

Country Comparisons Using Recent Labor Market Entrants

The analyses presented so far are based on the whole employed workforce. Next, we estimate linkage strength for workers who are no more than 10 years past the normal school-leaving age, and we compare this result to what we obtain using the entire workforce.[17] We maintain our restriction on a minimum of 100 cases per cell, and, as a consequence of the smaller sample size when using only recent labor market entrants, the number of educational categories shrinks to 54 in France, 42 in Germany, and 63 in the United States. We therefore reanalyze all employed workers using this same educational restriction so that we are using comparable categories. Table 4 shows the results.

In all three countries, the total linkage strength is higher for recent workers than for the entire workforce. This is in line with well-known findings that education has its largest benefits early in the career (Brzinsky-Fay 2007). One may have expected stronger linkages of recent entrants relative to the whole employed workforce in a country with high career mobility such as the United States; it implies that American workers initially move into occupations that are more directly connected with their education, and they gradually move to a broader set of occupations over their careers. Interestingly, however, we find the same (or even slightly stronger) pattern in Germany and France compared to what we find in the United States; in all three countries, recent entrants link better to their occupations than do older workers. A complete exploration of the relative contributions of structural change and career mobility is beyond the scope of this article, but our results demonstrate that the country ordering we find using the entire workforce is preserved using only recent entrants. They also highlight the importance of understanding how M evolves both over the career and over history. This issue is part of the broader intellectual agenda enabled by the linkage approach that we discussed earlier in the article.

SUBSTANTIVE IMPLICATIONS: SOME ILLUSTRATIONS

Occupation Space and Organization Space: Reconsidering the Difference between France and Germany

During the 1970s, Maurice et al. (1986) spent several years studying large metal and petrochemical manufacturing firms in France and Germany, concluding that the two countries differed in their structure of skills and wages. Maurice et al. asserted that in Germany, there is "a close correspondence between work force structure and the structure of occupational training"

[17] Normal school-leaving age for France and Germany is obtained from Schneider and Kogan (2008).

TABLE 4
COMPARISON OF LINKAGE STRENGTH USING RECENT LABOR MARKET ENTRANTS AND THE ENTIRE WORKFORCE WITH HARMONIZED EDUCATIONAL AND OCCUPATIONAL CODES

	RECENT ENTRANTS			ALL EMPLOYED WORKERS		
	France	Germany	United States	France	Germany	United States
Number of educational categories	54	42	63	54	42	63
Number of occupational categories	90	90	90	90	90	90
	Linkage Strength Components					
Occupational groups by educational levels	.330	.322	.252	.266	.261	.215
Fields of study within levels by occupational groups	.085	.098	.073	.062	.069	.059
Detailed occupations within groups by educational levels	.215	.320	.040	.168	.230	.029
Fields of study within levels by detailed occupations within groups	.399	.558	.204	.255	.415	.151
Total linkage strength	1.028	1.299	.569	.752	.975	.456
Ratio: Recent entrants/total workforce	1.37	1.33	1.25			
Sample size	45,608	29,867	279,454	216,253	185,934	1,430,831

(p. 11). In France, they reported that "training has a relatively weak influence on placement" (p. 3). Instead, they argued, "The [French] hierarchy seems to be based largely on the level of general education. In other words, there is no connection between the educational characteristics of workers and the productive structures within which they work" (p. 11).

The argument of Maurice et al., which has persisted into the contemporary comparative stratification literature, differentiates France from Germany in two key respects.[18] First, the distribution of young adults across educational outcomes differs in the two countries, with French workers having a higher average level of education and with a higher fraction of German workers being vocationally (or professionally) trained. The second difference is that, to quote Müller and Shavit (1998, p. 4), "the association between education and jobs tends to be looser in France than in Germany." In other words, France should show weaker linkage between education and occupations than Germany, and this weaker linkage should be structural; that is, the linkage should be typically weaker for specific educational categories rather than a consequence of compositional differences in the educational or the occupational distribution.

More recently, scholars have noted important changes in the French educational system in the 1990s and 2000s, which Ichou and Vallet (2013, p. 121) describe as creating a more "unified and massified" system, with internal stratification beginning at the end of *collège*, after which 62% of pupils are channeled into the vocational *lycée* and the remainder go on technological or academic tracks. The expansion of the French educational system has increased the pressure by higher class families to get their children admitted to *grandes écoles* (Ichou and Vallet 2013). But the current literature has not taken cognizance of the potential impact of this expansion for school-work linkage. Our

[18] Müller and Shavit wrote that "they [Maurice et al.] describe Germany as a system patterned along a *qualificational space*, while France is patterned in an *organizational space.* In Germany, vocational qualifications are used by employers to organize jobs and to allocate persons among them, whilst in France, education is less closely related to the workplace and vocational skills are mainly obtained on the job. Since organization-specific skills are often not recognized by other employers, the association between education and jobs tends to be looser in France than in Germany" (1998, p. 4). Paradoxically, however, Müller and Shavit found that the effect on occupational prestige of education considered as a hierarchical variable was larger in Germany than in France, in apparent contradiction to the assertions of Maurice et al. Apparently consistent with Maurice et al., Müller and Shavit found that Germans who completed only compulsory education with no vocational training (6% of men and 14% of women who entered the labor force in 1960 or thereafter) were less likely (relative to any higher educational category) to end up in a skilled occupation than were French workers with only compulsory schooling or a lower-secondary certificate (Brevet d'études du premier cycle) relative to any higher educational level. Note, however, that as recently as the 1954–58 birth cohorts, these lower categories in France held over 40% of the population (Goux and Maurin 1998), which is much higher than the proportion for the parallel categories in Germany.

results allow a contemporary comparison of linkage structure for France and Germany.

To recapitulate our findings reported above, Germany clearly has a stronger overall education-occupation linkage than does France, although the overall difference is arguably not as large as might have been expected. Moreover, figures 4–6 show that many educational outcomes (transportation, personal services, architecture, manufacturing, and arts at the secondary school level; health, engineering, computer technology, and arts at lower tertiary; and transportation, personal services, veterinary, agriculture, manufacturing, engineering, computer technology, business and administration, and teaching/education at upper tertiary) link as strongly or more strongly to occupations in France as in Germany. As discussed above in the analytical strategy, the strength of linkage is partly a function of the marginal distribution of occupations and of educational categories. To address the extent to which the German advantage in total linkage strength arises from differences in composition-invariant linkage and from differences in the marginal distributions of education and occupation, we decompose country differences in M into a component that is educational composition invariant and two components that depend on country differences in the marginal distributions for education and occupation as shown in equation (A6).[19] We use the harmonized occupational and educational variables for this analysis. The resulting decomposition is in the top portion of table 5.

Table 5 shows that the education composition-invariant linkage difference between France and Germany is currently very small at 0.024. This term captures differences in linkage strength between the two countries that are due to national differences in the conditional probabilities of being in the various occupations, given one’s educational outcome, if the occupational entropy and the marginal distributions of workers across educational categories are held constant across the two countries. The overall country difference in linkage strength now stems mainly from compositional differences between the two countries. Almost half of the difference (0.106) comes from the distribution of workers across occupations in the two countries, with the German distribution being more even (closer to uniform) than the French distribution. Second, the educational distribution difference of 0.112 indicates that the German educational distribution is shifted toward educational categories that more strongly link with occupations than in France.

We can instead take a “reverse temporal” look at national differences in terms of occupation distribution-invariant linkage differences. From this perspective (table 5), 0.175 of the 0.242 difference between Germany and

[19] For greater comparability in this analysis, we collapsed together the ISCED categories 0 and 1; the lower secondary 2A and 2B categories; the upper secondary categories 3A, 3B, and 3C; and the lower tertiary categories 4A and 5B.

TABLE 5

Decomposition of the Differences in Linkage Strength in France, Germany, and the United States Using Harmonized Educational and Occupational Categories

	Total Country Difference	(Educational) Composition-Invariant Linkage Difference	Occupational Entropy Difference Contribution	Educational Distribution Difference Contribution
Forward looking (education to occupation):				
Germany-France	.242	.024	.106	.112
Germany-France-United States (fields suppressed at secondary school level):				
Germany-France	.108	−.047	.106	.049
Germany-United States	.169	.144	.139	−.114
France-United States	.061	.220	.032	−.191
		(Occupation) Composition-Invariant Linkage Difference	Educational Entropy Difference Contribution	Occupational Distribution Difference Contribution
Backward looking (occupation to education):				
Germany-France	.242	.175	.053	.014
Germany–France–United States (fields suppressed at secondary school level):				
Germany-France	.108	.166	−.050	−.008
Germany–United States	.169	.323	−.192	.038
France–United States	.061	.164	−.143	.040

Note.—For the three country comparisons, secondary school differences are suppressed because the U.S. data do not have differentiation by field of study for students leaving education with a secondary school credential. The forward-looking decomposition is in terms of the conditional probability of working in an occupation, given one's educational outcome. The backward-looking decomposition is in terms of the conditional probability of having an educational outcome, given one's current occupation.

France is due to country differences in the conditional probability of being in the various education categories, given one's current occupation, while 0.053 is due to Germany's having higher educational entropy than France, and 0.014 is due to country differences in the marginal distribution of workers in the occupation structure. These alternative decompositions give complementary perspectives concerning the source of the difference in total linkage strength in the two countries. If seen from the forward-looking perspective of where people end up given their educational qualification, it appears that both countries have very similar levels of linkage in structural terms, that is, in terms of the conditional probabilities of working in this or that occupation, given a specific educational outcome. However, if approached from the reverse temporal focus on educational background given current occupation, one finds that a relatively large share of the total difference in linkage strength between Germany and France is driven by the average difference in the conditional probabilities of having this or that educational outcome, given one's occupation and weighted by occupational size. The alternative perspectives arise from the different weightings used in the alternative decompositions in a situation in which at the local level it is sometimes Germany and sometimes France that has the tighter linkage, depending on the outcome in question.

In either case, the substantive conclusion (supported by figures 4–6) is the same, namely, that a large proportion of the French workforce was trained in educational programs that link as strongly or more strongly to occupations as do their German counterparts, even as other programs link more strongly to occupations in Germany than in France. Overall linkage is stronger in Germany, but there is substantial variation in the country difference at the level of specific categories, and country differences in the marginal distributions of education and occupation explain at least some of the greater overall linkage in Germany than in France.

Maurice et al. (1986) argued that compositional differences in the educational and occupational structures of France and Germany were an important source of the difference in the structure of education and work in the two countries. However, they especially emphasized structural differences in the strength of linkage between educational outcomes and occupations. The analysis above provides evidence that structural differences between the countries either are smaller than expected or have eroded since the time of Maurice et al.'s analysis as a consequence of changes in the educational systems and labor markets of the two countries since the 1970s. The results also clearly support the conclusion that assertions of broad country-level differences can obscure more than they reveal. The French-German linkage differences go in both directions, depending on the educational outcome in question. Of course, whether the current structure of differences in the two countries has changed since the time of Maurice et al.'s analysis is a question that begs for historical analysis in order to be resolved.

A Closer Look at Differences between the United States and France or Germany

We have already seen that much of the linkage gap between the United States and either France or Germany stems from the lack of field of study differentiation for the large portion of the American cohorts who leave school with no more than a secondary school credential. We can further assess the sources of the remaining country differences by suppressing all fields of study at the secondary school level and (for greater harmonization) also suppressing the distinction between 6A and 6B. The results of this decomposition are in the bottom portion of table 5.

Table 5 shows that both France and Germany have stronger linkage across educational levels and tertiary fields of study than the United States, and this gap is primarily for structural reasons.[20] Germany in particular also gains linkage strength relative to the United States because its occupational distribution is tilted toward occupations that link relatively more strongly to educational categories. However, the United States gains on both France and Germany from an educational distribution that favors categories that link more strongly to occupations. This is straightforward to interpret, as a greater of share of the American workforce has tertiary degrees than is true of either Germany or France, and tertiary degrees in general have stronger linkages to occupations than do secondary credentials. This distributional advantage for the United States, however, is more than offset at the structural level; linkage is generally weaker in the United States than in France or Germany when comparing linkage strength for the same educational category. This summary story is readily confirmable in the pattern of linkage strength differences between the United States and either France or Germany that is revealed in figures 5 and 6.

Linkages and Relative Occupational Pay: A Comparison of Germany and the United States

A question of central interest to us concerns the implications of linkage structure for the distribution of wages and earnings and the decomposition of earnings into within- and between-occupational components. As a first step, we examine the consequences of linkage structure for within-occupation variance in log earnings and also for the relative mean occupational full-time earnings in Germany and the United States. We computed the mean log earn-

[20] The corresponding occupation distribution-invariant differences in conditional probabilities of educational origins given occupations, which are shown in table 5, are 0.32 between Germany and the United States and 0.16 between France and the United States. Both forms of the decomposition lead to the same conclusion.

ings for full-time workers for each of the harmonized occupational categories using our analysis samples. In the ACS, the respondent's occupation is the one at which the respondent works the most hours. We operationalized full-time earnings as the per period earnings for workers in the United States who say that they usually work 40 or more hours a week.[21] The Mikrozensus contains a question that asks a worker to indicate his or her status as either *Vollzeit* (full time) or *Teilzeit* (part time). The Mikrozensus only collects data on monthly net personal income (not earnings), measured in 24 categories, but (as we show below) this measurement difference does not have major implications for our results. Controlling for ISEI provides a rough control for the progressive income tax rates in Germany as well as for a possibly different relationship between occupational status and average earnings in the United States and Germany. We converted German full-time net personal income from euros into dollars using purchasing power parity (PPP), but because we are using logarithmic measures, the conversion factor has no substantive influence on our results below. As a check on the validity of our results, we also obtained data on full-time occupational gross earnings in Germany from two smaller studies, the BIBB/BAuA-Erwerbstätigenbefragung (BIBB) for 2006 and the 2002–9 waves of the German Socioeconomic Panel (SOEP). We converted nominal wages to 2006 euros and combined these data sources to produce a file of occupational gross earnings for ISCO-88 occupations. For the occupations where we had at least 50 observations in both the Mikrozensus and the combined surveys, the correlations between the gross and the net earnings measures were very high: .948 for all full-time workers, .948 for female full-time workers, and .936 for all male full-time workers. These high correlations strongly suggest that the Mikrozensus provides usable data for exploring cross-national differences in the structure of gross earnings, and we confirmed this conclusion by conducting parallel analyses on both sets of data.

First, we examine the relationship between within-occupation full-time earnings inequality (measured as the variance in log earnings) and linkage strength. Table 6 shows evidence that within-occupation earnings inequality is negatively related to the log linkage strength between educational categories and occupations. Net of occupational status, which we operationalize as the ISEI, every percentage increase in linkage strength is associated with a reduction in the variance of log earnings of about .0006 for males and about .0004 for females in the United States. The relationship between linkage strength and within-occupation earnings inequality is weaker for German than for American males, and the effect is not significant for Ger-

[21] It is possible that some of these earnings in the ACS may come from second or third jobs.

TABLE 6
REGRESSION OF THE WITHIN-OCCUPATION VARIANCE OF LOG FULL-TIME (FT) EARNINGS ON THE LOG OCCUPATIONAL LINKAGE STRENGTH

	UNITED STATES				GERMANY			
	Males		Females		Males		Females	
					Mikrozensus Net FT Earnings			
Log linkage strength (β_1)	−.064	(−2.4)	−.044	(−1.9)	−.035	(−2.1)	−.029	(−.7)
ISEI (β_2)	−.001	(−.5)	−.002	(−2.2)	.003	(3.9)	.001	(.6)
Constant	.557	(7.3)	.603	(9.0)	.108	(3.4)	.224	(2.6)
N	88		84		84		76	
					BIBB and SOEP Gross FT Earnings			
Log linkage strength (β_1)					−.036	(−1.7)	−.015	(−.9)
ISEI (β_2)					.001	(.9)	−.001	(−.5)
Constant					.152	(3.6)	.213	(5.9)
N					77		63	

NOTE.—Observations in each regression are limited to occupations that have at least 50 full-time worker observations of the relevant gender. Unstandardized effects; nos. in parentheses are *t*-ratios.

man female earnings, even though the point estimate is comparable.[22] We obtain similar results when we instead analyze the combined BIBB/SOEP data. Within-occupation earnings inequality is, from an accounting perspective, a component of total inequality. As such, the size of within-occupation earnings inequality may also have a causal effect on the size of total inequality depending on how shifts in within-occupation earnings inequality affect a country's level of between-occupation earnings inequality.

The next question is whether—at the level of the harmonized three-digit ISCO-88 occupations—there is a relationship between the relative strength of linkage for a given occupation in the two countries and the relative mean full-time log earnings. In figure 7 we present a scatterplot, where the vertical axis is the difference in the within-occupation mean log full-time earnings in the United States and Germany,[23] and the horizontal axis is the difference between the log linkage strength in the United States and in Germany.[24] The figure shows a clear positive relationship.

[22] The PPP conversion factor just adds a constant to the log of German earnings (and therefore also to the mean of log earnings within occupations) and has no effect on the variance of the log earnings within occupations.

[23] This is equivalent to the log of the ratio of the geometric means of the earnings of full-time workers in that occupation for the United States relative to Germany.

[24] Occupations are only shown in the figure if they have at least 50 full-time worker respondents in both the 2012 ACS and the 2006 Mikrozensus. The use of a PPP conversion produces a shift in the zero point of the vertical axis (and therefore affects the size of the intercept) but has no impact on the relative vertical distances among the observations.

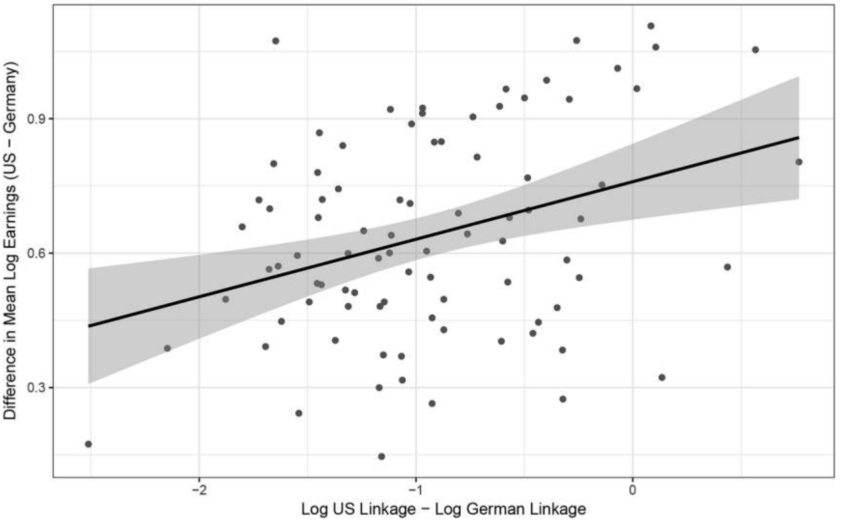

FIG. 7.—Occupational mean earnings difference between the United States and Germany by difference in linkage strength. Data are from the Mikrozensus. Observations are limited to occupations with at least 50 full-time worker respondents in both the United States and Germany. Color version available as an online enhancement.

We show the same relationship in table 7, net of a control for occupational status. In combination with figure 7, this table contains three messages. First, the positive relationship between relative occupational earnings and relative occupational linkage is partly (but only partly) explained by the fact that occupations with stronger linkage are generally also higher status occupations in both countries (with the relationship stronger in the United States than in Germany). Table 7, moreover, shows that the gap in mean occupational earnings in favor of the United States tends to be larger in occupations that have higher status scores and, correspondingly, smaller in occupations with lower status scores; this relationship is true for both male and female incumbents. Third, table 7 shows that—net of occupational status—the relative American advantage in full-time occupational earnings tends to grow in direct proportion to the relative strength of occupational linkage, both in general and specifically for the earnings of female workers. Conversely, the American advantage in mean occupation earnings is relatively small when the German advantage in linkage strength is relatively large. Further investigation shows that this relationship is driven primarily by the German linkage score: the higher the German linkage score, the more favorable the German-American full-time earnings ratio (net of occupational status) for both male and female workers. Again, the interpretation is similar when

TABLE 7
Regression of the Difference in Mean Log Occupational Full-Time (FT) Earnings between the United States and Germany on the Difference in Log Occupational Linkage Strength between the United States and Germany

	All Workers		Male FT Earnings		Female FT Earnings	
German net earnings data from 2006 Mikrozensus:						
Δ log linkage strength (United States–Germany)						
β_1	.072	(1.9)	.038	(.9)	.127	(2.9)
ISEI β_2	.005	(3.9)	.006	(4.1)	.005	(3.2)
Constant	.467	(5.6)	.388	(4.1)	.578	(5.8)
N	86		83		76	
German gross earnings data from the BIBB and the SOEP:						
Δ log linkage strength (United States–Germany)						
β_1	.075	(1.9)	.050	(1.1)	.120	(3.0)
ISEI β_2	.006	(4.2)	.008	(4.5)	.005	(3.2)
Constant	.029	(−.1)	−.058	(−.7)	.138	(1.5)
N	84		77		63	

Note.—Observations in each regression are limited to occupations that have at least 50 observations for both countries, either in total (for the "all workers" analysis) or for the relevant gender. Unstandardized effects; nos. in parentheses are t-ratios.

we use data from the BIBB/SOEP samples in place of the data from the Mikrozensus.

The interpretation of table 7 that we just offered emphasizes between-country differences in occupational mean log earnings. However, the interpretation can also be rephrased using the same statistical model in terms of within-country differences in mean log earnings among occupations.[25] The difference in mean log earnings for any two occupations in Germany is expected to be the difference in mean log earnings for the same two occupations in the United States, plus an adjustment to account for the different size of occupational status-associated between-occupation inequality in the two countries, plus a bonus if the difference in linkage strength between occupations j and j' is larger in Germany than the United States or a penalty if the difference is smaller.

The relationship between full-time earnings and linkage strength shown in figure 7 and in table 7 may or may not be causal. If it is causal, two mech-

[25] To see this, we express the equation underlying table 7 for two occupations (i.e., for occupations j and j') and then subtract one equation from the other and rearrange terms. The left side becomes the difference in mean log earnings for occupations j and j' in Germany. This difference equals the difference in mean log earnings for occupations j and j' in the United States plus two adjustment terms. The first adjustment term equals β_1 (see table 7) multiplied by the country difference in the difference in log linkage strength for occupations j and j'. The second adjustment term equals β_2 multiplied by the difference in occupational status for occupations j and j'.

anisms might be present. A technical mechanism might underlie this relationship if German occupations that are especially well linked with the German educational system have workers who are generally better trained than their American counterparts. An institutional mechanism might underlie this relationship if occupations in which workers have relatively similar educational credentials can more effectively organize or have stronger closure mechanisms (Bol and Weeden 2015). The relationship between occupational linkage and occupational closure is an important question for further research. In addition, the associations reported above suggest that country differences in overall wage and earnings inequality may arise in part from country differences in the size and structure of within- and between-occupational inequality.

DISCUSSION AND CONCLUSION

Employing a novel analytical approach to the study of school-to-work transitions, we have achieved greater clarity about the specific pathways that produce both between- and within-country differences in the structure of linkage between school and work. Drawing on multigroup segregation measures and, more specifically, the *M* index, we have examined school-work linkages in France, Germany, and the United States with greater precision than past studies, incorporating fields of study and specific occupations in addition to educational levels and major occupational groups. Adding this level of detail has enabled us to see that much information is lost when more limited educational and occupational categories or scales are used to study differences between countries. We therefore propose the linkage strength approach as a fruitful analytical strategy to employ in international comparisons of school-to-work transitions, especially by taking advantage of its decompositional properties to examine the structure of linkages in important and informative ways.

Expanding on the institutional focus of the fields of comparative stratification and the political economy of skill formation, we find that the linkage of graduates into the labor market is structured by the educational system in a country. However, we also demonstrate that there is much variability within countries in how strongly educational qualifications are linked to occupational destinations. In line with these literatures, we find that the linkage structure in Germany is much stronger than that in the United States, with France taking an intermediate position. In other words, we can better predict a worker's occupation by knowing the worker's educational level and field of study in Germany than we can in the United States.

However, our results are much more informative about how stronger linkages are generated, and some of our most important results are novel. First, we have shown that linkage strength varies substantially across levels and fields within countries. Strongly linked fields include computer science and health-related programs, while the social sciences link to the labor market more weakly in all three countries. Second, we have shown that linkage strength varies systematically with educational level even within the same field, being generally stronger at higher educational levels than at lower levels. Third, we have shown that country differences in linkage strength vary by both educational level and educational field. Fourth, we have shown that country differences in overall linkage strength depend on country differences in the linkage strength of educational fields and that misleading conclusions about country differences arise when fields of study are not taken into account. Fifth, we have shown that country differences in linkage strength arise both for structural and for compositional reasons. This fact underlies the important discoveries from this article that the overall German-French difference in linkage strength is smaller than is commonly assumed; that for many specific outcomes, linkage is as strong or stronger in France than in Germany; and that some of the overall national difference is due to compositional differences in the distribution of French and German workers across educational categories and across occupations. Sixth, we have found that linkage strength is considerably stronger among recent cohorts than in the entire workforce in all three countries in our study. Seventh, we have found that linkage strength is associated with earnings and with earnings inequality; in particular, workers tend to be paid better in occupations that more strongly link with educational levels and fields of study, and this earnings advantage can be seen even when we compare workers in the same occupation across countries.

Finally, at the theoretical level, we have developed an approach to the study of training regimes that quite explicitly focuses on the articulation between educational and labor market positions as a theoretically and empirically significant feature of training regimes. Our approach has provided persuasive empirical support for the theoretical proposition that the character of national training regimes resides in the granularity of linkage structure as much as in broad macroinstitutional characteristics that have been used to characterize national training regimes in the large social science literature on this topic. At a methodological level, we have demonstrated that entropy-based segregation measures provide an effective way to analyze this granular structure, to aggregate it to provide accurate summary statements about countries, and to make comparisons in the changing structure of linkage either across countries or within the same country over time.

Even those aspects of linkage structure that are well known are given brighter illumination by the new analytical approach. Consider the issue of vocational training at the secondary school level. It is of course well known that German secondary school programs are strongly differentiated by field of study, and—as our results make clear—the same is true of the French educational system. While linkage scores of secondary school credentials in Germany and France are generally (although not always) lower than are the linkage scores of lower tertiary credentials, it is notable how meaningful these vocational distinctions are in sorting secondary school educated workers into distinct occupations in the labor market in comparison with the highly diffuse occupational impact of a secondary school degree in the United States. It is, of course, an inevitable consequence of an undifferentiated secondary school system that its graduates populate relatively low-skill jobs in virtually all occupations that contain low-skill jobs. Nonetheless, the relatively strong sorting of vocationally educated German and French secondary school students stands in sharp contrast to the diffuse paths into employment of high school graduates in the United States. As noted earlier, Hanushek et al. (2011) argue that undifferentiated systems like that of the United States may provide greater labor market flexibility and therefore better employment chances later in life than systems that emphasize vocational qualifications. Given the extent to which employment rates fluctuate across countries in response to variations in social insurance systems and macroeconomic conditions as well as skill distributions, we view their conclusion as premature (Forster et al. 2016). Clearly, however, which system produces the greatest benefits over the entire work career is an important and still open question of relevance to both scholarship and social policy.

Earlier in this article, we discussed a broader research agenda that would benefit from systematic attention to the granular and the macro linkage structure of a country. We do not repeat that list here but note that important theoretical as well as empirical work needs to be done to realize the full value of this research program. Theories of the development of linkage structure already exist, most notably in the varieties of capitalism literature. As the case of France and Germany illustrates, the availability of a rigorous measurement of linkage makes it possible to achieve serious advances in this literature by providing a framework to formulate and test more precise hypotheses about various aspects of the granularity of linkage structure, taking into account the currently demonstrated substantial variation within countries. Our comparative results for France and Germany using both harmonized codes and native categories call attention again to Merton's advice about the importance of "establishing the phenomenon." They also call for a historical analysis of developments in France and Germany over the past 30 years (a period for which the data actually exist to support an empirical analysis of linkage) in order to determine how institutional and other developments may have modified in important respects the training regimes of one or both of these countries and how such modifications have affected some segments of the labor market more than others.

Another pressing concern is to theorize about the consequences of linkage. For example, our illustrative results above suggest that linkage structure affects the wage distribution and inequality. A human capital interpretation would assume that tight linkage improves productivity and generally raises wages and employment through market mechanisms. However, it is also plausible that theories of social closure, emphasizing the rents created by formal regulations governing the access to occupations such as licensure and certification, are helpful to explaining the value of linkage. Strong linkage may also come as a hindrance, when tight linkage reduces flexibility in the labor market and increases unemployment and inequality. None of these issues would easily be dealt with using the existing comparative literature, as this literature is too macro-oriented to appreciate the granularity of the linkage process and its consequences.

Our own conjecture is that the answer concerning the consequences of linkage will not be wholly on one side or the other of the divide between human capital and social closure arguments. Rather, we expect that the granularity of linkage will be of theoretical importance. For some educational pathways, stronger linkage may provide unambiguous benefits. For others, there may be trade-offs. We suggested above that linkage strength may affect the organization of work as well as its productivity, and the analysis of the relationship between the structure of linkage and productivity, union strength, licensing, and other forms of occupational closure are, along with the social mobility consequences of linkage, all important topics for future research.

APPENDIX A

The Measurement and Decomposition of Linkage Structure—Technical Appendix

We conceptualize the strength of linkages in terms of the association between school-leaving credentials and labor market position. For any given school-leaving credential, a strong linkage occurs when school leavers with that credential cluster in a relatively small number of labor market positions. When field of study is taken into account, the clustering should be even stronger. When this pattern occurs across the distribution of qualifications and fields of study, then education is tightly linked to the labor market. The most appealing measure of association for this phenomenon comes from the generalized entropy family of segregation measures (see Mora and Ruiz-Castillo 2011; see also Theil and Finizza 1971; Theil 1972; Reardon and Firebaugh 2002; the material below largely follows and builds on the discussions in Mora and Ruiz-Castillo [2009*a*, 2011]). These measures are based on the concept of entropy. We refer to them as "linkage" measures below, although they are formally identical to multigroup segregation measures. It is important to keep in mind that segregation in our context implies a tighter coupling between educational credentials and the occupational structure of the labor market. In other words, a labor market that is relatively highly segregated by educational credentials is one in which linkage between education and occupation is strong.

In this study, entropy ($T(P_g)$) is defined as the expected gain in information about someone's education by actually observing his or her education. It can be written as

$$T(P_g) = \sum_{g=1}^{G} p_g \log\left(\frac{1}{p_g}\right),$$

where $g = 1, \ldots, G$ index educational states and $P_g = \{p_1, \ldots, p_G\}$ is the set of probabilities of being in each of the G educational states. Entropy $T(P_g)$ is at a minimum when everyone has the same education and a maximum when all education states have the same proportion of the population. Our fundamental interest is in the change of entropy concerning education that comes from knowing one's occupation or, equivalently, the change in entropy concerning occupation that comes from knowing one's education. Entropy within occupations will generally be lower than overall entropy because the typical occupation conveys some information about the typical education of an occupational incumbent. This reduction in entropy becomes the measure of the strength of linkage at the aggregate level, at the level of specific major occupational groups or major educational groupings, or at the level of individual occupations or educational levels or specific fields of study within educational levels. In particular, we focus on the Mutual information index (M) because of its attractive properties (Mora and Ruiz-Castillo 2011). In this analysis, the M index measures the average reduction in entropy in P_g between its overall value and its value within a specific occupation, averaged over all occupations:

$$M = \sum_{j=1}^{J} p_j (T(P_g) - T(P_{g|j})),$$

where $j = 1, \ldots, J$ indexes occupations. Equivalently the M index can be formulated as the average reduction in entropy in the probability distribution across occupations, P_j, between its overall value and its value within a specific educational category, averaged over all education categories. We will refer to M as the linkage strength in a country.

The M index has the advantage of being decomposable.[26] In our context, let X^k be the set of occupations within occupational major group k, and let

[26] The M index divided by the educational entropy gives a measure known as H; M divided by occupational entropy gives a measure known as H^* (Mora and Ruiz-Castillo 2011). These alternative measures have the disadvantage of not being decomposable both by educational categories and by occupations.

X be the set of all occupations. Then $X = X^1 \cup \ldots \cup X^K$. M has the property that

$$M(X) = M(\tilde{X}^1 \cup \ldots \cup \tilde{X}^K) + \sum_{k=1}^{K} p_k M(X^k), \tag{A1}$$

where $\tilde{X}^k$ is the set of all workers in major group k treated as if they are all in a single super-occupation. This formula says that M equals the segregation of workers by education across occupational major groups plus the sum of the weighted within-major-group segregation values. This property allows us to determine the extent to which education-occupation linkage occurs primarily at the major occupational group level or at the level of detailed occupations within major groups, and it allows us to compare the relative importance of educational levels and of fields of study within educational levels in constituting the overall structure of linkage in a country.

The M index has the additional advantage of being decomposable into linkage components for every specific occupation or educational category. This is important because it allows us to assess the contribution of each occupation and educational category to a country's overall structure of linkage or to assess the importance of differences in the structure of linkage involving specific educational and occupational categories to cross-national differences in wage and earnings inequality. As discussed by Frankel and Volij (2011; see also Alonso-Villar and Del Río 2010), "local" linkage gives the extent to which the distribution across occupations of workers with a particular education outcome differ from the distribution across occupations of all workers.[27] Local linkage in terms of educational outcomes ($M(\text{ed})_g$) can be written as

$$M(\text{ed})_g = \sum_j p_{j|g} \log\left(\frac{p_{j|g}}{p_j}\right), \tag{A2}$$

where $p_{j|g}$ is the conditional probability of working in occupation j given that one is in educational group g, and p_j is the unconditional probability of working in j. Total linkage strength (M) can then be written as a weighted sum of these local linkage measures; that is,

[27] In other words, the local linkage measure for any specific educational category is the expected information in the transformation of the set of marginal occupational proportions to the set of conditional occupational proportions (i.e., conditional on a worker having that specific educational level and field of study; Mora and Ruiz-Castillo 2009*a*). One can also express local linkage ($M(\text{occ})_j$) in terms of the extent to which the educational distribution for workers in a given occupation differs from the educational distribution of workers in general.

$$M = \sum_g p_g M(\mathrm{ed})_g, \tag{A3}$$

where the weights are given by the relative size of each educational level-field category. It follows that the contribution of each specific educational category to total linkage strength is partly a consequence of the size of its local linkage score and partly a consequence of its relative share of all educational outcomes. Total linkage strength can similarly be expressed as the weighted average of the local linkage scores for occupations ($M(\mathrm{occ})_j$; see eq. [1]).

The linkage strength of educational category g (i.e., $M(\mathrm{ed})_g$) is itself not a pure "margin-free" measure of linkage because its value depends on the distribution of workers across occupations. To see this, note that the ratio $p_{j|g}/p_j$ can be rewritten as the ratio of the joint probability of being in occupation j and educational category g divided by the predicted joint probability if j and g are independent of each other. This ratio is independent of the marginal distributions of either j or g. If we write this ratio as

$$\alpha_{gj} = \frac{p_{j|g}}{p_j} = \frac{p_{jg}}{p_j p_g}, \tag{A4}$$

we can rewrite equation (A4) as

$$p_{j|g} = p_j \alpha_{gj},$$

and, therefore,

$$M(\mathrm{ed})_g = \sum_j p_j \alpha_{gj} \log(\alpha_{gj}). \tag{A5}$$

The $M(\mathrm{ed})_g$ index is clearly affected by the occupational distribution; the "pure linkage" measures $\alpha_{gj} \log(\alpha_{gj})$ for each combination of educational category and occupation are summed to produce the overall linkage strength for category g (i.e., $M(\mathrm{ed})_g$) using weights equal to the relative size of each occupation.

To repeat: M is not a "margin-free" measure of linkage. Country differences in M will be influenced by country differences in the marginal distribution of educational categories, which affect the sum in equation (A3), and by the marginal distribution of occupations, which affect the sum in equation (A5). However, country differences in M can be decomposed in two ways to isolate that part of M which is composition invariant by X, that part which affects the size of M solely through differences in the marginal distribution of X between the countries, and that part which is a difference in the entropy of Y between the countries, where X and Y stand for educational categories and occupations, respectively (or, alternatively, occupations and educational categories, respectively; Mora and Ruiz-Castillo 2011). We show the decomposition below for the difference in M due to educational composition-invariant association (ΔN_g) and due to differences in the distribution of occupational (ΔO_g) and educational (ΔE_g) categories. To be precise, we can write the difference in M for countries k and k' as

$$M_k - M_{k'} = \Delta N_g + \Delta O_g + \Delta E_g, \tag{A6}$$

where

$$\begin{aligned}
\Delta N_g &= \tfrac{1}{2}\Delta N(P_g(k)) + \tfrac{1}{2}\Delta N(P_g(k')) \\
\Delta N(\Pi_g) &= \sum_{g=1}^{G}\pi_g\sum_{j=1}^{J}\left\{p_{j|g}(k)\log(p_{j|g}(k)) - p_{j|g}(k')\log(p_{j|g}(k'))\right\} \\
\Delta O_g &= T_{\text{occ}}(k') - T_{\text{occ}}(k) \\
T_{\text{occ}}(k) &= \sum_{j=1}^{J}p_j(k)\log\left(\frac{1}{p_j(k)}\right) \\
\Delta E_g &= \tfrac{1}{2}\Delta E(P_g(k)) + \tfrac{1}{2}\Delta E(P_g(k')) \\
\Delta E(\Pi_g) &= \left\{\sum_{g=1}^{G}(p_g(k) - \pi_g)\sum_{j=1}^{J}p_{j|g}(k)\log(p_{j|g}(k))\right\} \\
&\quad - \left\{\sum_{g=1}^{G}(p_g(k') - \pi_g)\sum_{j=1}^{J}p_{j|g}(k')\log(p_{j|g}(k'))\right\},
\end{aligned} \tag{A7}$$

where k and k' are countries, $P_g(k)$ and $P_g(k')$ are the distributions across educational categories for countries k and k', $p_g(k)$ is the fraction of the population of country k in educational category g, $p_{j|g}$ is the probability of being in occupation j given that one is in educational category g, and Π_g is an argument whose components (the π_g terms) are replaced alternately by the proportions from the $P_g(k)$ distribution or from the $P_g(k')$ distribution, as indicated in the formula above for ΔN_g and ΔE_g. Note that the contribution of the occupational distributions to the total difference in linkage strength is just the difference in entropy (or equivalently, the negative of the difference in Theil's index) for the occupational distributions in the two countries. The contribution of the education distributions to the total difference in linkage strength is the weighted difference in the sum of the differences in proportions for each educational outcome, where the weights are measures of concentration (i.e., linkage) of workers with that educational outcome in a relatively small number of occupations; the less uniformly distributed are workers with that educational category across the occupations, the larger is the weight. See Mora and Ruiz-Castillo (2011) for further details and also for the alternative decomposition expressed in terms of an occupation distribution-invariant term, a difference in education entropy, and a (weighted) difference in the occupational distribution across the two countries.

The linkage measures defined above have statistical distributions that are described in Mora and Ruiz-Castillo (2009*b*). Because our sample sizes are large, sampling error is generally not large enough to be of substantive importance. For results where sampling error is of interest, we estimate standard errors using bootstrapping.

APPENDIX B

The Educational Systems of France, Germany, and the United States: A Brief Summary

The French educational system underwent a reform toward comprehensive education at the first stage of secondary education in the late 1970s and is therefore less stratified than it used to be. Today, all students except those with special education needs enter *collège* at around age 11–12, a comprehensive form of education that lasts four years. At the end of *collège*, however, a major branching point exists in the French schooling system in which students enter the vocational, technological, or academic track in the *lycée*. Different forms of *baccalauréat* exams exist. Although each form formally grants access to university, the transition to university is strongly stratified on the basis of the type of *baccalauréat* that is taken. At the tertiary level, the major distinction is between regular universities and the elite *grandes écoles*, which require a stage of preparatory classes after the *baccalauréat* exam.

Despite the inclusion of a tracked upper secondary system, the French system is considered to be less vocationally specific than the German system. Even though vocational and technological *baccalauréat* exams exist, the role of employers in the design of vocational qualifications is very limited. Also, at the tertiary level there is not an explicit vocational option as is the case in Germany. Standardization is very high in France, both in terms of inputs (curricular standardization, school budgets, teacher training) and outputs (centralized exams such as the *baccalauréat*).

The German educational system is highly vocationally specific, with a large dual system of school-and-work based learning. The responsibility of vocational training is delegated largely to employers. At the postsecondary phase, it is estimated that 59% of students enter vocational training (Neugebauer et al. 2013). A feature in the German system is that a special form of vocational tertiary education exists that prepares for professions (e.g., teaching, health care, computer programming). Like the apprenticeship system, these *Fachhochschulen* are considered to produce high "skill transparency" for employers.

The German system is also strongly stratified. Pupils are situated in full comprehensive education only until grade 4 (around age 10), after which they are sorted into either of three school types, *Hauptschule*, *Realschule*, and *Gymnasium*. *Gymnasium* prepares for the *Abitur*, the university entrance examination. Students finishing the *Hauptschule* and *Realschule*, which comprises about two-thirds of all students (Neugebauer et al. 2013), typically enter vocational training after their secondary school. It must be said that comprehensive education is extended in the secondary schools organized as *Gesamtschulen*, although the size of this type of comprehensive education varies considerably across German states (*Länder*). The German educational system is highly standardized, although some policies are standardized at the level of the *Länder* rather than at the national level. The system of vocational training in particular is highly standardized across the nation.

The educational system in the United States is more fragmented than is the case in France or Germany. The level of standardization is therefore rather low, although forms of standardization have been implemented in the private market, such as the Standardized Aptitude Test (SAT), to deal with the lack of transparency of educational qualifications for college admissions. Stratification of the system is low in high school because the American high school offers a comprehensive curriculum. Tracking obviously exists within schools, although the practice of whether and how students are tracked varies considerably across schools. Although these less transparent forms of tracking may exacerbate inequalities by social origin (Lucas 1999), it seems fair to say that these forms of stratification in the American educational system do little to improve the transparency of the skills of school leavers for prospective employers. The vocational orientation of the American system is also limited, with little employer involvement in the design of the secondary or postsecondary curriculum.

APPENDIX C

Coding Advanced Degrees in the United States

Table C1 illustrates the imputation process we employed to match workers with advanced degrees in the ACS to fields of study. Column 1 lists the occupations where imputation was used. Column 2 shows the fraction of occupational incumbents in each occupation who have advanced degrees in the ACS. Column 3 shows the imputed field of study that we used for each of these occupations, and column 4 shows the ISCO occupation to which this census occupation is mapped. In tables C2 and C3, we then computed linkage strength for five different operationalizations. The first of these is the

ACS data with no adjustment for the lack of information about fields of study for graduate degree holders. The second of these is the SIPP data, which have this missing information, where we maintain the 100 observation threshold for including a category in the linkage computation. The third operationalization is the SIPP data with a 50 observation threshold. We then employ two imputations of graduate degree field of study in the SIPP. The first imputation, which we refer to as the ACS-SIPP imputation, starts with respondents working in the professional and managerial occupations listed in table C1. For each of these occupations, it uses the SIPP to estimate the proportion of graduate degree holders whose field of study is a close match to their occupation (see col. 3 of table C1). It then randomly changes the field of study of degree holders in the ACS who work in these occupations for every occupation in which the proportion of BA fields of study in the close-matching field of study in the ACS is lower than the proportion of graduate degree holders in the close-matching field of study in the SIPP. We then employed a fourth, simpler imputation, which we describe as "ACS-boost," which simply boosts the number of graduate degree holders in the occupations of table C1 whose field of study matches their occupation by the proportion of ACS workers in this occupation who have graduate degrees.

Tables C2 and C3 compare these alternative methods for three different subsets of educational levels and fields of study: (1) the educational categories that meet the 100 observation SIPP threshold, (2) the educational categories that meet the 50 observation SIPP threshold, and (3) the educational categories that meet the 100 observation ACS threshold. These tables demonstrate that the set of alternative measures all yield very similar results. ACS-boost gives the least conservative linkage measure for the United States. Given that our comparison countries have relatively high linkage strength, the use of ACS-Boost makes it unlikely that we are underestimating the linkage strength in the United States when making cross-national comparisons.

TABLE C1

Field of Study Imputation for U.S. Census Occupations with a Large Share of Advanced Degrees

Census Occupation (1)	Share of Advanced Degrees (2)	Imputed Field (3)	ISCO Occupation (4)
Chief executives	.27	Business and administration	Legislators and senior officials
Computer and information systems managers	.25	Computing	Specialist managers
Financial managers	.20	Business and administration	Specialist managers
Engineering managers	.38	Engineering	Production and operations managers
Medical and health services managers	.31	Health	Production and operations managers
Natural sciences managers	.60	Life sciences	Production and operations managers
Management analysts	.37	Business and administration	Business professionals
Accountants and auditors	.20	Business and administration	Business professionals
Computer scientists and system analysts	.21	Computing	Mathematicians, statisticians, and related
Architects, except naval	.35	Architecture and building	Architects, engineers, and related
Aerospace engineers	.33	Engineering	Architects, engineers, and related
Biomedical engineers	.33	Engineering	Life science professionals
Chemical engineers	.28	Engineering	Architects, engineers, and related
Civil engineers	.26	Engineering	Architects, engineers, and related
Computer hardware engineers	.31	Engineering	Mathematicians, statisticians, and related
Environmental engineers	.42	Engineering	Life science professionals
Marine engineers	.20	Engineering	Architects, engineers, and related
Materials engineers	.22	Engineering	Architects, engineers, and related
Mechanical engineers	.20	Engineering	Architects, engineers, and related
Petroleum, mining, and geological engineers	.23	Engineering	Architects, engineers, and related
Agricultural and food scientists	.36	Life sciences	Life science professionals

Biological scientists	.48	Life sciences	Life science professionals
Medical scientists	.93	Life sciences	Life science professionals
Astronomers and physicists	.65	Physical sciences	Professionals
Atmospheric and space scientists	.41	Physical sciences	Professionals
Chemists and material scientists	.41	Physical sciences	Professionals
Environmental scientists and geoscientists	.48	Physical sciences	Life science professionals
Physical scientists	.72	Physical sciences	Life science professionals
Psychologists	.94	Social and behavioral sciences	Social science and related
Urban and regional planners	.55	Social and behavioral sciences	Architects, engineers, and related
Social workers	.35	Social services	Architects, engineers, and related
Clergy	.53	Social services	Religious professionals
Lawyers	.96	Law	Legal professionals
Postsecondary teachers	.74	Education	College and higher ed. teaching prof.
Chiropractors	.96	Health	Health associate professionals
Dentists	.99	Health	Health professionals
Dieticians and nutritionists	.31	Health	Health associate professionals
Optometrists	.99	Health	Health associate professionals
Pharmacists	.51	Health	Health professionals
Physicians and surgeons	.99	Health	Health professionals
Podiatrists	.98	Health	Health associate professionals
Audiologists	.89	Health	Health professionals
Occupational therapists	.37	Health	Health associate professionals
Physical therapists	.51	Health	Health associate professionals
Speech-language pathologists	.90	Health	Health associate professionals
Veterinarians	.99	Health	Health professionals
Health diagnosing and testing practitioners	.68	Health	Health associate professionals

TABLE C2
Comparing Segregation Measures Using the SIPP versus ACS Imputation for Advanced Degrees

	SIPP	ACS	ACS-SIPP	ACS-Boost
Results using 58 level-field combinations:				
Total linkage strength	.431	.402	.426	.425
Occupational groups by educational levels	.210	.206	.208	.205
Detailed occupations within groups by educational levels	.057	.054	.057	.056
Fields of study within levels by occupational groups	.030	.027	.030	.031
Fields of study within groups by fields of study within levels	.134	.115	.131	.133
Sample size	1,274,024	1,414,525	1,417,209	1,412,104
Results using 66 level-field combinations:				
Total linkage strength	.436	.409	.431	.437
Occupational groups by educational levels	.212	.209	.210	.208
Detailed occupations within groups by educational levels	.057	.055	.056	.055
Fields of study within levels by occupational groups	.030	.028	.030	.032
Fields of study within groups by fields of study within levels	.137	.118	.134	.142
Sample size	1,274,667	1,425,977	1,427,605	1,424,811

TABLE C3
Comparing Segregation Measures Using ACS Imputation Variations

	ACS	ACS-SIPP	ACS-Boost
Total linkage strength	.423	.444	.463
Occupational groups by education levels	.216	.216	.216
Detailed occupations within groups by educational levels	.058	.058	.058
Fields of study within levels by occupational groups	.028	.031	.033
Fields of study within groups by fields of study within levels	.121	.139	.156
Sample size	1,448,793	1,448,552	1,448,694

Note.—Results use 82 level-field combinations.

APPENDIX D

Tables Referred to in Main Text

TABLE D1
ISCED 1997 Educational Levels

Level	Description
0	Preprimary education
1	Primary education
2B	Lower secondary, direct access to 3C
2A	Lower secondary, access to 3A/3B
3C	Upper secondary, labor market access
3B	Upper secondary, access to 5B
3A	Upper secondary, access to 5A
4A	Preparation for entry to level 5
5B	Tertiary education, occupation specific
5A	Tertiary education, theoretical
6	Tertiary education, advanced (Germany and France)
6B	Tertiary education (U.S. master's)
6A	Tertiary education (U.S. Ph.D.)

TABLE D2
Fields of Study

0 General programs	52 Engineering/engineering trades
14 Teaching/education	54 Manufacturing and processing
21 Arts	58 Architecture and building
22 Humanities	62 Agriculture, forestry, and fishery
31 Social and behavioral science	64 Veterinary
32 Journalism and information	72 Health
34 Business and administration	76 Social services
38 Law	81 Personal services
42 Life sciences	84 Transport services
44 Physical sciences	85 Environmental protection
46 Mathematics and statistics	86 Security services
48 Computing	99 Unknown or unspecified

TABLE D3
Occupation Major Groups

Managers	Skilled agricultural workers
Professionals	Skilled production
Lower professionals, technicians	Machine operators, assemblers
Clerical workers	Low-skill workers/laborers
Service/sales workers	

TABLE D4

Harmonized ISCO Three-Digit Occupations

11 legislators and senior officials	235 other teaching professionals	323 nursing and midwifery associate professionals	413 material-recording and transport clerks	613 market-oriented crop and animal producers	742 wood treaters, cabinet-makers, and related trades workers	828 assemblers
110 legislators	241 business professionals	330 teaching associate professionals	414 library, mail, and related clerks	700 craft and related trade workers	743 textile, garment, and related trades workers	831 locomotive-engined drivers and related workers
122 production and operations department managers	242 legal professionals	334 other teaching associate professionals	419 other office clerks	712 building frame and related trades workers	744 pelt, leather, and shoemaking trades workers	832 motor-vehicle drivers
123 other department managers	243 archivists, librarians, and information professionals	341 finance and sales associate professionals	421 cashiers, tellers and related clerks	713 building finishers and related trades workers	800 plant and machine operators and assemblers	833 agricultural and other mobile-plant operators
130 general managers	244 social science and related professionals	342 business services agents and trade brokers	422 client information clerks	714 painters, building structure cleaners and related trades workers	812 metal-processing plant operators	834 ships' deck crews and related workers
200 general professionals	245 writers and creative or performing artists	343 administrative associate professionals	510 personal and protective services workers	720 metal, machinery, and related trades workers	813 glass, ceramics, and related plant operators	910 sales and services elementary occupations
212 mathematicians, statisticians and related professionals	246 religious professionals	344 customs, tax, and related government associate professionals	512 housekeeping and restaurant services workers	722 blacksmiths, tool-makers, and related trades workers	815 chemical-processing plant operators	913 domestic and related helpers, cleaners, and launderers

214 architects, engineers, and related professionals	311 physical and engineering science technicians	345 police inspectors and detectives	513 personal care and related workers	723 machinery mechanics and fitters	816 power-production and related plant operators	914 building caretakers, window, and related cleaners
221 life science professionals	312 computer associate professionals	346 social work associate professionals	514 other personal services workers	724 electrical and electronic equipment mechanics and fitters	820 machine operators and assemblers	916 garbage collectors and related laborers
222 health professionals (except nursing)	313 optical and electronic equipment operators	347 artistic, entertainment, and sports associate professionals	516 protective services workers	730 precision, handicraft, printing, and related trades workers	822 chemical-products machine operators	921 agricultural, fishery, and related laborers
231 higher education teaching professionals	314 ship and aircraft controllers and technicians	348 religious associate professionals	520 models, salespersons, and demonstrators	732 potters, glass-makers, and related trades workers	823 rubber and plastic products machine operators	932 manufacturing laborers
232 secondary education teaching professionals	321 life science technicians and related associate professionals	410 office clerks	610 market-oriented skilled agricultural and fishery workers	734 printing and related trades workers	826 textile-, fur-, and leather-products machine operators	933 transport laborers and freight handlers
233 primary and pre-primary teaching professionals	322 modern health associate professionals	412 numerical clerks	612 market-oriented animal producers and related workers	740 other craft and related trades workers	827 food and related products machine operators	999 missing

TABLE D5
Linkage Strength by Condensed Levels and Fields in France

	0	1	2AB	3ABC	4A/5B	5A/6B/6A
No field	.84	.52	.18	.13	...	1.06
Teaching/education	...	...	...	...	...	2.39
Arts	...	...	...	1.04	1.72	1.22
Humanities	...	...	...	.27	...	1.05
Social and behavioral science	...	...	...	.24	...	.79
Journalism and information	...	...	...	...	1.42	1.89
Business and administration	...	...	...	.40	.62	.99
Law	...	...	...	...	1.20	1.36
Life sciences	...	...	...	...	2.00	1.03
Physical sciences	...	...	...	...	1.23	1.37
Mathematics and statistics	...	...	...	...	...	1.42
Computing	...	...	...	...	1.57	2.10
Engineering/engineering trades	...	...	...	.62	.83	1.47
Manufacturing and processing	...	...	...	.67	.59	1.21
Architecture and building	...	...	...	.92	.86	1.39
Agriculture, forestry, and fishery	...	...	...	1.25	1.09	1.31
Veterinary	...	...	...	...	...	3.58
Health	...	...	...	1.11	2.19	3.12
Social services	...	...	...	1.03	...	...
Personal services	...	...	...	1.11	.62	1.17
Transportation	...	...	...	1.21	.93	1.95
Security Services	...	...	...	...	...	...
Environment	...	...	...	.86	...	1.10
Unknown or unspecified	...	...	...	...	...	...

TABLE D6
Linkage Strength by Condensed Levels and Fields in Germany

	0	1	2AB	3ABC	4A/5B	5A/6B/6A
No field	...	.84	.34	.27	...	.77
Teaching/education	...	...	...	2.16	1.77	1.65
Arts	...	...	...	1.07	1.44	2.00
Humanities	...	...	...	1.21	1.20	1.36
Social and behavioral science	...	...	...	...	.68	1.09
Journalism and information	...	...	...	...	...	2.89
Business and administration	...	...	...	.58	.80	.95
Law	...	...	...	...	...	3.16
Life sciences	...	...	...	...	...	1.98
Physical sciences	...	...	...	1.47	...	1.57
Mathematics and statistics	...	...	...	1.47	1.96	2.07
Computing	...	...	...	.86	1.74	2.06
Engineering/engineering trades	...	...	...	.68	.76	1.46
Manufacturing and processing	...	...	...	.70	1.14	.76
Architecture and building	...	...	...	.94	1.07	1.98
Agriculture, forestry, and fishery	...	...	...	1.50	1.80	1.29
Veterinary	...	...	...	...	...	2.71

TABLE D6 (*Continued*)

	0	1	2AB	3ABC	4A/5B	5A/6B/6A
Health	. . .	. . .	. . .	1.49	1.86	3.42
Social services	. . .	. . .	. . .	1.32	1.62	2.50
Personal services	. . .	. . .	. . .	.89	1.32	1.21
Transportation	. . .	. . .	. . .	1.02	1.26	1.73
Security Services	. . .	. . .	. . .	3.01	2.79	2.50
Environment	. . .	. . .	. . .	. . .	. . .	. . .
Unknown or unspecified	. . .	. . .	. . .	. . .	. . .	. . .

TABLE D7
Linkage Strength by Condensed Levels and Fields in the United States

	0	1	2AB	3ABC	4A/5B	5A/6B/6A
No field	.51	.68	.38	.09	. . .	. . .
Teaching/education	. . .	. . .	. . .	. . .	.71	1.19
Arts	. . .	. . .	. . .	. . .	. . .	.70
Humanities	. . .	. . .	. . .	. . .	.24	.45
Social and behavioral science	. . .	. . .	. . .	. . .	.53	.47
Journalism and information	. . .	. . .	. . .	. . .	. . .	.55
Business and administration	. . .	. . .	. . .	. . .	.29	.58
Law	. . .	. . .	. . .	. . .	. . .	4.27
Life sciences	. . .	. . .	. . .	. . .	.74	.76
Physical sciences	. . .	. . .	. . .	. . .	. . .	1.15
Mathematics and statistics	. . .	. . .	. . .	. . .	. . .	.78
Computing	. . .	. . .	. . .	. . .	.47	1.41
Engineering/engineering trades	. . .	. . .	. . .	. . .	.68	1.12
Manufacturing and processing	. . .	. . .	. . .	. . .	1.14	. . .
Architecture and building	. . .	. . .	. . .	. . .	.77	2.90
Agriculture, forestry, and fishery	. . .	. . .	. . .	. . .	.63	.46
Veterinary	. . .	. . .	. . .	. . .	. . .	. . .
Health	. . .	. . .	. . .	. . .	1.02	2.06
Social services	. . .	. . .	. . .	. . .	. . .	1.75
Personal services	. . .	. . .	. . .	. . .	.65	.41
Transportation	. . .	. . .	. . .	. . .	1.24	1.41
Security Services	. . .	. . .	. . .	. . .	1.34	.88
Environment	. . .	. . .	. . .	. . .	. . .	.61
Unknown or unspecified	. . .	. . .	. . .	. . .	.09	.34

TABLE D8
RELATIONSHIP BETWEEN EDUCATIONAL LINKAGE STRENGTH AND PERCENTAGE OF WORKERS WITH THAT EDUCATIONAL OUTCOME IN THE MOST COMMON OCCUPATIONS FOR THAT EDUCATIONAL OUTCOME

	P3		P5		P10	
Main effects only:						
Linkage	.19	(.007)	.17	(.006)	.12	(.005)
Intercept	.22	(.01)	.36	(.01)	.56	(.008)
R^2	.77		.75		.71	
Country-linkage interactions:						
Linkage-France	.20	(.009)	.18	(.009)	.14	(.007)
Linkage-Germany	.18	(.007)	.16	(.007)	.12	(.006)
Linkage-United States	.19	(.008)	.17	(.008)	.12	(.007)
Intercept	.22	(.01)	.35	(.01)	.56	(.01)
R^2	.78		.76		.71	

NOTE.—SEs are in parentheses. Observations are harmonized educational outcomes by country. Occupations are measured with three-digit ISCO. P3 is the proportion of workers in the three most common occupations for each specific educational outcome; P5, the proportion in the five most common occupations; P10, the proportion in the 10 most common occupations. $N = 237$.

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