

Chapter 6

Discrimination Data Analysis: A Multi-disciplinary Bibliography

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Abstract Discrimination data analysis has been investigated for the last fifty years in a large body of social, legal, and economic studies. Recently, discrimination discovery and prevention has become a blooming research topic in the knowledge discovery community. This chapter provides a multi-disciplinary annotated bibliography of the literature on discrimination data analysis, with the intended objective to provide a common basis to researchers from a multi-disciplinary perspective. We cover legal, sociological, economic and computer science references.

6.1 Introduction

Discrimination refers to an unjustified distinction of treatment on the basis of any physical or cultural trait, such as gender, race, religion or sexual orientation. The problems of assessing the presence, the extent, the nature, and the trend of discrimination are then of primary importance. In the last fifty years, such problems have been investigated from social, legal, economic, and, recently, from a computer science perspective. The issues of data collection and data analysis are persistent, unifying themes along all the perspectives. We present an annotated multi-disciplinary bibliography specifically focusing on “data-driven”, or empirical, or analytical, approaches. The ease of data storage and retention, the ever increasing computing power, the development of intelligent data analysis and mining techniques make it possible to apply “in-the-large” and to improve over classical statistical and econometric techniques. The reference literature, however, is abundant and spread over publications of many disciplines, as witnessed by our references: social sciences, psychology, economics, finance, health research, housing and urban development, statistics, biometrics, econometrics and data mining.

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A complete bibliography would be an utopian goal. Our priority is to provide the interested reader with references to survey, comparison, and overview papers as well as with recent works on the subject. The chapter is structured as follows. After introducing the relevant concepts and references from social and legal perspectives in Section 6.2, we concentrate on the vast research on economic models of labour discrimination in Section 6.3. The approaches for collecting and analyzing controlled data using (quasi-)experimental scientific methodologies are presented in Section 6.4. Section 6.5 discusses discrimination in profiling and scoring, and, finally, Section 6.6 reports on recent work on using data mining for discrimination discovery and prevention.

6.2 Sociological and Legal Perspectives

From a sociological perspective, there are three main causes of discrimination: prejudice, rational racism, and unintentional discrimination. *Prejudice* leads to discrimination when it concerns unfairly or unreasonably formed negative attitudes against a protected¹ group. The vicious cycle of discrimination (Newman, 2008) starts from a situation where prejudice causes a protected group to be socially disadvantaged. This is interpreted as evidence that the group is inferior, which, in turn, creates renewed prejudice by increasing social distance, by reinforcing negative stereotypes, and by legitimating negative feelings. Psychologists have investigated situations of anxiety or concerns, called stereotype threats (Steele & Aronson, 1995), where persons have the potential to confirm a negative stereotype of their social group, which results in reduced performances of individuals. *Rational racism* is the result of rational thinking. A form of rational racism is statistical discrimination, occurring when the lack of knowledge about the skills of an individual is compensated by a prior knowledge of the average performances of the group or category the individual belongs to. Another example of rational thinking occurs when an employer foresees a negative impact on his business due to the prejudice of his customers against employees belonging to a protected group. Finally, *unintentional discrimination* occurs not because of malevolent decisions, but due to the lack of awareness on the effects of a decision. This is the case of indifference, incorrect (execution of) procedures or practices, lack of planning and analysis of the decision outcomes. Also, a form of unconscious or implicit discrimination has been considered in the literature (Bertrand et al., 2005; Greenwald & Krieger, 2006; Kang & Banaji, 2010). Together with the concept of indirect discrimination (see later on), unintentional discrimination poses considerable problems for the data analyst to carefully take into account the effects of decisions from the point of view of different protected groups. We refer to (R. Brown, 2010; Newman, 2008) for a sociological overview of prejudice, to (Whitley & Kite, 2009) for a psychological discussion², to (Quillian, 2006) for a

¹ We use the term “protected group” for any social group protected by anti-discrimination laws.

² See <http://www.understandingprejudice.org> for links to prejudice-related resources.

review of racial prejudice, and finally, to (Harford, 2008) for a discussion of rational racism. (Yamagishi et al., 1999) review social theories of in-group favoritism.

In the legal context, provisions on equality or non-discrimination³ are firmly embedded within the key human rights treaties of the United Nations Legislation (United Nations Legislation, 2011). Anti-discrimination laws, however, have evolved differently in common law countries compared to civil law ones. The United States (US) Federal Legislation (U.S. Federal Legislation, 2011), the U.K. Legislation (U.K. Legislation, 2011) and the Australian Legislation (Australian Legislation, 2011) follow the common law characteristic of “the absence of systematisation, or a desire thereof” (Schiek et al., 2007, Introductory Chapter), with the result that laws have been developed ground-by-ground and with reference to specific contexts, possibly with different ruling from one case to another. The European Union (EU) Legislation (European Union Legislation, 2011) and the EU Member States follow a principled approach, resulting in laws covering a (long) list of grounds of discrimination. For a deeper legal discussion and comparison of national and international laws, we refer the reader to books on international group rights (N. Lerner, 2003; Schiek et al., 2007), on EU laws (Ellis, 2005; E.U. Agency for Fundamental Rights, 2011), and on US laws (Bamforth et al., 2008). Several independent authorities (equality enforcement bodies, regulation boards, consumer advisory councils, commissions) provide advice, monitor, and report on discrimination compliances. For instance, the EU Commission⁴ publishes an annual report on the progress in implementing the Equal Treatment Directives by the Member States (Chopin & Do, 2010); and in the US Attorney General reports to the Congress about the annual referrals to the Equal Credit Opportunity Act. A general legal principle is to consider *group under-representation* in obtaining a benefit as a quantitative measure of (indirect) discrimination against a protected group. Data collection and statistical data analysis are recognized as fundamental both in the common law and in the civil law countries (R. M. Blank et al., 2004; Makkonen, 2006, 2007). It is commonly agreed, however, that the statistical conclusions establish *a prima facie* evidence of discrimination, which may be rebutted by the respondent using further arguments (e.g., a genuine occupational requirement or an objective justification). We refer to (Wingate & Thornton, 2000; Finkelstein & Levin, 2001) for a review of statistical methods in discrimination litigations. The book edited by (Kaye & Aickin, 1992) contains a collection of papers on the subject. A continuously updated book on statistical methods and case laws is maintained by (Paetzold et al., 1994). Finally, the interdisciplinary economic-legal survey by (Donohue, 2007) provides an overview of the connections between economic models and empirical findings from the one side, and the US anti-discrimination laws on the other side. A related legal concept that is worth mentioning is the one of *affirmative actions*, sometimes called *positive actions*, which are a range of policies to overcome and to compensate for past and present discrimination by providing opportunities to those traditionally denied

³ The term “non-discrimination law” recalls a set of negative obligations, while “equality law” recalls, in addition, a set of positive obligations to reach the ideal of equal treatment (Bell, 2002).

⁴ See also the European Network of Legal Experts <http://www.non-discrimination.net>, and the Migration Policy Group <http://www.migpolgroup.com>.

for (ENAR, 2008; Holzer & Neumark, 2004; Sowell, 2005). They range from the mere encouragement of under-represented groups to preferential treatment or quotas in favor of those groups (see e.g., Holzer & Neumark, 2006; R. Lerner & Nagai, 2000).

Since discrimination can arise only through the application of different rules or practices to comparable situations or of the same rule or practice to different situations, a relevant legal distinction is between direct and indirect discrimination. When such rules or practices explicitly treat one person less favourably on a forbidden ground than another is, has been or would be treated in a comparable situation, we have *direct discrimination*, sometimes called *systematic* discrimination or *disparate treatment*. When an apparently neutral provision, criterion or practice results in an unfair treatment of a protected group, we have *indirect discrimination*, sometimes called *adverse impact* (Tobler, 2008). While direct discrimination is intentional and “directed” towards individuals, typically on the basis of their visible traits, such as ethnic origin, race, sex and age, indirect discrimination is concerned with avoiding the circumvention of the prohibition to discriminate, and to enforce such a prohibition substantively, even in the case of unintentionality.

6.3 Labour Economic Perspective

In the labor market, different treatments among groups of workers can be measured in terms of their wages (*wage differentials*), in the degree of participation in the labor force (*employment differentials*), or in the degree of segregation in specific occupations or industries (*segregation differentials*). Public surveys routinely collect data on demographic characteristics and attitudes of residents (e.g., in the US, the General Social Survey - GSS), on the distribution of labor forces in the labor market (e.g., Current Population Survey - CPS), and so on. Empirical research techniques have applied statistical inference to collected data either with the purpose of testing the consequences predicted by a theoretical economic model, or to assess the contribution of different types of discrimination to the overall different treatments in the labor market. The main data analysis techniques adopted include statistical tests on rates and proportions (Agresti, 2002; Fleiss et al., 2003; Sheskin, 2004), (generalized) linear regression models (Dobson & Barnett, 2008; Hardin & Hilbe, 2007; McCullagh & Nelder, 1989), and econometric models (Greene, 2008).

Two major theoretical models of discrimination have been considered in the economic literature. *Taste-based discrimination*, originally proposed by (Becker, 1971), has no rational or economic basis, but only a prejudiced personal taste against protected groups. Wage differentials are due to an additional psychological cost for employing minority workers. Differently, *statistical discrimination*, originated by (Arrow, 1971) and (Phelps, 1972) and systematized by (Aigner & Cain, 1977), starts from the assumption that employers cannot perfectly assess worker productivity at the time of hiring. This market imperfection gives them an incentive to use easily observable characteristics, such as sex and race, as proxies for the expected produc-

tivity, estimated by their prior knowledge on the average productivity of the group the worker belongs to. Wages are then set on the basis of the expected productivity of the group, not on the basis of the person's productivity. We refer the reader to (Altonji & Blank, 1999) for a comprehensive mathematical introduction to both theories of economic discrimination, as well as for past empirical approaches to show direct evidence. More recent or comprehensive reviews of theories and empirics in labor market are available in (Cain, 1987; Charles & Guryan, 2011; Kunze, 2008; Lang & Lehmann, 2011). (Weichselbaumer & Winter-Ebmer, 2005) conduct a meta regression analysis of the works on gender wage differentials, where each point of data is not an individual but a research study. (Neal & Johnson, 1996) observed that, after controlling for the ability of a worker, the racial wage gap greatly reduces. In such a study, ability was measured through the controversial *Armed Forces Qualifying Test* (AFQT) score, a test of cognitive skills taken by male adolescents and available from the National Longitudinal Survey of Youth. In the following, we briefly review the most recent lines of research and extensions of the two economic models.

Approaches on taste-based discrimination. The additional cost of minority workers in presence of taste-based discrimination leads to an equilibrium wage differential and to segregation of minority workers in less discriminating firms or for specific occupations. Lower earning for discriminatory firms implies that discrimination occurs mainly in low competitive markets. This is known as the *static implication* of the Becker's model⁵. Influential papers are (Charles & Guryan, 2008), which combine GSS data (to measure racial prejudice) with CPS data (to measure differences in wages), and (Hellerstein et al., 2002), which relate firm profitability to the proportion of female workers both in low competition and high competition markets. Recent approaches using survey data include (Sano, 2009; Tsao & Pearlman, 2010; Zhang & Dong, 2008). On the basis of the identity of the discriminator, Becker's model distinguishes *employer discrimination* (taste in hiring), *customer discrimination* (taste in buying), and *co-employee discrimination* (taste in co-operating). Recent analyses of consumer discrimination have been conducted on data from restaurants (Parrett, 2011; Myers, 2007), contact jobs (Combes et al., 2011), retail stores (Leonard et al., 2010), Major League Baseball (Coyne et al., 2010) and taxicab drivers (Ayres et al., 2005). Evidence of correlation between the predominant race of customers and the race of the marginal hired worker has been shown in (Holzer & Ihlanfeldt, 1998).

The working context of *professional sports*, such as baseball, basketball, football, and soccer, offers an unusually good opportunity of studying discrimination. The problem of estimating the productivity of workers is here substantially solved by extensive, publicly available (from online sport almanacs), measures of the per-

⁵ The *dynamic implication* of the Becker's model predicts that non-discriminating employers earn higher profits by hiring members of the protected group, and, in the long run and in a competitive market, discriminatory firms will be driven out of the market. The dynamic implication has been investigated in the context of banking deregulation (Black & Strahan, 2001; Levine et al., 2008), globalization (Black & Brainerd, 2004; Neumayer & de Soysa, 2007; Oostendorp, 2009) and in the adoption of equality laws worldwide (Weichselbaumer & Winter-Ebmer, 2007).

performances of players and coaches. Research has covered discrimination in hiring, in retaining (along seasons), in segregating (to specific game roles), and in salary of players, as well as customer discrimination. The last topic is also known as *fan discrimination*, typically measured using TV audience (Aldrich et al., 2005), game attendance (Foley & Smith, 2007; Hersch, 2009; Wilson & Ying, 2003), the trading value of sport cards (Broyles & Keen, 2010; Primm et al., 2011), the votes for best player awards (Jewell et al., 2002). As far as salary discrimination in professional sports is concerned with, there is an extensive literature on the subject. We mention only a few recent papers (Berri & Simmons, 2009; Holmes, 2011; Frick & Deutscher, 2009; Goddard & Wilson, 2009; Palmer & King, 2006; Yang & Lin, 2010), and refer the reader to the surveys (Kahn, 1991b, 2000, 2009).

Extensions of taste-based discrimination, called *search models* (Altonji & Blank, 1999; Lang & Lehmann, 2011), take into account the costs for workers of searching jobs by interacting with prejudiced and non-prejudiced firms, and, for consumers, the costs of searching sellers of their same racial group (Flabbi, 2010; Kuhn & Shen, 2009; Sulis, 2007; Usui, 2009). Finally, a line of studies, initiated by (Hamermesh & Biddle, 1994), investigates the “beauty premium” in labor market. As a recent work, we mention (Cipriani & Zago, 2011), who study favoritism to attractive students in taking exams at University. The effectiveness of blind decisions in reducing gender discrimination has been evaluated for orchestra auctions in (Goldin & Rouse, 2000).

Approaches on statistical discrimination. Some extensions of the statistical discrimination model deal with what happens as the employer’s information on workers’ productivity changes, e.g., at the selection time or over the course of the job. These dynamic extensions, contrasted to a static model, are known as *employer learning* models. (Farber & Gibbons, 1996) propose a dynamic model of learning about worker ability in a competitive labor market. Altonji and Pierret provide a first important strand literature on learning models (Altonji & Pierret, 2001). We complement the studies surveyed in the recent paper (Lang & Lehmann, 2011) by mentioning: (Cheung, 2010), in testing whether parental education is used as a proxy for the ability of workers; and (Wang, 2010), in considering height as an easily observable characteristic.

Also, the differential observability or learnability of worker’s productivity among groups has been taken into account by *screening discrimination* models, originally introduced in (Lang, 1986). Such differences are due, e.g., to miscommunication problems or weak interactions among groups. As an example, (Grogger, 2011) analyzes audio data from telephone interviews to understand the role that speech may play in explaining racial wage differences, and (Pinkston, 2006) shows that the level of education has a large impact on wages. Similar work emerges from the health literature, when testing whether miscommunication problems influence a diagnosis (Balsa et al., 2005; Mcguire et al., 2008) or whether “expert” patients obtain a more favorable treatment (Grytten et al., 2011). Another strand of statistical discrimination models studies how negative rational stereotypes of employers differentiates firms’ hirings and wages, and workers’ investments, e.g., in education. (Lang & Lehmann, 2011) call this class as *rational stereotyping* models. Finally, we refer to

the survey (Fang & Moro, 2010) for a theoretical discussion of models of statistical discrimination and affirmative actions.

6.4 (Quasi-)Experimental Perspective

A recurring problem in discrimination analysis is the collection of controlled data, as opposed to observational data, for which the results of analytical and statistical techniques can be interpreted without any concern for external or confounding factors. This has been tackled through quasi-experimental and experimental methods, that we review in the next two subsections.

6.4.1 Auditing

Auditing, also known as *field experiments*, follows a quasi-experimental approach to investigate for the presence of discrimination by controlling the factors that may influence decision outcomes. The basic idea consists of using pairs of *testers* (also called *auditors*), who have been matched to be similar on all characteristics that may influence the outcome except race, gender, or other grounds of possible discrimination. The tester pairs are then sent into one or more situations in which discrimination is suspected, e.g., to rent an apartment or to apply for a job, and the decision outcome is recorded. The difference in the outcomes among the paired groups provides then a measure of discrimination. A summary of recent audit studies in employment discrimination is due to (Pager, 2007). (Riach & Rich, 2002) review and compare the statistical significance of field experiments on racial, sex, and disability discrimination in employment, and on discrimination on housing sale and rental. Criticism of the conclusions drawn from audit methods is discussed in (Heckman & Siegelman, 1993) and (Heckman, 1998), while (Riach & Rich, 2004) comment on ethical implications of such methods. (Quillian, 2006) discusses how the measurement of discrimination through audit methods should incorporate recent advancement in psychological theories of prejudice.

We categorize three different approaches in detecting discrimination by auditing.

Situation testing occurs when the testers come in contact with the decision maker. This is the case, for instance, of job interviews involving human testers, who are selected and trained in advance to act similar each other (Bendick et al., 2010; Moreno et al., 2004; Pager & Quillian, 2005; Pager et al., 2009; Turner & Ross, 2005; Turner et al., 2002). A strong point in favor of situation testing is that testers can record the cause of discrimination, such as prejudice or stereotypes, hence allowing for a causal analysis of the discrimination cases. A limitation of situation testing is that the phase of data collection is expensive. In addition, situation testing cannot be applied at all in some contexts, e.g., in wage rising discrimination, or in disparate application of contractual terms, e.g., in house lending (Roscigno et al., 2009). (Bendick, 2007)

reviews more than 30 situation testing studies in employment discrimination in the US, while (Rorive, 2009) covers the EU Member States context.

In *correspondence testing*, the data scarcity problem is mitigated by designing paired ad-hoc fake resumes or application forms to be sent to advertised vacancies, and by assigning to each of them a typical white American name or an African-American sounding name (Arai et al., 2008; Banerjee et al., 2009; Bertrand & Mullainathan, 2004; Carlsson & Rooth, 2007; Kaas & Manger, 2010; Neumark, 2010). Other grounds of discrimination have been covered with a correspondence testing approach in job applications, including sex (Riach & Rich, 2006; Booth & Leigh, 2010), obesity (Rooth, 2009), sexual orientation (Drydakis, 2009), ethnicity (McGinnity et al., 2009).

Larger opportunities for data collection are offered by emerging Internet job advertisement services, known as *e-recruiting* (Booth et al., 2010; Edin & Lagerström, 2006). The synthetic generation of resumes is tackled in (Lahey & Beasley, 2009) by a parametric tool that mitigates the bias that is present in manually generated CVs. The legal implications of possible discrimination in e-recruiting, as compared to classical means of recruiting, are discussed in (Hogler et al., 1998). In addition, contexts other than employment can be covered, such as discrimination in product advertising in internet marketing (Doleac & Stein, 2010; Nunley et al., 2010), and in on-line rental housing (Ahmed & Hammarstedt, 2008; Bosch et al., 2010; Friedman et al., 2010; Hanson & Hawley, 2011; Taylor, 2010).

6.4.2 *Controlled Experiments*

Field experiments construct control groups by matching similar persons and then observing the outcome of a quasi-experiment in a *natural* environment, e.g., in a job selection procedure. Empirical data from field experiments reflect a variety of environmental factors: disentangling these factors may be difficult if not impossible. Controlled experiments are conducted in an *artificial* environment, such as a laboratory, under tightly controlled conditions, including selection of treatment and control groups and strict rules on their behavior and actions. On the one hand, the impact of a specific factor can be evaluated by systematically varying it. On the other hand, confounding variables and other extraneous stimuli can be minimized. Controlled experiments are very useful to test the predictions of some theoretical model or to pre-test the impact of some ruling or laws before their application. Also, controlled experiments are repeatable, by definition, and less expensive than field experiments. The main criticism against controlled experiments is that they suffer of lack of realism, also called *external validity*. (Harrison & List, 2004) propose a taxonomy of experiments. We refer to (Charness & Kuhn, 2011; Levitt & List, 2007) and (R. M. Blank et al., 2004, Chapter 6) for an in-deep discussion on methodological strengths and on the limits of generalizing results obtained from experiments.

We distinguish here two classes of controlled experiments, namely laboratory experiments and natural experiments.

(Levitt & List, 2007) review five classes of games used in the economic literature to measure social preferences through *laboratory experiments*, including fairness, trust, and conditional reciprocity. The reviewed games include dictator and ultimatum games, public goods games, trust and gift exchange games. As an example, (Fershtman & Gneezy, 2001) adopt trust games, dictator and ultimatum games to test for ethnic discrimination. The trust game assumes a “player A”, who is given a fixed amount of money and asked to transfer a certain amount to “player B”. The transferred amount is triplicated. Then, “player B” can choose to transfer any part of the received amount back to “player A”. Players A and B are randomly paired from students of different ethnicity. The lower average amount of money transferred to players of a specific ethnicity, compared to others ethnicities, is considered evidence of discrimination. Recent controlled experiments can be found in the context of sports card market (J. List, 2004), employment (Feltovich & Papageorgiou, 2004; Falk et al., 2008) and wages differentials (Güth et al., 2010; Dickinson & Oaxaca, 2009), beauty and speech differences (Andreoni & Petrie, 2008; Rödin & Özcan, 2011). Moreover, gender (Slonim & Guillen, 2010), racial (Castillo & Petrie, 2010) and district-based (Falk & Zehnder, 2007) differences have been studied in the context of in-group discrimination and favoritism.

Natural experiments occur in real life (yet, controlled) situations. The experimenter only observes the behavior of participants, who typically are not aware of the experiment. Television game shows are a typical example, where discriminatory choices of participants can be studied in a controlled environment. Discrimination analysis has been reported in (Antonovics et al., 2005, 2009; Bagues & Villadoniga, 2008; Levitt, 2004), with data gathered from the *Weakest Link* game show, in (Lee, 2009) with data from *American Idol* TV contest show, and in (J. A. List, 2006) with data from *Friend or Foe?*. Sources of favoritism to attractive people by analysing data from a TV game show based on the prisoner’s dilemma are studied in (Belot et al., 2008). In addition to the criticism of external validity, natural experiments have also the problem that not all factors are under control, e.g., the selection of participants to a TV game show.

6.5 Profiling Perspective

Profiles consists of patterns, rules, or any other form of knowledge that can be used to screen people when searching for those with a certain behavior. They occur in many context, from criminal investigation to marketing, from genetic screening to web site personalization, from fraud prevention to location-based services. Profiling is the process of extracting profiles, either by manually eliciting them from domain experts or by automatically inferring them from historical data using increasingly sophisticated machine learning and data mining techniques. The process of profiling also concerns the application of profiles to screen individuals, e.g., as in the case of credit risk scoring and in the identification of security risks – which are covered in

the next two subsections. We refer to (Hildebrandt & Gutwirth, 2008) for a cross-disciplinary perspective of automated profiling.

6.5.1 Racial Profiling

Profiling is an illegal practice as soon as its application results in direct or indirect discrimination against protected groups. In this section, we concentrate on *racial profiling*, defined as “the practice of subjecting citizens to increased surveillance or scrutiny based on racial or ethnic factors rather than reasonable suspicion” (J. Chan, 2011). Among several possible contexts of racial profiling, vehicle stops have attracted the vast majority of studies⁶. Numerous data collection efforts have been initiated by law enforcement agencies, often as a result of litigation or of legislation, for the purpose of understanding the vehicle stop practices of its officers. Attributes collected concern the stop (time, date, location, reason, duration), driver (race, gender, age), vehicle (make, model), officer (age, gender, race, education, experience), and the outcome of the stop (e.g., warning, citation, arrest, search, seizure of contraband). The objective of data analysis is to identify racial patterns of disparity. One of the early surveys on racial profiling is due to (Engel et al., 2002). More recent papers include (Farrell & McDevitt, 2010; Tillyer et al., 2010), reviewing vehicle stops approaches. The adequacy of statistical analysis of racial profiling in addressing legal issues is also discussed in (Tillyer et al., 2008). For a legal comparison of US and EU laws, see (Baker & Phillipson, 2011).

(Tillyer et al., 2010) categorize existing approaches depending on whether they deal with the initial decision or with the outcome of a stop.

In *initial stop* studies, the actual rate of stops by drivers’ race is compared with benchmark data providing the expected rate of stops assuming no police bias. The outermost difficulty of the approach consists of identifying accurate benchmarks of the expected driver population at risk of being stopped. (Engel & Calnon, 2004), and (R. M. Blank et al., 2004, Chapter 9) outline strengths and limitations of six primary data sources and their use in the design of benchmark data: census data, observations of roadway usage, official accident data, assessments of traffic violating behaviour, citizen surveys, and internal departmental comparisons. Alternative means for collecting benchmark data are proposed in (Alpert et al., 2004; Jobard & Lévy, 2011; Quintanar, 2009; Ridgeway & MacDonald, 2009; Gelman et al., 2007).

Post-stop outcome studies focus on the identification of racial disparities in a specific outcome of the stop by taking as reference population the whole set of stops. An example of post-stop outcome analysis consists of checking whether the search for drugs among stopped vehicles is biased against the driver’s race. In this respect, starting from the influential paper proposed in (Knowles et al., 2001), several extensions and critiques have been presented (Antonovics & Knight, 2009; Anwar

⁶ Other contexts include profiling in airport security (Gabbidon et al., 2011; Persico & Todd, 2005), fraud investigators (Leopold & Meints, 2008), capital sentences (Alesina & Ferrara, 2011), and consumer profiling (Gabbidon et al., 2008; Schreurs et al., 2008).

& Fang, 2006; Gardner, 2009; Rowe, 2009; Sanga, 2009). We refer to the surveys (Tillyer et al., 2010; Engel, 2008) for extensive references. Recent additional approaches include (Anbarci & Lee, 2008; Blalock et al., 2007; Pickerill et al., 2009; Ridgeway, 2006).

6.5.2 Credit Markets

Discrimination in the lending process may occur at several steps, from advertising, to pre-application enquires, to loan approval/denial, up to loan administration (Turner & Skidmore, 1999). Among the various credit markets, mortgage lending has received most of the interest. In all cases, however, the main challenge is in the difficulty of estimating the risk of granting a loan to an applicant on the basis of her financial capacity and her personal characteristics.

In the US, the *Home Mortgage Disclosure Act* (HMDA) requires lenders to gather and to make available census data about their mortgage applications. Since 1990, the HMDA has been integrated with information on discrimination grounds of applicants. One of the first relevant contribution is due to researchers at the Federal Reserve Bank of Boston in the research work known as *Boston Fed Study* (Munnell et al., 1996). They supplemented the original census HMDA data for Boston with additional information on the credit history of more than 3,000 individual applicants, including data from more than one hundred financial institutes. Several criticisms of the Boston Fed study appeared in the literature (Ross & Yinger, 2002, Chapter 5), (Longhofer & Peters, 1999), (Turner & Skidmore, 1999, Chapter 3). Among the problems highlighted, we mention data errors, misclassification problems, endogenous explanatory variables and the omitted variables bias (e.g., loan amount and indicator of cosigner were missing). A theoretical and empirical survey on racial disparities in mortgage lending markets in the context of the fair housing legislation is provided in (LaCour-Little, 1999). (G. Dymski, 2006) describes the state-of-the-art on discrimination in housing and credit markets both from a legal and an economic perspective. A recent review has been proposed in (Yezer, 2010), which devises three approaches of testing disparities in loan approval decisions: mortgage rejection, pricing and defaults.

In *mortgage rejection*, the disproportionate rate of rejected decisions between racial groups of applicants is considered *prima facie* evidence of discrimination. Empirical studies (Clarke et al., 2009; Dietrich, 2009; Dietrich & Johannsson, 2005; Goenner, 2010; Sanandaji, 2009) include the analysis of HMDA data at *bank level* (i.e., a model for each bank under analysis) or at a *market level* (i.e., a single model aggregating variables for several banks). An experimental comparison of the two approaches is reported in (Blackburn & Vermilyea, 2006). Other sources of data range from micro-lending data (Agier & Szafarz, 2010) to on-line data derived from a peer-to-peer lending site (Pope & Sydnor, 2011).

Mortgage pricing concentrates on the dataset of approved loans, by considering whether a minority group is systematically charged with the highest interest rates.

Recent mortgage pricing studies consider gender and racial discrimination in consumer credit (Edelberg, 2007), such as credit cards and education loans, in private firm credit (Albareto & Mistrulli, 2011; Blanchard et al., 2008; Blanchflower et al., 2003; Cavalluzzo et al., 2002; Muravyev et al., 2009), in subprime home loans (Bocian et al., 2008; Reid & Laderman, 2009), in household credit (Weller, 2008). Using survey data, (P. Cheng et al., 2009) found that women pay higher rates because they do not search for best-rate loans as much as men do.

Mortgage default studies adopt the percentage of mortgage defaults as a measure of discrimination. Intuitively, if different default rates are observed for equally creditworthy groups that differ in some discrimination ground, this is considered *prima facie* evidence of discrimination. Recent contributions on the subject include (C. L. Brown & Simpson, 2010; S. Chan et al., 2010; Yezer, 2010). A discussion of the limitations of data on mortgage defaults, including unobserved variables and sample-selection bias, can be found in (Turner & Skidmore, 1999, Chapter 5).

Discrimination in mortgage rejection and pricing has often occurred indirectly, through the practice of *redlining* (Hillier, 2003), (Turner & Skidmore, 1999, Chapter 4), which consists of denying credit or of applying higher interest rates to people living in some specific neighborhood. The use of geographic attributes may hide (intentionally or not) the fact that such a neighborhood is populated mainly by people of a specific race or minority. US cities, in particular, show a very high racial divide. The percentage of individuals of a protected group in a neighborhood is often used as a measure of the level of segregation (James & Tauber, 1985; Reardon & Firebaugh, 2002). Empirical works combine HMDA data with census data (Silverman, 2005; E. Blank et al., 2005; Blackburn & Vermilyea, 2007; Ding et al., 2008; Ezeala-Harrison et al., 2008; Wyly et al., 2008; Rugh & Massey, 2010; Squires et al., 2009; Vicki et al., 2009; G. A. Dymski et al., 2011) to test for such a form of indirect discrimination. As an alternative, (Campbell et al., 2008) use proprietary data on unsecured debt. Other studies on redlining use house market data (Aalbers, 2007; Ezeala-Harrison et al., 2008), consumer credit card data (Brevoort, 2011; Cohen-Cole, 2009), and insurance data (Ong & Stoll, 2007; Ross & Tootell, 2004).

Finally, in the related context of consumer markets, *price discrimination* is the practice of a retailer, wholesaler, or manufacturer of selling the same product, with the same marginal cost, at different prices based on buyers' willingness to pay (Armstrong, 2006). Differential pricing discriminating racial minorities has been observed in the car sales market (Ayres, 1995; Ayres & Siegelman, 1995; Goldberg, 1996).

6.6 Knowledge Discovery Perspective

The issue of discrimination analysis has been considered from a knowledge discovery, also known as data mining, perspective along two directions: discrimination discovery and prevention.

Discrimination discovery from data consists in the actual discovery of discriminatory situations and practices hidden in a large amount of historical decision records. The aim is to unveil contexts of possible discrimination on the basis of *legally-grounded* measures of the degree of discrimination suffered by protected-by-law groups in such contexts. The legal principle of under-representation has inspired existing approaches for discrimination discovery based on pattern mining. Starting from a dataset of historical decision records, (Pedreschi et al., 2008; Ruggieri et al., 2010a) propose to extract classification rules such as $RACE=BLACK, PURPOSE=NEW_CAR \rightarrow CREDIT=NO$, called *potentially discriminatory* (PD) rules, to unveil contexts (here, people asking for a loan to buy a new car) where the protected group (here, black people) suffered from under-representation with respect to the decision (here, credit denial). The approach has been implemented on top of an Oracle database by relying on tools for frequent itemset mining (Ruggieri et al., 2010b), and extended in (Pedreschi et al., 2009; Ruggieri et al., 2010c; Luong, 2011). The main limitation of the approach is that there is no control of the characteristics (e.g., capacity to repay the loan) of the protected group, versus, or as opposed to others in this context.

This results in an overly large number of PD rules that need to be further screened. (Luong et al., 2011) exploit the idea of situation testing. For each member of the protected group with a negative decision outcome, testers with similar characteristics are searched for in a dataset of historical decision records. If one can observe significantly different decision outcomes between the testers of the protected group and the testers of the unprotected group, one can ascribe the negative decision to a bias against the protected group, thus labeling the individual as discriminated. The approaches so far described assume that the dataset under analysis contains items to denote protected groups. This may be not the case when such items are not available, or not even collectable at micro-data level, e.g., as in the case of the loan applicant's race. (Ruggieri et al., 2010a, 2010c) adopt a form of rule inference to cope with the indirect discovery of (either direct or indirect) discrimination.

Discrimination prevention in data mining and machine learning consists of extracting models (typically, classifiers) that trade off accuracy for non-discrimination. In fact, mining from historical data may mean to discover traditional prejudices that are endemic in reality (i.e., taste-based discrimination), or to discover patterns of lower performances, skills or capacities of protected-by-law groups (i.e., statistical discrimination). Mining algorithms may then assign to such discriminatory practices the status of general rules, which are subsequently used for automatic decision making in socially sensitive tasks (see e.g., (N. Cheng et al., 2011; Chien & Chen, 2008; Yap et al., 2011)).

Discrimination prevention has been recognized as an issue in the tutorial (Clifton, 2003, Slide 19), where the danger of building classifiers capable of redlining discrimination in home loans has been put forward. In predictive statistics, the same issue has been raised by (Pope & Sydnor, 2007). The naïve approach of deleting attributes that denote protected groups from the original dataset does not prevent a classifier to indirectly learn discriminatory decisions, since other attributes strongly correlated with them could be used as a proxy by the model extraction algorithm.

This issue has been observed in (Pope & Sydnor, 2007; Ruggieri et al., 2010a). We categorize three non mutually-exclusive strategies toward discrimination prevention: (i) a controlled distortion of the training set (a pre-processing approach) (Kamiran & Calders, 2009; Zliobaite et al., 2011; Luong et al., 2011; Hajian et al., 2011); (ii) a modification of the classification learning algorithm (an in-processing approach), by integrating anti-discrimination criteria within it (Calders & Verwer, 2010; Kamiran et al., 2010; Kamishima et al., 2011); (iii) a post-processing of the classification model, once it has been extracted, to correct its decision criteria (Pedreschi et al., 2009; Calders & Verwer, 2010).

6.7 Conclusions

The collection and analysis of observational and experimental data is the main tool for assessing the presence, the extent, the nature, and the trend of discrimination phenomena. In this chapter, we provided an annotated bibliography of the main references and of recent works on discrimination data analysis from a multi-disciplinary perspective. Our intended objective was to provide a guidance through the abundant literature to researchers and anti-discrimination analysts that are faced with data analysis problems. Substantively, the reader is referred to works on sociological causes, legal norms, economic models, empirical studies, data collection approaches, profiling methods, discrimination discovery techniques, and discrimination prevention algorithms in data mining. The bibliography section includes 262 references, half of which appeared in the last five years (2007-2011). This demonstrates a never-ending interest on the topic of discrimination data analysis.

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