

Social Closure in Markets, Families, and Networks
Explaining the Emergence of Intergroup Inequality as a
Result of Exclusionary Action across Contexts

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Summary

The study of social inequality has been slow to fully capitalize on the advantages offered by recent developments in mechanism-based explanations in science, by a turn towards generative processes in theory development and by empirical research that promises to leverage causal explanations across contexts. Acknowledging the need to put forward an effective explanatory agenda that avoids the pitfalls of both grand theories and the 'balkanization' of research into highly specialized theories that are confined to particular domains, the present study develops an explanation of social inequality based on social mechanisms and empirically tests its validity across contexts. For this purpose, the Weberian concept of social closure is redefined as exclusionary action and its fruitfulness in explaining the emergence of social inequality in markets, families, and networks is empirically assessed.

Social closure has been chosen as a central mechanism in the production of inequality because it applies to a myriad of phenomena across levels of analysis and forms of inequality. The concept has undergone important extensions since its introduction by Weber in *Economy and Society*, in which closure was used to denote the concerted actions undertaken by groups with the purpose of securing privileges either through group boundaries or through restrictions to access markets. This dissertation reviews these conceptual extensions and by way of synthesis offers a general definition of closure as exclusionary action. According to this new definition, closure not only encompasses intentional collective action aimed at securing privileges but also entails unintended exclusionary acts by individuals that have a similar effect on the distribution of valued resources or opportunities among groups. Thus defined, closure can be viewed as a general transformational mechanism (Hedström & Ylikoski, 2010) that explains the emergence of intergroup inequality resulting from interaction processes among individuals or groups.

A typology of closure, that classifies exclusionary action according to an actor's intentional or unintentional exclusionary motives and direct or mediated forms of interaction is presented and illustrated in different domains. First, closure is studied as practiced by professional groups in markets in the form of group closure and market closure that generate intergroup differences in market share. Second, exclusionary action is further explored when carried out by parents who

invest selectively in siblings according to their perceived skills, gender or birth order, thereby producing skill inequality both within and across generations. And third, exclusionary action is studied in processes of network formation among preschool children that lead to the segregation of personal networks according to language skills and can potentially affect language development early in the life-course. Given the multidimensionality of social inequality and the generality of closure across contexts, this study investigates exclusionary action using multiple methods, specifically agent-based simulation models (ABM) and exponential random graph models (ERGM), a special modeling tool used in social network analysis (SNA).

The main findings of the present investigation can be summarized as follows:

Social mechanisms

- Social mechanisms and mechanistic explanations appeal to a way of theorizing and conducting empirical research that focuses on generative causality, an explicit reconstruction of how causes bring about effects. There are two ways to approach a mechanistic agenda in sociology. First, as a style of research social mechanisms are synonymous with causal explanation, generative causality, and middle-range theorizing. Second, as an ontology of the social world, social mechanisms demand the search for phenomena that are recurrent in time, robust to initial conditions, and causally productive of comparable outcomes.
- The mechanistic agenda in sociology, if adopted, may prove to be fruitful in properly spelling out the inner workings of social inequality, aiding causal inference and producing deeper causal explanations that make intelligible how inequality comes about across contexts. Even if such explanations constitute the ultimate goal of a mechanistic approach, understanding and controlling are additional gains from focusing on social mechanisms in the study of social inequality. Not only does this make sociological explanations more effective but, perhaps more importantly, it may allow knowledge to be converted into interventions targeted at reducing inequality.
- For both the gullible and the skeptical, this thesis is an invitation to reconsider the idea of mechanisms and mechanistic explanations in sociology by filtering out programmatic biases and focusing on its core message about causation and understanding through causal explanation. Only then will it be possible to conduct a fair discussion on the desirability and viability of a mechanistic agenda in sociology.

Closure as exclusionary action

- *Weber's definition.* There two meanings of the word 'closure' in Weber's writings that are confused in contemporary usage of the concept. The first, group closure, denotes how groups draw boundaries against outsiders to exclude them from the privileges of participating in the group. The second, market closure, describes a form of economic action by which groups instrumentally use their boundaries with the explicit purpose of limiting or eliminating competition from rival groups and thus securing access to economic resources and opportunities. Despite the differences, both forms of interaction presuppose the existence of collective actors and intentionality about the goal of excluding outsiders from privileges and opportunities.
- *A new definition.* In this study, the Weberian definition of closure was extended beyond strategic collective action inspired by the works of Raymond Murphy, Frank Parkin, Charles Tilly, and Vincent Roscigno, to include all forms of preferential or discriminatory interactions and transactions among groups or categorically bounded individuals that accrue or secure benefits to one group or category by actively excluding others. Different forms of closure were classified in a 'closure space' that spans two dimensions: motives (intentional or unintentional) and forms of interaction (direct or mediated). Given the different manifestations of exclusionary action that result from the combination of motives and forms of interaction, closure can be used as a transformational mechanism to explain the connection between the micro-level of interaction and the macro-level of intergroup inequality across multiple domains. Three contexts were studied: markets, families, and networks.
- *Markets.* A market for professional services in which groups compete for market share and individuals compete for group membership was simulated using an agent-based model. Contrary to expectations, high level of market and group closure do not produce the highest levels of intergroup inequality. The interaction between group and market closure is, in fact, not linear and depends on market conditions, in particular unemployment rate and number of competing groups. Even if low degrees of group closure increase intergroup inequality in combination with high levels of market closure, the benefits of market closure for a particular group are reduced as group closure increases. By contrast, a low degree of group closure in combination with no market closure produces low intergroup inequality; as the degree of market closure grows, so does inequality. Finally, and irrespective of levels of group or market closure, a reduced number of groups and a higher unemployment rate push market share inequality upward. In short,

- closing the group can be as effective as closing the market in producing intergroup inequality among professional groups.
- *Families.* Exclusionary action inside the family results from the unequal distribution of parental resources among siblings. Intentional forms of closure may be the consequence of gender, birth order, or skills-related parental bias. Some siblings may also receive more than their fair share unintentionally. The timing of investments and the available resources to parents, which are functions of number of children and child spacing explain why the distribution of resources inside the family departs from a perfectly egalitarian rule even if parents try to spread resources evenly among their children. The consequences of these intended or unintended variations in the intrahousehold distribution of resources on skill inequality were explored using an agent-based simulation model. The simulation can be described as a middle-range model, informed by research on skill formation and the intrahousehold allocation of resources. Simulation experiments made evident the effects of closure on skill inequality: the more equal resources are distributed inside the family, the lower the intragenerational inequality (more equally distributed skills among individuals) and the higher the intergenerational inequality in society (higher parent-child correlations and sibling correlations), and vice versa. Hence closure inside the family has the potential to affect the production of skill inequality both within and across generations.
 - *Networks.* Closure in the form of preferential tie formation in networks conditions access to valuable resources. In particular, there is evidence that the number and composition of peer networks may affect language development. The friendship networks of 125 preschool children in two German kindergartens were analyzed using exponential random graph models (ERGM) to explore whether language skills in German affect tie formation in a way that those who are more proficient (native speakers) end up with networks that are more favorable to further their language development, while those with lower language skills (children whose native language is not German) lose from less favorable networks. Model estimates show that known processes such as reciprocity, triadic closure, gender and age differences in activity and popularity as well as age and gender homophily predict network ties. The primary language spoken at home, a proxy for German language skills, also affects tie creation. Children with lower German language skills prefer to befriend children with higher German language skills, while the latter are indifferent to language when choosing friends. Moreover, children with higher language proficiency in German

are more active and popular in building friendship ties and hence enjoy bigger networks. The net effect of this relationship between language skills and friendship ties on inequalities in German language development is ambiguous: composition effects seem to favor children with low German language skills, because they tend to have a higher proportion of friends with high German language proficiency (but have smaller networks), whereas size effects seem to benefit children with high German language skills, because they have more peers to practice with (but have a higher share of friends who are less proficient in the German language).

Contributions of the study The main contributions of this investigation can be summarized as follows:

- i) Social mechanisms and mechanistic explanations in sociology.
 - This study offers a general definition of social mechanisms, an enriched heuristic that is free from particular ontological and methodological preferences.
 - It shows how to conduct mechanism-based research, emphasizing methods that allow explicit modeling processes that actively bring about the explanandum.
 - It calls attention to the programmatic bias in discussions of social mechanisms in sociology.
- ii) Closure as an explanation of social inequality.
 - This dissertation has redefined the Weberian concept of closure as an action-based transformational mechanism connecting various forms of exclusionary action at the microlevel to intergroup inequality at the macrolevel across contexts.
 - It offers a typology of different manifestations of closure, classifying them according to the form of interaction and motives of action involved in exclusionary action.
 - Based on three separate studies it shows how exclusionary action brings about inequality in markets, families, and networks.
- iii) Agent-based modeling (ABM) and the life course.
 - A first step is taken toward bringing together ABM and social inequality research from a life course perspective.

- The code for a simulation model about parental investments and skill inequality is available for the scientific community to use and further develop.¹

iv) Network formation among preschool children.

- Exponential random graph models (ERGM) are used to investigate the so far neglected role of language proficiency in friendship tie formation.
- Network formation is analyzed from the perspective of peer effects and of their potential impact on the creation and reproduction inequality of language development.

¹ See <http://www.openabm.org/model/4084/version/1/view>

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Introduction: mechanisms, inequality, and closure

The last two decades have witnessed a renewed interest in mechanisms and mechanism-based explanations in both philosophy and science. Discussions surrounding the existence of mechanisms and their proper definition, as well as methods to identify and model them in order to improve our scientific understanding of the physical and social world, have become ubiquitous in various disciplines ranging from biology (Bechtel, 2006; Bechtel & Abrahamsen, 2005; Machamer, 2004; Machamer, Darden, & Craver, 2000) and neuroscience (Craver, 2007) through medicine (Schaffner, 1993; Thagard, 1999) and economics (Lawson, 1997, 2003) to political science (Collier & Mazzuca, 2008; Johnson, 2006) and sociology (Hedström & Swedberg, 1998a). Briefly, the mechanistic agenda in philosophy and science aims to solve two perennial questions found at the core of the metaphysics of causation and the epistemology of causal explanation: What is the relationship between cause and effect? How do we formulate scientific causal explanations? According to the mechanistic approach, causation should refer to the generative phenomena connecting cause and effect, the 'mechanisms' which actively bring about the effects studied (Harré, 1972, 115–8; Machamer, 2004, 34; Machamer et al., 2000, 21–22; in sociology, see Goldthorpe, 2001). Furthermore, 'mechanistic explanations' are a plea to move beyond the logical formalities of a deductive-nomological framework, as dictated by the covering-law model of Hempel and Oppenheim (1948), and to seek instead to reconstruct how causes produce effects as explicitly and transparently as possible (Bunge, 1997, 2004).

The mechanistic view of the world in scientific thought is certainly not new (Bechtel, 2006, ch. 2). Mechanistic models of nature go as far back in the history of modern science as the 17th century when the first natural philosophers, as a reaction against the dominant teleological perspective of Aristotle, which opposed mechanisms to nature, began to use machines as models for making sense of the world. Galileo, Descartes, and Boyle all conceived of natural phenomena such as the movement of planets, the inner workings of the human body, and the properties of chemical elements, as machines operating according to straightforward mechanisms resembling man-made objects like clocks or mills. It was Newton who introduced the idea of laws of nature and put an end to this first

surge of mechanical thinking in early modern science (Bechtel, 2006, 23–4). After Newton's laws came Hume's idea of causation at distance and with it the logical positivists of the 20th century who, led by Hempel and Oppenheim, developed the deductive nomological model of explanation (the D-N model). According to this model, which radically departs from the mechanistic models of the 17th century, scientific explanations consist exclusively of subsuming phenomena under general laws given certain antecedent conditions (Hempel & Oppenheim, 1948). Although the D-N model quickly became the dominant view in the philosophy of science after its publication in 1948, Railton (1978) and Salmon (1984) revived the idea of mechanisms and mechanistic explanations in the philosophy of science later in the 20th century and successfully recaptured the attention of contemporary natural and social scientists (Glennan, 2002, 343).

In sociology, too, the concepts of 'social mechanism' and 'mechanistic explanation' have increasingly found their way into both theoretical and empirical work. The mechanistic agenda in sociology has appealed to many because of its promise to solve some fundamental methodological issues inside the discipline. Aside from general criticism of the covering-law model, the champions of this approach claim that adherence to a mechanistic agenda should reduce the risks imposed by a heavy reliance on correlational analysis as the preferred tool for causal inference, in particular the dangers of spurious correlations and endogeneity, and should avoid the pitfalls of sociological theorizing based on statistical analysis or variable-based sociology on the one hand and the search for grand theories or closed theoretical systems on the other. As a solution to each of these challenges, social mechanisms and mechanism-based explanations should provide more 'transparent' causal explanations that reconstruct how causes bring about effects (Elster, 1990, 1999; Hedström & Swedberg, 1996); aid causal inference by minimizing the risks of endogeneity and spurious correlation (Elster, 2007; Hedström, 2008; Hedström & Swedberg, 1998b); and favor multidisciplinary while reducing theoretical fragmentation by concentrating on middle range theories (Hedström, 2005; Hedström & Bearman, 2009; Hedström & Swedberg, 1998b).

However, in developing a mechanistic agenda in sociology, these very ambitious goals have been displaced by more mundane programmatic priorities that serve particular theoretical and methodological preferences. Some have gone so far as to denounce the whole effort as pure "mechanistic talk" that simply reformulates old methodological and theoretical debates in the discipline using new concepts but without adding anything substantively new (Norkus, 2005). This programmatic bias of the mechanistic agenda in sociology has confronted sociologists with a dilemma that resembles the one faced by statisticians struggling to judge the truth of a hypothesis: the risks of extreme gullibility and extreme skepticism. Some are already convinced of the advantages of a mechanistic agenda in sociology, while others are no longer paying attention to the debate.

In parallel to the recent surge of mechanisms in the realm of science, the last decade has witnessed a growing focus on issues related to social inequality. In fact, it would not be very controversial to assert that social inequality has become one of the most recurrent and prominent subjects of both national and global policy agendas (International Monetary Fund, 2007; The World Bank, 2005; United Nations, 2005, 2013), matched perhaps only by the increasing challenges posed by climate change.³ Not only income, education, and health but also housing, work conditions, political participation, access to technology, and all constitutive elements of individual life chances in general, are the subject of debate from the perspective of social inequality.

In this context of an increasing need for scientific knowledge to tackle real-world problems, sociological theorizing and research seem to lag behind. Regrettably, efforts to explain social inequality appear to have languished under the weight of the tired tradition of class analysis (Grusky & Sørensen, 1998), or have gone unnoticed given the high level of specialization and domain specificity found in what has been lamented as the 'balkanization' of inequality research (Reskin, 2003). Thus, in a way, sociological stratification analysis has yet to capitalize on the promises of a mechanistic approach (Diewald & Faist, 2011), by looking for explanations that are effective in accounting for the particularities of specific contexts while providing a certain level of generality and explanatory power across contexts that can be applied to real-world problems.

Among the causes so far identified in sociology as being responsible for the emergence of inequality, which include most prominently cumulative advantage, exploitation and discrimination (Therborn, 2006; Tilly, 1998), social closure is perhaps one of the most general and prevalent phenomena responsible for multiple forms of inequality. As he briefly discussed in *Economy and Society*, Weber introduced the concept of closure to describe two different group-related phenomena. Closure denotes, first, the more or less intentional process of groups drawing boundaries against outsiders, driven not only by economic interests but also by tradition or affectual bonds (Weber, 1978, 43–6). Group closure leads to the formation of exclusive groups regulated by formal or informal membership rules such as those observed, for example, in private clubs or political parties. Besides the creation of group boundaries, Weber also used the word 'closure' to describe a form of economic action in which groups strategically instrumentalize their boundaries with the sole purpose of limiting or eliminating competition from rival groups to secure access to economic resources and opportunities (Weber, 1978, 339–48). In this second type of closure, it is not the group but the market that becomes closed to free entry and free competition. In closed markets, allo-

3 See the most recent report of the Intergovernmental Panel on Climate Change (IPCC) at <http://www.ipcc.ch>

cation is conditioned by group membership, as in the extreme case of regulated markets for professional services where entry is reserved only for licensed practitioners.⁴

Since, in both cases, the outcome of closure is the emergence of 'outsiders,' either in the form of individuals excluded from a group (e. g., women in a men-only club) or groups excluded from a market (e. g., unlicensed lawyers in a regulated market for legal services), the concept has greatly appealed to contemporary sociologists devoted to the study of stratification and inequality. On the theoretical side, the concept of closure with its double meaning of market closure and group closure has been extended and articulated into broader theories of stratification by Parkin (1979), Murphy (1988), and, more recently, Tilly (1998) and Roscigno (2007). At the same time, and mostly influenced by the works of Parkin and Murphy, empirical research on stratification over the past two decades has shown a growing interest in closure as a mechanism producing different forms of intergroup inequality, including dimensions such as gender, race, occupation, and citizenship, among others (see **Table 0.1**).⁵

The goal of the present investigation is twofold. First, it aims to bring needed clarity to the debate about social mechanisms in sociology by discussing its philosophical foundations and critically reviewing the direction taken by the debate inside the discipline. Second, it generalizes the Weberian concept of closure as an action-based mechanism in the production of inequality and applies it to the explanation of inequality in three contexts: markets, families, and networks. The ultimate objective of this work is to show how to apply mechanism-based science to the study of social inequality.

The study is divided into four main parts and a total of seven chapters. The first part deals with mechanisms and mechanistic explanations in science (**Chapter 1**). The second part turns to the definition of social closure. It first reviews Weber's original formulation (**Chapter 2**) and explores the two sides of the concept, as group closure and as market closure. After revisiting the Weberian definition

4 There are at least two alternative uses of the word 'closure' in sociology that are not directly related to the Weberian definition. The first is found in Giddens (1973) and his theory of class structuration. There, he uses the word 'closure' to refer to intergenerational and individual mobility chances (p. 107). Coleman (1988) also employs the word 'closure' in his seminal article on social capital to refer to the density of personal ties in social networks. Network closure is a condition for both the effective normative control of individuals and the emergence of trustworthiness within networks (pp. 105–7) and has subsequently been used in research on social capital (e. g., Burt, 2005). Neither of these two alternative usages of the word 'closure' should be confused with the Weberian definition used here.

5 Concepts similar to the Weberian notion of closure and their use in stratification theory are discussed in Murphy (1988) and Manza (1992). In economics, too, the dynamics of groups acting strategically to secure benefits has been widely studied. Prominent examples in this literature are the economic theory of groups (Olson, 1971), the theory of clubs and public goods (Buchanan, 1965), studies on rent-seeking, and the voluminous body of research on economic regulation and interest groups (Buchanan, 1980; Rowley, 1991; Tollison, 1982).

Table 0.1: Selected studies applying the concept of closure empirically

Subject(s)	Article(s)
Professions and occupations	Amark (1990); Chua and Clegg (1990); Chua and Poullaos (1998); Giesecke and Verwiebe (2009); Groß (2009); Haupt (2012); Hollenberg (2006); Kelner, Wellman, Welsh, and Boon (2006); Kidder (2004); Lee (2010); Macdonald (1985); O'Regan (2008); Ramirez (2001); Richardson (1997); Walker and Shackleton (1998); Weeden (2002); Weiss and Miller (2010); Welsh, Kelner, Wellman, and Boon (2004).
Gender and racial discrimination	Elliott (2001); Neuwirth (1969); Roscigno (2007); Roscigno, Garcia, and Bobbitt-Zeher (2007); Roscigno, Karafin, and Tester (2009); Stainback (2009); Tomaskovic-Devey (1993a, 1993b).
Ageism	Roscigno, Mong, Byron, and Tester (2007).
Workplace incivilities	Roscigno, Hodson, and Lopez (2009).
Educational homogamy	Smits (2003); Smits and Park (2009).
Citizenship	Brubaker (1992).
Welfare state	Rodger (1992).
Social movements	McCauley (1990).
Religion	Vertigans (2007).

and discussing its extensions by later theoretical and empirical work in Sociology, a general definition of closure as exclusionary action is formulated and different forms of closure are identified and classified according to the form of interaction and motive of action implied by acts of closure (**Chapter 3**). The third part applies the new definition of closure to the study of inequality in markets (**Chapter 4**), with an agent-based simulation of a labor market where both professional groups and individuals compete for jobs; in families (**Chapter 5**), with an agent-based simulation of parental investment decisions in children and skill inequality within and across generations; and in networks (**Chapter 6**), analyzing data on friendship ties of preschool children and the effect of German language skills on tie formation. The fourth part concludes by discussing both theoretical and empirical aspects of previous chapters (**Chapter 7**).

Some parts of this work have already been shared with the scientific community. **Chapters 2** and **4** can be found as a working paper (Cardona, 2013a). Most of **Section 1.2** and some parts of **Section 1.3** are also available as a working paper (Cardona, 2013b), while **Chapter 5** has been published in the *Journal of Artificial*

Societies and Social Simulation (Cardona, 2014a).⁶ Also, the main ideas about Weber's definition of closure and the mechanistic agenda in sociology mentioned in this introduction and further in **Chapter 7**, were already discussed in one way or another in the two aforementioned working papers (Cardona, 2013a, 2013b).

The remaining parts of this work, i.e. **Chapter 1** (except **Section 1.2** and some parts of **Section 1.3**), **Chapter 3**, and **Chapter 6**, have not been published before.

6 See <http://jasss.soc.surrey.ac.uk/17/4/8.html>

I. Social mechanisms

Chapter 1

Social mechanisms and mechanistic explanations in sociology

This chapter reviews the recent discussion in philosophy and sociology that followed from the reintroduction of the idea of mechanisms in science by the works of Railton (1978) and Salmon (1984). The aim of this literature review is not to address, let alone resolve, all philosophical intricacies raised by this renewed metaphysical and methodological perspective in scientific inquiry. Instead, the survey of the literature will serve the higher purpose of helping to lay the theoretical and methodological foundations for the present study by providing answers to the following two questions:

- (i) What are the advantages of adopting a mechanistic approach in sociology?
- (ii) Which are the core elements of the mechanistic approach and how should they be put into practice? That is, how to define, identify, model, and empirically test social mechanisms?

It is only after having answered these two questions, that it will become clear why the new definition of closure as a transformational mechanism connecting the level of action with the aggregate level of intergroup inequality is not only justifiable as an adequate scientific explanation, but also meaningful and promising for advancing an explanatory agenda in the study of social inequality.

Given the sociological scope of this study, the primary focus in reviewing the literature will be placed on the reception of mechanisms and mechanistic explanations in sociology. Nonetheless, a first step will consist of reviewing the philosophical literature on the subject, for it is the philosophers and not the sociologists or any other scientists who are best capable of spelling out, in all its complexity and depth, the debate surrounding mechanisms and mechanistic explanations. This is not to say, of course, that the philosophical and sociological debates do not take each other into account. On the contrary, both philosophers and sociologists borrow constantly from each other to advance their arguments and are fairly

aware of the homologous discussions on mechanisms and mechanistic explanations taking place outside their disciplines. In this sense, to review both bodies of literature separately responds not only to a real substantive division but partially also to an argumentative strategy adopted for the sake of exposition.

Having said that, it is true that philosophers, at least in this particular case, are better acquainted with the work of sociologists than the other way around. Furthermore, asserting that the contributions of both disciplines should be seen as equally integral parts of the same debate on mechanisms and mechanistic explanations is not to deny the fact that each discipline focuses on its own problems and addresses its specialized audience. It is fairly evident for anyone familiar with the subject that while philosophical discussions tend, as a rule, to relate to broader issues on the theory of causation and the theory of explanation *in general*, social scientists usually focus their effort on narrower, intradisciplinary issues on method (Kuorikoski, 2009, 143–4). These more general considerations on causation and explanation found in philosophical publications on the subject will without a doubt prove to be very useful in illustrating the complexities of appealing to mechanisms in science and will be most fruitful in dispelling deeply entrenched misunderstandings in sociology about social mechanisms and mechanistic explanations.

Recognizing the importance of the contribution of philosophy for making sense of social mechanisms and mechanistic explanations in sociology, the present chapter is divided into three sections. **Section 1.1** briefly outlines the main debates found in the philosophy of science on mechanisms and mechanistic explanations. Here the emphasis will not be placed on spelling out each of the competing positions championed by different authors in the philosophical literature, nor on discussing their highly contested validity or mentioning their innumerable detractors and suggested revisions. The aim of this review is rather to prepare the ground for the discussion on social mechanisms by pointing out the most relevant conceptual distinctions and disputes found in the philosophy of science as well as to show that the subject is far from being reducible to some simplified metaphysical and epistemological assumptions as some social scientists tend to believe. **Section 1.2** provides an analysis of the reception of this wider philosophical discussion on mechanisms and mechanistic explanations in sociology. Again, the focus will continue to be on showing the most prominent positions in the debate and not on reviewing all their empirical or theoretical intricacies nor on providing a comprehensive account of all other authors related to the discussion. In this section too, the definition of social mechanisms to be used henceforth in this study will be presented. Summing up the theoretical and methodological lessons learned from the ideas advanced in the first two sections, **Section 1.3** gives an answer to the two questions raised at the beginning of this introduc-

tion on the usefulness and appropriateness of social mechanisms for the present investigation.¹ This section is of particular importance because it provides an explicit formulation of the methodological and theoretical assumptions made in this dissertation.

1.1 Philosophical considerations

Most of the recent philosophical discussions on mechanisms and mechanistic explanations tend to be confined to particular scientific disciplines like molecular biology or neuroscience (Tabery, 2004). Some philosophers, however, have tried to offer more general accounts of mechanisms, which can be applied, at least potentially, to various disciplines of both natural and social sciences (e. g., Bunge, 1997, 2004; Glennan, 1996, 2002). Irrespective of the field of application, the philosophical literature on the subject can be divided into two different, though closely related aspects: (1) metaphysical questions on the existence of mechanisms (ontological discussions) and on the principles governing their existence (causality, law-like principles), and (2) epistemological considerations about how to explore, reconstruct, and represent a supposedly mechanistic reality, or if mechanisms are not conferred an ontological existence, about how to make sense of observed phenomena using mechanistic explanations.²

To distinguish between metaphysical and epistemological claims, the following review of the literature will consistently make use of the concepts *mechanism* and *mechanistic explanation* to refer to each side of the discussion, respectively. The denomination “mechanism” will thus be reserved exclusively for ontological statements on mechanisms: mechanism *are*, they *exist* in the real world and are *constitutive* in a very essential way of real phenomena. On the other hand, “mechanistic explanation” will refer to *representations* and *abstractions* of reality in the form of models or propositions that can be described as mechanistic either because they are models of ontologically existing mechanisms or solely because they are some sort of mechanism-based thinking used to abstract a non-mechanistic reality.

Keeping ontological and epistemological claims apart will prove to be a very helpful way to avoid misunderstandings even if they ultimately can hardly be

1 Most of **Section 1.2** and some parts of **Section 1.3** can be found as a working paper in Cardona (2013b).

2 To avoid lengthy digressions on even more general philosophical matters, the concepts of “metaphysics,” “ontology,” and “epistemology” are here understood in a very general and loose sense: *Metaphysics* is the major branch of philosophy devoted to the investigation of the nature of reality, in particular, to answering the questions on what reality is and what the principles are which apply to everything that is real. *Ontology* in turn can be defined as the part of metaphysics concerned with the investigation of existence and being. *Epistemology*, on the other hand, is concerned with the nature and scope of human knowledge about reality, not with reality itself (Craig, 1998).

treated separately. As Kuorikoski (2009, 145) observes, if concepts are correctly applied, they must correspond to real things in the world; likewise, ontological claims about the world can readily be translated into theories and models. As a consequence, epistemological and ontological claims should tend to overlap. Nonetheless, insisting on this distinction may be useful for yet another reason: it corresponds roughly to the different approaches to the discussion found in the philosophy of science compared with sociology. While the philosophy of science is mostly concerned with ontological issues of the real existence of mechanisms as constituent parts of the world, social sciences tend to focus on epistemological questions on the construction of sound social theories and the conduction of solid empirical research to better explain social phenomena.

1.1.1 Mechanisms: metaphysical issues

Both the existence of mechanisms and the properties governing their functioning are subject to metaphysical deliberation. In fact, besides defining mechanisms, concerns about causality and the nature of the regularities brought about by mechanisms occupy a prominent position in most contemporary philosophical discussions on mechanisms. Spelling out the different views on these two fronts will therefore be the first step in reviewing the philosophical literature on the subject. Some other issues such as reduction, which could also have been addressed from an ontological perspective, will be treated for the sake of argument in the next subsection on epistemological considerations. As already noted, the division between metaphysical and epistemological aspects is to some extent expository and allows some flexibility in presenting the different topics. To begin with, and before defining mechanisms, it may be convenient to briefly dispel a widespread misunderstanding about the recent surge of mechanisms in science, namely whether they are 'mechanical' or not.

Are mechanisms mechanical? Put briefly, the contemporary view on mechanisms is not mechanical in the sense that the concept was originally used in 17th century philosophy of science. According to Deutsch's brief reconstruction of the early history of mechanistic thinking in the Renaissance, the classical view of mechanisms, or what he calls the "classical model of mechanisms," can be summarized as follows (Deutsch, 1951, 234): (1) the whole is exactly the sum of its parts, (2) mechanisms can be run in reverse, (3) they always preserve their properties even if disassembled and reassembled, and (4) each part always performs the same function irrespective of other parts and independent of time. As Deutsch observes, this type of mechanism in which neither interaction between the parts nor interaction with the environment play any role whatsoever and where time is

irrelevant resembles at best carefully crafted manmade machines. But even machines may prove to be more complex than the classical model of mechanisms requires because they normally include interacting parts and most likely do not comply with the 4 properties he formulated as the core characteristics of the classical view on mechanisms.

In this sense, most real mechanisms are nonmechanical. The classical conception of mechanisms is best understood as a highly idealized *metaphor* that hardly corresponds to any existing mechanism in the world—a point that has consistently been made in the contemporary discussion on mechanisms (e. g., Machamer et al., 2000, 2; Gorski, 2009, 152–7).

Three approaches to mechanisms: processes, systems, and processes in systems.

If mechanisms are not strictly mechanical, how should they be described? As Glennan (2002, 2009) argues, mechanisms can be conceived as processes or as systems. A third view is to combine both notions of system and process by regarding mechanisms as processes *in* systems (Bunge, 1997, 2004). The following are descriptions of each of these three approaches along with brief discussions of their differences.

(i) The *process approach* to mechanisms goes back to the works of Railton (1978) and was further elaborated by Salmon (1984). Although Salmon focuses primarily on mechanistic explanations and causation rather than on the metaphysics of mechanisms (Bechtel & Abrahamsen, 2005, 423), and does not even offer an explicit definition of the concept (Glennan, 2002, 343), his views on mechanisms can be inferred from his more general framework on causation. It suffices to know that for Salmon, processes and their interaction—in opposition to events—are to be regarded as the fundamental entities of causality or of what he calls “the causal structure of the world,” which is the way causal influences are transmitted and propagated in time and space (Salmon, 1984, 146–7).³ Although Salmon does not provide any definition of processes, he contrasts them with events by arguing that they show a greater persistence in time and extension in space (p. 139). He further distinguishes between causal processes and pseudo-processes, the former being the only ones capable of transmitting information and energy, of preserving some uniform structure over time, and of displaying some self-determination or robustness to external influences (pp. 141–7). Based on this view of process (or causal process) as persistent, interacting, information-transmitting, and robust, structured events, mechanisms are processes to the extent that they constitute *sequences of causally interconnected or interacting events persistent in time and space*

³ See Dowe (2009) for a short discussion about Salmon’s theory and other process theories of causation.

(Glennan, 2009, 323).

(ii) To a certain extent the second approach is similar to but essentially different from the process perspective, resorting to systems as the basic ontological form of a mechanism. This *systems approach* to mechanisms appeals to many contemporary philosophers of science and is especially popular in the life and brain sciences (Bechtel, 2006; Craver, 2007; Machamer et al., 2000). The definition of mechanisms as a system differs from author to author and in most cases involves deeper metaphysical considerations about the nature of the system, and the parts, properties, and forms of interaction (e. g., Machamer, 2004). In general terms, however, and combining elements from the definitions of various authors, a mechanism is a system if it corresponds to *a concrete object in the world consisting of a (hierarchically) organized and stable collection of parts interacting within some boundary in a regular way to produce certain outcome(s)*. **Table 1.1** summarizes some prominent definitions of the systems approach to mechanisms. The accounts of Bechtel and Abrahamsen explicitly refer to biology, especially cell biology (see also Bechtel, 2006). Similarly, Machamer et al. limit their definition of mechanisms to systems in neurobiology and molecular biology, although in contrast to Bechtel and Abrahamsen they leave the possibility open to extend their approach to other scientific fields like cognitive or social sciences (Machamer et al., 2000, 2). Glennan, on the other hand, aims for a more comprehensive framework for mechanisms, excluding only fundamental physics from his analysis (Glennan, 1996, 10).⁴

The distinction between mechanisms as processes and mechanisms as systems may be easily drawn by recalling from the definition of system the idea of stable structure. As already mentioned, processes may be understood as robust sequences of events that, though interconnected and persistent in time and space, do not resemble concrete objects in the world with a definite constitutive structure or a stable configuration of parts, as systems do. This difference can best be illustrated with an example: a system is a *thing* like an organism or a cell, a watch, or an engine; a process, on the other hand, may simply consist of more contingent sequences of events like a baseball striking a window (Glennan, 2002, 345).⁵ In the latter case, even if the process of breaking a window with a baseball may display some robustness (i.e., every time someone hits a baseball and directs it with a certain velocity against a glass window, the window will break), it would

4 Although these three accounts on mechanisms are not directly related, there is an ongoing debate on how they can complement each other. For example, Tabery (2004) has recently argued that an improved definition of mechanisms can be formulated by combining the concept of interaction (Glennan, 1996, 2002) with the concept of activity (Machamer et al., 2000).

5 See also Glennan (2009, 322–26). The example of a baseball colliding with a window was originally used by Salmon to illustrate the concept of process (Salmon, 1984, 139).

Table 1.1: Systems approach to mechanisms: Selected definitions

Author(s)	Definition	Field of application
Bechtel & Abrahamsen	"a mechanism is a structure performing a function in virtue of its component parts, components operations, and their organization. The orchestrated functioning of the mechanism is responsible for one or more phenomena" (Bechtel & Abrahamsen, 2005, 423).	Biology (especially cell biology).
Glennan	"a mechanism underlying a behavior is a complex system which produces that behavior by the interaction of the number of parts according to direct causal laws" (Glennan, 1996, 53). "a mechanism for a behavior is a complex system that produces that behavior by the interaction of a number of parts, where the interactions between parts can be characterized by direct, invariant, change-relating generalizations" (Glennan, 2002, 344).	All sciences except fundamental physics.
Machamer, Darden, & Craver	"mechanisms are entities and activities organized such that they are productive of regular changes from start or set-up to finish or termination conditions" (Machamer et al., 2000, 3).	Neurobiology and molecular biology (future extension to other fields like cognitive or social sciences not precluded).

be misleading to refer to this very contingent configuration of causally interconnected events as a stable "window-breaking system" (Glennan, 2009, 325). That processes are to be distinguished from systems should not, however, imply that they are completely independent from one another. In fact, systems can readily be understood as higher-level entities composed of various processes; the opposite, as shown by the example of the baseball breaking the window, is not necessarily true: processes are not systems, nor are they always parts of systems.

(iii) The close relation between systems and processes is explicitly addressed in a third approach to mechanisms advanced by Bunge (1997, 2004). Bunge, a philosopher of science with extensive works on natural and social sciences, subscribes to the philosophical view of reality called *systemism*, according to which everything that happens in the universe is a system or part of a system (Bunge, 2004, 190). From this systemic point of view, he defines a mechanism as "a process in a concrete system, such that it is capable of bringing about or preventing some change in the system as a whole or in some of its subsystems" (Bunge, 1997, 414). In later publications a more compact definition can be found of a mechanism as "a process (or sequence of states, or pathway) in a concrete system, natural or

social” (Bunge, 2004, 186).⁶ Hence, despite his view of reality as being ontologically constituted by systems, Bunge defines mechanisms not as systems but as the processes that systems rely on in order to function. These processes, as Bunge emphatically underscores, are not independent of systems but embedded in them (Bunge, 1997, 439–40). So, for example, if one regards the market, the family, and democracy as social systems, then market transactions, child socialization, and voting would constitute, in each case, concrete processes (or mechanisms) embedded in and specific to those distinct systems (pp. 447–8).

The objection could be raised that Bunge’s view on mechanisms should not be granted the status of “third approach,” but should instead be regarded either as a special case of the process approach or as part of the systems approach. Yet there are good reasons to conceive of this third definition of mechanisms as a different approach. On the one hand, and against the first objection, even if mechanisms are always processes, not all processes are mechanisms (Bunge, 1997, 415). It is true, though, that Bunge’s systemic view of the universe regards everything as belonging to a system. Even so, it can readily be accepted that sequences of events, like the ones Salmon is referring to (e. g., the baseball hitting a window), are not necessarily part of any system and may still be regarded as processes. On the other hand, and meeting the second objection, it would be equally erroneous to classify Bunge’s view on mechanisms as a subsidiary of the systems approach, for not only does he define mechanisms as processes in a system and not as the system itself (i.e., cell metabolism and not the cell itself is a mechanism), but also, and more convincingly, he explicitly distances himself from both Machamer et al. (2000) and Glennan (1996, 2002). Bunge reproaches the former by contending that the definition of mechanisms they suggest is “not only imprecise but also incorrect” (among other things for failing to properly define systems); as for Glennan, he observes that the suggested definition of system is very narrow and requires further elaboration (Bunge, 2004, 183). Accordingly, Bunge’s theory of mechanisms can best be seen as a third approach to mechanisms that is independent from, even if closely related to, processes and systems.

Mechanisms and causation. The debate on mechanisms overlaps with a further major issue in the philosophy of science: causation. As a matter of fact, most philosophers taking part in the discussion on mechanisms in science, irrespective of which of the three approaches mentioned in the foregoing discussion they feel obliged to, appeal explicitly or tacitly to some notion of causal connection. The

⁶ For Bunge a concrete system is “a bundle of real things held together by some bonds or forces, behaving as a unit in some respects and (except for the universe as a whole) embedded in some environment.” (Bunge, 1997, 415). Mechanisms are only present in material systems, such as natural, social, and technical systems, and not in immaterial one, as in the case of conceptual and semiotic systems (Bunge, 2004, 191).

myriad of theories on causation abound in Western philosophical thought, hence multiplying the potential variations of any account on mechanisms depending on which theory is assumed. For instance, and just to name some of the most prominent alternative theoretical approaches to causation, causes can be understood as some sort of consistent dependence between two events (regularity theory), as some event whose absence prevents other events from occurring (counterfactual theory), or as events that can be manipulated to give rise to some further events (interventionist theory) (Beebe, Hitchcock, & Menzies, 2009, parts II and III).

However, no account of mechanisms is bound to any specific theory of causation. Not only can different accounts about mechanisms draw upon different theories on causation, but also one and the same definition of mechanisms can be readily modified by making different assumptions about the nature of causation. For instance, the mechanism account by Machamer et al. (2000) has been reformulated to comply with the counterfactual theory of causation, by describing the functioning of mechanisms as invariant under interventions (Woodward, 2002). Despite this flexibility and diversity in the relation between mechanisms and causation, two questions can be raised. First, given that different theories of causation can be used with mechanism accounts, which *kind* of causation theory is most likely to be compatible with mechanisms? Second, is a mechanistic theory of causation possible? That is, can causation itself be mechanistically defined?

(i) As can be inferred from numerous recent publications on mechanisms (e. g., Machamer et al., 2000, 21–2), theories of mechanisms favor a notion of causation that is *generative* in nature and thereby directly opposed to the Humean or regularity theory of causation. According to Hume, two events are regarded as causally related if they are contiguous, one of them precedes the other, and it can be observed that both are constantly conjoined even if the “secret connection” bringing them together is not observable (Psillos, 2009). By contrast, the generative notion of causality assumed in theories of mechanisms conceives of causes not merely as inexplicably connected with effects, but instead—and that is the crucial difference—as actively *producing* the effects. This last point is made most emphatically by Machamer (2004, 34), who further illustrates the idea of generative causation with the following illuminating example: A very ill patient may die if a doctor does not intervene to cure her; if this were to happen, the non-intervention of the doctor would certainly precede and be incontestably related to the death of the patient (the doctor may even be held accountable for letting the patient die); however, following a generative view of causation, the cause of death is the illness rather than the doctor, for it is the former and not the latter which directly corresponds to the cause *producing* death (pp. 35–6).

(ii) On top of this widespread assumption among philosophers that mechanisms are wedded to a generative notion of causation, causality itself has been

defined based on mechanisms. Glennan (1996, 2002, 2010), one of the leading philosophers championing this position next to Machamer et al. (2000), contends that the Humean “hidden connection” can be made explicit only if the mechanisms connecting cause and effect are identified (Glennan, 1996, 65–6). Hence, according to this view, causation may be unequivocally established only if a mechanism is uncovered connecting the phenomena at issue (Glennan, 1996, 56). It follows by implication that all phenomena regarded as causally connected are to be decomposed in their underlying mechanisms. Yet, as Glennan admits, there is a limit to this mechanistic decomposition because not every causally related phenomenon can be reduced to a mechanism, especially when it comes to explaining the inner workings of mechanisms. Consequently, there has to be another way in which phenomena are connected inside a mechanism without another, deeper mechanism intervening. This type of nonmechanical connection is what Glennan (2002) calls “fundamental physical laws” or “the brute nomological facts of our universe” (p. 348). Machamer et al. (2000), do not mention laws as those non-mechanical principles governing the functioning of mechanisms but instead resort to “entities” and “activities.”

In any case, the conclusion is the same: restricting causality to mechanical connections may prove to be limited in scope given the necessity, at some point, to refer to deep nonmechanical principles. This restriction renders the mechanical theory of causation less general and, as Psillos (2004) suggests, calls for other, more comprehensive theories like Woodward’s counterfactual theory (Woodward, 2002).

Mechanisms and their regularities. Almost as central as the philosophical discussion on mechanisms and causation is the debate concerning the nature of the regularities brought about by mechanisms. Two major questions are most commonly debated: (1) the generality of such regularities and (2) the origin of such regularities, that is, whether mechanisms depend on lower-level mechanisms or on deeper non-mechanical principles in order to function.

(i) According to the three definitions of mechanisms introduced above, the functioning of a mechanism should regularly produce certain outcome(s) that are not limited to a single occurrence (e. g., one neuron) but are instead equally expected in all other individuals sharing the exact same characteristics (e. g., all neurons). Yet, as stressed by Bechtel and Abrahamsen (2005, 424–5) as well as by Bunge (2004, 191), mechanisms are still *by definition* concrete things in the world: they embody specific objects productive of some specific outcome or a specific process in a specific system bound to a specific context. Consequently, and despite similarities among different mechanisms, the regularities they produce are of fairly limited generality and by no means represent universal principles that apply to other processes or systems different from those they are referring to.

Therefore, the regularities brought about by, say, cell metabolism apply at best to other occurrences of cell metabolism and not, for example to human digestion, despite the similarities.

(ii) A different question aside from the generality of the regularities produced by mechanisms is *how* mechanisms produce such regularities, that is, what governs the functioning of mechanisms so that the same outcome is produced regularly? It is true that a mechanism can be decomposed into deeper mechanisms in such a way that its regular functioning is simply due to the regular function of some other, lower-level mechanism. This mechanistic decomposition, as already explained above, cannot go on indefinitely into deeper mechanisms and must eventually reach nonmechanical principles.

To refer to these nonmechanical principles governing the stable internal functioning of mechanisms, different philosophers appeal to alternative ontological categories. Machamer et al. (2000) call them “entities” and “activities,” Glennan (1996, 2002) “fundamental laws of physics,” and Woodward (2002) regularities invariant under interventions.⁷ Bunge, by contrast, appeals to laws and emphasizes that mechanisms are lawful, meaning that they satisfy some law(s) (Bunge, 2004, 196–7).⁸ He further remarks, rather ironically, that “mechanisms without conceivable laws are called miracles” (p. 196), unscientific conjectures based on immaterial entities or processes. In any case, and despite these differences in the characterization of the internal workings of mechanisms, there appears to be consensus among the many philosophers writing on mechanisms about the fact that, in order to function, mechanisms depend on some non-mechanical regularities, law-like or otherwise that cannot be reduced to mechanisms.

1.1.2 Mechanistic explanations: epistemological concerns

Besides defining mechanisms, their causal properties, and the principles governing their functioning, the philosophical debate on mechanisms has devoted considerable effort to the characterization of mechanistic explanations. Loosely defined, a mechanistic or mechanism-based explanation is nothing more than an explanation with the description of the functioning of a mechanism as explanans and the outcome of a mechanism as explanandum.⁹ The characterization of mechanism-based explanations in the philosophical literature generally

7 In later publications, Glennan himself abandoned the concept of law to describe the internal functioning of mechanisms and replaced it with Woodward’s idea of “direct, invariant, change relating generalizations” (see Table 1.1).

8 Bunge also mentions random mechanisms or processes that are not deterministic. However, these random processes usually represent lower levels of higher level causal or deterministic processes and should thus be regarded as always having some stable causal component (Bunge, 2004, 195–6).

9 This definition will be further elaborated in Section 1.3.2.

starts with a criticism of the covering-law model or of correlational analysis. It then usually moves on to provide an assessment of the alleged advantages of mechanism-based explanations and ends up with some methodological considerations about the construction of mechanistic models and the way of mechanism-based empirical research is conducted. The present section focuses on the characterization and alleged advantages of mechanistic explanations. Because the third section of this chapter will directly address the question of putting mechanistic-explanations into practice, methodological issues concerning modeling and testing mechanisms will not be discussed at this point.

Beyond the covering-law model. After it was introduced in 1948, the deductive-nomological (D-N) model or covering-law model of explanation proposed by Hempel and Oppenheim became the preferred reference of scientific inquiry. According to their original paper (Hempel & Oppenheim, 1948), scientific explanation should meet some minimal logical and empirical requirements or “conditions of adequacy” to be regarded as scientific. These prescribe, in short, that the *explanans* or statements constituting the explanation of the phenomena consist of both a general law and a set of true antecedent conditions from which, by means of logical deduction, the *explanandum* or description of the phenomena to be explained can be inferred (Hempel & Oppenheim, 1948, 136–40). Explaining and understanding in the D-N model are thus reduced to the expectability of the phenomena that results from combining specific circumstances and laws (Hempel, 1965, 337).

However sound and appealing the covering-law model appeared to many scientists who make use of it, criticism of the model grew almost as fast as its widespread use in science. According to Craver’s review of the criticisms on the covering-law model (Craver, 2007, 35–40), three main arguments can be raised against Hempel and Oppenheim’s influential work. First, genuine law-like generalizations cannot always be easily distinguished from accidents (e. g., temporal sequences, correlations, or effect-to-cause relations); second, irrelevant statements can be included in the explanans that may fundamentally blur the explanation without violating any condition of the D-N model; third, phenomena call for an explanation even if by subsumption to a general law, they are regarded as unexpected (or improbable). In addition to these objections to the D-N model summarized by Craver (2007), some authors have pointed out that the existence of laws may be confined almost exclusively to physics, hence the applicability of the covering-law model may be limited, especially in the social sciences (Elster, 2007, 35–6).

It is in light of this criticism to the covering-law model, and the resulting skepticism toward its capacity to produce satisfactory scientific explanations, that the

recent interest in mechanistic explanations can best be understood. As already mentioned in the discussion on mechanisms as processes, the reintroduction of the concept of mechanism and mechanistic explanation in contemporary philosophy of science can be traced back to Railton (1978) and his concerns about the covering-law model. According to Railton, subsuming an event under a law makes for a logically correct explanation at best; albeit one that is able neither to shed any light on the causes underlying the phenomena nor to provide a satisfactory answer to the questions *why* and *how* it occurred. From this objection to the covering-law model, he came to a conclusion that became the central argument championed by virtually all contemporary advocates of mechanistic explanations thereafter: the covering-law model is not incorrect but incomplete, and it can be greatly *improved* if the mechanisms underlying the phenomena to be explained are made a constituent part of the explanation (Railton, 1978, 207-8).

The question then arises how exactly mechanism-based explanations can do better than the covering-law model. In a nutshell, the answer to this question is fairly simple. Unlike the subsumption of phenomena under general laws, which is basically a logical deductive procedure, mechanistic explanations show *how* the phenomena described by the explanandum come about. Accordingly, a mechanistic explanation consists not merely in alluding to a general principle as causing the phenomena to be explained but instead, and perhaps more meaningfully for scientific inquiry, in reconstructing causation and rendering it intelligible. This difference in *quality* between explanations resulting from the covering-law model and those based on mechanisms can best be illustrated using Bunge's distinction between shallow or black-box explanations and deep or translucent-box explanations. While the former type of explanation solely connects input and output, thereby hiding the inner workings of the phenomena, only the latter one allows to look inside the box and see how things actually work (Bunge, 1997, 427-8).¹⁰ Thus, the covering-law model is best described as a black-box while mechanistic explanations may rather be seen as translucent boxes.

The alleged advantages of mechanistic explanations. Knowing *how* is the distinctive characteristic of mechanistic explanations. Yet, the assertion that mechanism-based explanations are better solely because they open the black box of the covering-law model, even if it is intuitively appealing, does not sufficiently clarify why knowing the *how* constitutes a better scientific explanation than subsuming phenomena under general principles. Several arguments on the advantages of mechanistic explanations have so far been advanced. Most of them refer to

¹⁰ Bunge also mentions "gray-box explanations" as some sort of underdeveloped translucent-box account. The distinction is, however, not relevant for the present illustration of the opposition covering-law/mechanism (see Bunge, 1997, 427-8).

specific scientific disciplines and therefore have only limited validity, while others can be regarded as advantages of mechanism-based explanations in scientific research in general. Among the latter, three can be mentioned as the main advantage of resorting to mechanisms to construct scientific explanations: aiding causal inference, improving our understanding of phenomena, and making intervention and control possible.

(i) A first, central argument championed by the advocates of mechanistic explanations contends that knowing the *how* is the gold standard of causal inference, serving both as a means of unveiling causal relations and as a tool to avoid well-known pitfalls in causal inference like the problem of confounders (unmeasured common causes explaining the correlation of two variables mistakenly regarded as causally connected), and endogeneity (mixing up cause and effect or, synonymously, dependent and independent variables). This first argument, which has been advanced in both a strong version and a weak version, may be understood best not as a criticism of the covering-law model but as a response to the widespread empiricist statistical practices of correlation-based causal inference. This practice, which consists in inferring the causal connection between two variables based on their correlation, has been called by Bunge “the mindless accumulation of data and the mindless search for statistical correlations among them” (Bunge, 2004, 207–8).

The strong version of this first argument subscribes to the aforementioned mechanistic theory of causation according to which two events are causally related *only* if there is a mechanism connecting them. As pointed out by Steel (2004, 56), this strong version of mechanistic causation can be applied to causal inference in two ways. The first, as already mentioned, is a positive interpretation and states that finding a mechanism is *sufficient* to establish causation between two variables. On the other hand, the same idea can be negatively stated by arguing that mechanisms are *necessary* to raise causal claims; hence, if no mechanism can be identified then no causality can be inferred even if two variables are observed to correlate. If one or both of these interpretations are taken to be true, identifying a mechanism would no doubt resolve the problem of causal inference. However, such strong formulation of mechanisms and causal inference fails to recognize the limitations of a mechanistic theory of causation. In particular, it neglects the fact that mechanisms are neither always necessary nor sufficient to establish causation (e. g., experimental manipulation can be used instead), and that other theories of causation may also produce reliable causal inferences without resorting to mechanisms (e. g., Woodward, 2002, 2003).

Despite this criticism, which mostly applies to the natural sciences, some philosophers of the social sciences, like Weber (2007), still defend the strong position on mechanisms and causal inference. Weber argues that since experimentation

outside the natural sciences is rare and simulation studies are not reliable for causal inference, social scientists are “almost always” left with the knowledge about mechanisms as the only tool to justify causal claims (p. 358). Appealing as it sounds, this position on the necessity of mechanisms in social sciences to establish causation has met strong resistance. As a direct reply to Weber’s position, Steel (2007) objects saying that “simply pointing out that a problem is hard to solve without mechanisms does not show that mechanisms will help” (p. 361). He adds that the causal inference problem in the social sciences “might be unsolvable with or without mechanisms” (p. 363) and concludes that causal inference based on mechanisms may not differ that much from inference based on statistical data (p. 364). The discussion is far from settled and, as Steel (2007) pleads, may require a positive account of why and under which conditions knowledge of mechanisms in the social sciences is needed or useful to draw causal inferences.

Until such a positive account has been distilled from philosophical deliberations on mechanisms and causality, an intermediate position between Weber’s optimism and Still’s pessimism may safely be defended. Following Gerring (2007), and still referring to the social sciences, an intermediate position consists of conceiving of mechanisms not as necessary or sufficient for causal inference, but as complementary to other inference methods. According to Gerring’s argument, it may be easily accepted without making any strong assumptions on mechanisms and causality, that by using mechanisms *in addition* to other non-mechanical inference methods like statistical information, causal inference may be more reliable and convincing (pp. 173–5). In particular, as Psillos (2004, 316–7) observes in his comparison of mechanistic and counterfactual accounts on causation, knowledge about mechanisms may indeed aid causal inference and scientific explanations by helping to resolve the problems of confounders and endogeneity.¹¹ It follows that resorting to mechanisms should be understood safely as a tool to *improve*, at best, causal inference rather than a necessary condition to make it possible.

(ii) A second very common argument advanced by the advocates of mechanistic explanations suggests that knowing the *how*, besides aiding causal inference, improves our understanding of phenomena. To mention an example, following this line of argument, Bunge (1997, 455) contends that knowledge about mechanisms, on *how* things work, provides a deeper understanding as compared with explanations based on the covering-law model, statistical correlations, or mere descriptions, and should therefore be favored. Moreover, knowing *how* may be regarded as an end in itself for it satisfies what Bunge (2004) refers to as “the pleasure of understanding” (p. 207). These claims are, it seems, not mere conjectures. As quoted by Machamer (2004, 34), there appears to be psychological evidence

¹¹ See Steel (2004, pp. 59ff.) for a discussion of the limitations of mechanism-based explanations to fully account for the problem of confounders in the social sciences.

suggesting that intuitive ways of thinking about causal connections in daily life may be mechanistic: adults and children apparently make sense of the phenomena they experience by assuming that some sort of active causal agent underlies events.¹² Consequently, mechanism-based explanations may be worth pursuing not only because they are regarded as essential for understanding phenomena, but also because mechanistic thinking may in fact be a very basic human intuition used in making sense of phenomena experienced as causal.

(iii) A third argument found in philosophical discussions on mechanistic explanations claims that knowing the *how*, in addition to aiding causal inference and improving our understanding of phenomena, is requisite for manipulation and control. Bunge (1997), for instance, concludes that “there is nothing like the disclosure of mechanisms [...] to empower us to control natural and social processes” (p. 422). This line of argument, which can readily be accepted in the natural sciences, proves to be more problematic in the social sciences where experimentation and direct manipulation are rarely possible.

Despite these limitations, mechanistic explanations in the social sciences for the purpose of manipulation and control could be used to leverage interventions through social policy. According to Weber (2007, 352–4), an advocate of using mechanism-based explanations for social policy, knowledge about mechanisms enables social scientists to extrapolate results from empirical research to multiple contexts, thereby making inferred causal connections useful for policy interventions. This view, though appealing, is highly contested. Reiss (2007, 178–9), for instance, argues that even if mechanisms have been identified and the causal relations they are supposed to describe are true, it is most unlikely that a policy intervention could modify the cause in exactly the right way without modifying other causes of the phenomena so as to bring about the desired outcome in every case. As a reason for this difficulty he underscores that the policy variable, e. g., prohibiting smoking in bars, does not exactly correspond to the causal agent to which the mechanistic explanation refers, e. g., nicotine causing lung cancer (p. 180). In addition to that, the extrapolation of empirical results from one context to other may prove to be highly problematic and not free of the same limitations that all inductive generalizations share (see also Steel, 2007, 361–2). It may therefore be safe to conclude, Reiss argues, that manipulation and control as a property of mechanistic explanations should be confined to the natural sciences where experimentation is possible and interventions can be performed more directly; their application to social policy, on the other hand, should be first fully understood and positively addressed before preaching that mechanisms solve all the problems of translating research into practical policy measures.

¹² The studies quoted by Machamer et al. (2000) are Baillargeon, Kotovsky, and Needham (1995) and Ahn and Kalish (2000). Still another study, not mentioned by Machamer, is Koslowski (1996), which draws similar conclusions regarding the importance of mechanisms for scientific thinking.

To sum up, it is true that mechanistic explanations may be advantageous for many purposes like improving causal inference, deepening our understanding of phenomena, or enhancing the possibility of manipulation and control. However, and specifically in the social sciences, some caution is advised against overstating the role of mechanistic explanations to solve methodological problems. As Steel (2007) emphatically asserts, “mechanisms are not a magic wand that can be waived to make methodological problems vanish” (p. 363).

Generality of mechanistic explanations. That mechanistic explanations are a response to the covering-law model is not to say that they are incompatible with, let alone opposed to, laws.¹³ Mechanisms opposing the existence of some fundamental principles were already shown to be misleading, if not impossible: the functioning of a mechanism relies to some extent on certain deep nonmechanical principles described by some philosophers such as Glennan or Bunge as laws. An analogous opposition of mechanistic explanations to laws, understood as a general hypothesis, is equally misleading yet can be found in the writings of prominent social scientists (e. g., Elster, 1999, 5), as will be discussed in **Section 1.2**.

To put it briefly, the generality of a mechanism-based explanation depends on the generality of the mechanisms it refers to and includes in its explanans. If very general mechanisms are assumed, then general mechanistic explanations will follow; on the contrary, if only a specific mechanism is included in the explanans, then nothing more than the output of this very mechanism may constitute the explanandum. Yet, as mentioned above, given the fact that mechanisms are *by definition* concrete systems, processes, or processes in systems productive of some regular outcome, one is forced to conclude that all mechanistic explanations are specific, for any attempt to elevate the functioning of mechanisms or the regularities they bring about to the level of a general principle applicable to a wider range of phenomena would be contrary to their definition. If mechanisms are assumed to be concrete, how then is it possible to talk about general mechanistic explanations, let alone general mechanisms?

Even if there are no general mechanisms (they are all concrete), it may still be possible, by means of *analogy* and *abstraction* (Bunge, 2004, 194–5), and by looking for similarities among them (Bechtel & Abrahamsen, 2005, 437–9), to group concrete mechanisms into more general *kinds*. If used in a mechanism-based explanation, these more abstract *kinds* of mechanisms confer on the explanation a broader scope and allow it to refer to a wider range of analogous phenomena. In fact, if these mechanism *kinds* are general enough, there is no reason not to

¹³ Laws are here loosely defined as “generalizations of wide scope that apply to many different kinds of systems and [...] have few or no (or at least a very limited set of) exceptions” (Woodward, 2002, 368).

describe them as general hypotheses or laws. Hence it is perfectly possible to formulate very general, law-like hypotheses using a mechanism *kind* that is wide in scope and thereby to produce general mechanistic explanations. It is for this reason that Bunge emphatically stresses that the opposite of mechanistic explanations is a black-box explanation and not lawfulness (Bunge, 2004, 200) and that the search for laws should not be replaced by a search for mechanisms, but instead that law statements incorporating mechanisms should be preferred (Bunge, 1997, 442). However, as Bunge (2004, 195) warns, it must be borne in mind that these groups or *kinds* of mechanisms are mere *representations* of different specific mechanisms and should not be confused with the original, concrete mechanisms.

Most interestingly, if some mechanism *kind* is general enough to describe the regularities brought about by many types of concrete mechanisms, a mechanism-based explanation could be formulated to resemble the form of the D-N model, that is, the subsumption of a particular event under a general law-like generalization (Glennan, 2002, 348–9). Even in this latter case, an essential difference between the D-N model and mechanistic explanations remains: while the D-N model is applied to particular cases modifying the antecedent conditions, a mechanistic explanation addresses particular cases by adapting the description of the mechanism itself (Bechtel & Abrahamsen, 2005, 439). Despite this very central difference, opposing mechanistic explanations against explanations that comply with the D-N model should therefore best be regarded as an assertion about the transparency and depth of explanations rather than as a claim about the generality of scientific hypotheses or about the logical adequacy of the explanans.¹⁴

Reduction in mechanistic explanations. Reduction in mechanism-based explanations is particular to each scientific discipline and depends heavily on the assumed definition of mechanisms. For instance, according to the systems approach as applied in the natural sciences, mechanisms are complex multilevel and nested objects that cannot be reduced to some fundamental level but instead call for what Wimsatt (2006) refers to as “mechanistic reduction.” This form of reduction poses analyzing phenomena at their different constitutive levels without favoring one level over the other (Bechtel & Abrahamsen, 2005, 426) with the assumption that lower-level properties are equally relevant to bring about phenomena as higher-level properties (Craver & Bechtel, 2007; Glennan, 2010). Accordingly, defining a fundamental level of analysis to construct mechanistic explanations is mostly a matter of convenience in specific scientific fields and entails *deciding* which level is relevant and where to stop when going to deeper levels of one mechanism or

¹⁴ In the social sciences it seems that only a few authors have arrived at this same conclusion—that the generality of mechanism-based explanations is not the crucial difference to laws or law-like generalization. As will be further elaborated in **Section 1.2**, one of the rare cases is Mayntz (2004, 240).

in looking for further nested mechanisms (Machamer et al., 2000, 13). By contrast, as will be seen in the next section on the reception of mechanisms and mechanism-based explanations in sociology, the question concerning reduction in mechanistic explanations in the social sciences is part of the broader debate on methodological individualism versus holism and bears only limited resemblance to analogous discussions in the natural sciences or the systems approach to mechanisms. In this sense, reviewing the discussion on reduction and presenting it as a reflection on mechanistic explanations *in general* would be misleading.

Table 1.2 sums up the review of the main aspects of the contemporary philosophical literature on mechanisms and mechanistic explanations. Again, the selection of subjects is representative and not exhaustive and focuses on the core elements of the philosophical discussion that are relevant for the formulation and later application of social mechanisms in sociology.

1.2 The sociological reception

Now that the philosophical literature has been reviewed, this section turns to the sociological reception of mechanisms and mechanistic explanations to discuss both the central claims of the mechanistic agenda and the difficulties of putting its recommendations into practice.¹⁵

As in the natural sciences, use of the word “mechanism” in the social sciences and, in sociology in particular, is not new. Over half a century ago, Merton (1968) included the concept of mechanisms in his writings, which he defined as “[...] social processes having designated consequences for designated parts of the social structure” (p. 43). Some years later, in his book *Social Mechanisms*, Karlsson (1958) discussed different mathematical, rational-choice-based models to explain the functioning or the “mechanisms” of society (p. 9). Despite these early references to the notion of mechanism, it was only after Hedström and Swedberg published a collection of essays on social mechanisms in 1998 that the concept took on a clearly programmatic character in sociology. This “new mechanistic perspective”, as Reiss (2007, 166-7) labeled it, groups together researchers from various disciplines in the social sciences who share the common commitment to explain social phenomena based on the underlying mechanisms that produce them.

As already stated in the introduction to this chapter, reviewing the literature on mechanisms and mechanistic explanations is not a goal in itself but an intermediate step in figuring out the most appropriate way to use a mechanistic approach in the present study. Accordingly, the focus of the review is not broad but narrow; it concentrates on the most prominent aspects of the discussion in

¹⁵ Some passages of this section are reproduced in slightly modified form in Cardona (2013b).

Table 1.2: Review of the philosophical literature on mechanisms and mechanistic explanations: Summary of metaphysical and epistemological issues

Mechanisms	Mechanistic explanations
<p>Are mechanisms mechanical? Mechanisms are not mechanical as the classical, 17th-century use of the concept implies.</p>	<p>Criticism of the covering-law model. The D-N model is a black-box; mechanistic explanations are translucent boxes showing <i>how</i> things work.</p>
<p>Different approaches. Mechanism can be defined as (i) processes or persistent chains of events, (ii) systems regularly productive of a certain outcome, or (iii) processes in concrete systems.</p>	<p>Advantages of mechanistic explanations. (i) improving causal inference by helping to resolve the problems of confounders and endogeneity; (ii) understanding phenomena in a way compatible with intuitive causal thinking, and (iii) possibly enabling/improving intervention and control, also in the social sciences in the form of social policy.</p>
<p>Causation. Mechanisms imply a generative notion of causality most directly opposed to the regularity view of Hume; however, some specific theory of causality is not always explicitly invoked and different approaches to mechanisms can be modified by assuming different causation theories. Furthermore, causality itself can—with some limitations—be mechanistically formulated.</p>	<p>Generality. No matter how concrete mechanisms may be, mechanistic explanations can, by means of analogy, be formulated so as to have a general scope. Mechanism-based explanations may display different levels of generality, the higher of which may be similar (and not opposed) to law-like hypothesis.</p>
<p>Regularities underlying and produced by mechanisms. As concrete objects in the world, mechanisms and the regularities they bring about do not represent general principles but are instead wedded to specific processes, systems, or processes in systems. Moreover, even if a mechanism may be decomposable in lower-level mechanisms, the regular functioning of mechanisms relies at some deep level on mechanically irreducible principles (e. g., laws or entities and activities).</p>	<p>Reduction. Reduction in mechanistic explanations cannot be generalized to a standard methodological rule; it depends both on the definition of mechanism and on the scientific discipline or field of application.</p>

sociology without going any further into the details and controversies of the different positions. This, however, is not a simple task. Conducting a survey of the literature focusing only on the main aspects presents two main difficulties. First, the new mechanistic program in sociology is highly heterogeneous (Brante, 2008, p. 271, footnote 1), so it is difficult to provide a complete review of the literature without mentioning the numerous particularities of each author who make use of the concept. Second, surveys of recent discussions on social mechanisms are abundant, so any new attempt to review the literature would, at best, render the same results already found in published articles (Gerring, 2007; Gross, 2009; Ma-

honey, 2001; Mayntz, 2004; Norkus, 2005).¹⁶ In other words, not only would it be impossible to review social mechanisms in sociology without mentioning the particularities, but also, and perhaps more decisively, the demanding task of producing a comprehensive summary of the different views on social mechanisms has already been carried out successfully, if not exhaustively, by more than one author over the past decade.

All these things considered, the literature review in this section follows a different strategy. Instead of expending fruitless efforts in rewriting what has already been written (either attempting a new review of the literature or redundantly summarizing the already existing reviews), the mechanistic approach in sociology will be selectively assessed. The works of the two main authors who champion the recent surge of interest in social mechanisms, John Elster and Peter Hedström, will be discussed; based on their work, the most relevant issues raised by the reception of mechanisms in sociology will be addressed. It is true that the views of Elster and Hedström on mechanisms are not consensually accepted, nor do they cover the variations and alternative formulations of the subject put forward by different authors in the last two decades. Nonetheless, they offer a comprehensive account of social mechanisms that deals with the most relevant aspects of introducing mechanisms in sociology, providing sufficient input to outline the core elements of this approach, and assess the best way of putting it into practice.

This section is divided into three parts. After discussing the works of Elster and Hedström in the first part, the second part critically examines the difficulties of adopting a mechanistic approach in sociology. This second part is not restricted to the works of Elster and Hedström. It also draws upon the different review articles as well as other articles about social mechanisms that tackle the problematic aspects of the discussion on social mechanisms. Finally, the third part takes stock of this review, giving a direct answer to the two questions raised at the beginning of this chapter about the use of mechanisms and mechanistic explanations in sociology and providing the definition of social mechanisms that will be adopted throughout this study.

1.2.1 Leading advocates of a mechanistic approach in sociology

Among the authors championing the new mechanistic program in sociology, Elster and Hedström are widely regarded as the most central figures. Their influence in the contemporary discussion on social mechanisms not only has been recognized by numerous authors taking part in the debate (e. g., Abbott, 2007;

¹⁶ In addition to these articles, Schmid (2006) offers a very comprehensive work on mechanisms and mechanistic explanations in sociology. The work has not received much attention in the discussion on social mechanisms, presumably because it is written in German.

Bunge, 2004; Mahoney, 2001; Norkus, 2005), but also can be attested to by the numerous empirical studies that have applied their definition such as those by Wikström and Sampson (2003, 121), Barrera (2008, 2–3), and Baker and Faulkner (2009, 1533), to name just a few of the most recent ones. Moreover, Elster's and Hedström's works on social mechanisms rank among the most frequently cited publications in the social sciences on this subject.¹⁷

Both authors have been very active in publishing their views on mechanisms and mechanistic explanations, changing some of their ideas and consolidating others over the years. In the case of Elster, five books contain most of his thoughts on mechanisms. His early notions on mechanisms, found in Elster (1983), were modified in Elster (1990) and worked out in more detail in Elster (1998), Elster (1999) and Elster (2007).¹⁸ As for Hedström, his early views on the subject can be found in Hedström and Swedberg (1996) and in perhaps his most quoted article of 1998 (Hedström & Swedberg, 1998b), which is included as an introduction to the collection of essays on social mechanisms published in conjunction with other advocates of the mechanistic approach like Boudon, Stichcombe, and Elster (Hedström & Swedberg, 1998a). Besides these two early articles, Hedström's ideas on mechanisms are most comprehensively developed in his book *Dissecting the Social: On the Principles of Analytical Sociology* (Hedström, 2005). His most recent publication (Hedström & Ylikoski, 2010) basically summarizes the argument put forward in that book.

The numerous publications of both Elster and Hedström, as well as the many small modifications of their ideas make it difficult to summarize their views in a straightforward way. Taking this difficulty into consideration, the following review will seek to extract the pieces of thought that remained constant in each author's work and will attempt to reconstruct the evolution of the ideas that have changed over the years. Special attention will be given to these author's arguments favoring mechanistic explanations, their various definitions of social mechanisms (including their different typologies), and other issues such as the nature of the inner workings of mechanisms and their generality.

Why social mechanisms and mechanism-based explanations? As already discussed in some detail in **Section 1.1**, the mechanistic approach to science aims both to extend the covering-law model of scientific explanation beyond the use of laws and toward deeper explanations and to overcome the difficulties of causal inference posed by correlational analysis.

¹⁷ See the Science Citation Index (SCI) at <http://www.isiknowledge.com>

¹⁸ Elster (1998) is the exact same article as Elster (1999), and Elster (2007) is a slight modification of these last two.

In their plea for mechanisms and mechanistic explanations in the social sciences, Elster and Hedström consistently share these same views about the covering-law model and correlation-based causal inference. Regarding causal inference, both authors extensively discuss the issues of spurious correlation, endogeneity, and confounders that apparently are aggravated by the sole use of correlation tools (Elster, 1990, 5–6; Elster, 2007, 21–3; Hedström & Swedberg, 1998b, 17; Hedström, 2005, 23). As for the deductive-nomological (D-N) model, they also agree that using laws to explain social phenomena results in black-box explanations that simply connect input and output, adding hardly anything to our understanding of phenomena, not to mention their skepticism about the very existence of laws in the social sciences (Hedström & Swedberg, 1998b, 8–9; Hedström, 2005, 15–7; Elster, 2007, 32,35), which serves well their preference for mechanism-based explanations.¹⁹

Concerning the question of how a mechanistic approach may help improve these insufficiencies, Elster and Hedström provide slightly different answers. In Elster's view, resorting to mechanisms makes causal inference more robust to the risks posed by mere correlational analysis (Elster, 1983, 24; Elster, 2007, 33). In addition to that, the use of mechanisms may provide deeper explanations that effectively improve our understanding of social reality (Elster, 1990, 6; Elster, 1999, 10). On the other hand, although Hedström gives a similar argument in support of the benefits of mechanisms and mechanism-based explanations, highlighting the same advantages mentioned by Elster (causal inference, intelligibility of explanations, and understanding of phenomena), he further emphasizes some additional disciplinary aspects of a mechanistic approach in sociology related to theory building.

In Hedström's opinion, sociological theorizing either has degenerated into variable-based sociology, or the use of statistical analysis as a way of generating theories, or has lost itself in unsuccessful attempts to formulate grand theories (Hedström & Swedberg, 1998b, 6; Hedström, 2005, 11–4). Between these two tendencies—empiricism on the one hand and highly abstract theories on the other—he suggests adopting a middle course that would produce theories having an intermediate scope of generality based on mechanisms (Hedström & Swedberg, 1998b, 1; Hedström, 2005, 1). According to Hedström, making use of mechanisms in this way would allow one to go beyond the empirical level of statistical analysis and,

19 A mechanistic explanation is still a deductive type of argument compatible with the D-N model (Hedström, 2005, 30). Hence, claims raised against the covering-law model by these two authors should be seen as a critique of the use of laws in explanation and not as an objection to the logical framework implied by the model. Considering the underlying logical structure of explanations, the only difference between a nonmechanistic-deductive explanation and a mechanistic deductive explanation is that only in the former case does the explanandum consist of the output of a mechanism and the explanans of the description of the mechanism bringing about that output (cf. Glennan, 2002, 347).

without having to provide a general theory of society, to reach a certain level of generality above mere empirical findings. This, in turn, would bring two significant advantages to sociological theorizing and research. First, it would open the way for interdisciplinary research, since one and the same mechanism may be relevant for more than one discipline (Hedström & Swedberg, 1998b, 6); and second, given the middle level of generality of mechanism-based explanations, such explanations would reduce the tendency toward theoretical fragmentation observed in sociology by consolidating many dispersed theories under a common mechanism (Hedström, 2005, 28).

To recap so far, according to Elster and Hedström, social mechanisms and mechanistic explanations should solve the problems of using correlational analysis as a method for causal inference, of resorting to laws in the formulation of explanations as prescribed by the D-N model, and of formulating sociological theories following the logic of variable-based sociology or the search for grand-theories. As a solution to these problems Elster and Hedström make a case for (i) causal inference based on mechanisms that resolve the problem of spurious correlation, endogeneity, and confounders; (ii) mechanism-based explanations that make explanations more intelligible and favor our understanding of social phenomena; and (iii) mechanism-based theorizing as theories of middle scope of generality that favor multidisciplinary and reduce theoretical fragmentation inside sociology. Although these reasons are not shared by everyone taking part in the discussion on social mechanisms in sociology, they do constitute a comprehensive list of the potential advantages of adopting mechanisms and mechanistic explanations in sociology.

As discussed in **Section 1.1**, similar reasons have been voiced in the philosophy of science in favor of mechanisms and mechanism-based explanations—in particular, points (i) and (ii) above—including additional arguments not mentioned by Elster or Hedström, such as the possibility of using mechanism-based research to enhance our capacity for control and intervention. Worth noticing is the difference in depth with which the arguments about the benefits of mechanisms have been put forward in sociology as compared with philosophy. Particularly in regard to mechanisms and causal inference, and the closely related issue of a mechanistic theory of causation, sociologists tend to oversimplify the discussion and be apologetic about the advantages of mechanisms for causation without devoting much energy to critically exploring potential difficulties of such an approach. In this regard the philosophical literature provides a much more unbiased account and should therefore be preferred as a major source for matters about causality and causal inference.

Defining social mechanisms. Interestingly, most of the discussion about the need for and potential advantages of a mechanistic approach to sociology has been conducted without the participants having arrived at some minimal consensus as to what a social mechanism is. Indeed, most of the controversies in sociology about the introduction of mechanisms and mechanism-based explanations revolve around the intricacies of their definitions and are less concerned with questioning their relevance as a type of theorizing, a way to improve explanations, or a solution to the problem of causal inference.

Elster, and particularly Hedström, have repeatedly struggled to come to grips with this concept, changing their definition quite often as can be seen in **Table 1.3**.²⁰

Table 1.3: A comparison of Elster’s and Hedström’s definitions of social mechanisms

Elster	Hedström
“[...] intentional chains from a goal to an action as well as causal chains from an event to its effect” (Elster, 1983, 24).	“[...] an integral part of an explanation which (1) adheres to the three core principles stated above [direct causality, limited scope and methodological individualism], and (2) is such that on the occurrence of the cause or input, I, it generates the effect or outcome, O” (Hedström & Swedberg, 1996, 299).
“[...] nuts and bolts, cogs and wheels – that can be used to explain quite complex phenomena” (Elster, 1990, 3).	“[...] an integral part of an explanation which (1) adheres to the four core principles stated previously [action, precision, abstraction and reduction], and (2) is such that on the occurrence of the cause or input, I, it generates the effect or outcome, O” (Hedström & Swedberg, 1998b, 25).
“[...] frequently occurring and easily recognizable causal patterns that are triggered under generally unknown conditions or with indeterminate consequences” (Elster, 1998, 45); see also Elster (1999, 1) and Elster (2007, 36).	“[...] a constellation of entities and activities that are linked to one another in such a way that they regularly bring about a particular type of outcome” (Hedström, 2005, 11).

If we compare the views of these two authors, Elster seems to be much more consistent in his definition of mechanisms. To him, mechanisms are those intentional *somethings*—causal chains; “nuts and bolts, cogs and wheels;” causal patterns—that connect cause and effect on a regular basis. This view on mechanisms follows directly from his conception of causality. According to Elster, causality

²⁰ Elster does not use the term “social mechanism” but only the word “mechanism.” However, because he is explicitly writing within the social sciences, it may be safe to call his account on mechanisms “social.”

has to be temporally and spatially local, meaning that action at a distance is impossible and that any effect is to be traced back to the existence of the continuous and contiguous causal chains *producing* it (Elster, 1983, 28–9). Thus, the core idea behind his definition is not, as it is in the natural sciences, a complete account of the ontological underpinnings of mechanisms (e. g., processes, systems, or processes in systems), but rather results most directly from his generative view on causality, which does not go further than recognizing the existence of some regular causal chains or patterns.

Hedström takes a similar approach to the definition of mechanisms, at least in his first two articles (Hedström & Swedberg, 1996, 1998b). Here he merely characterizes the “fundamental principles” that a mechanistic approach to sociology should adhere to (methodological individualism, middle-range theorizing, and direct causality), without giving any explicit account of what mechanisms are. Aside from these principles, which some years later became the principles expressed in his text on analytical sociology, he merely describes mechanisms in these first two articles as *something* producing some output from an input. Unlike Elster, who refers to the mechanisms connecting cause and effect as regular causal chains or patterns, Hedström gives in his first publications no description whatsoever of what exactly these mechanisms are supposed to be.

This lack of clarity about the nature of mechanisms was dispelled in Hedström’s book on analytical sociology, published in 2005, in which he takes on the task of explicitly defining the nature of that “something” connecting input and output referred to in his first works on mechanisms (Hedström, 2005). To do so, he adopts Machamer’s ontology of “entities” and “activities” (Machamer et al., 2000) and without much further elaboration, imports it into sociology by simply replacing the words “entity” with individual actor and “activity” with action. Accordingly, social mechanisms are nothing more than the constellation of individuals and actions regularly producing an outcome (Hedström, 2005, 25–6).²¹ As in Elster’s definition, Hedström also does not resort to any of the ontological categories mentioned in the previous chapter to describe social mechanisms; for him what constitutes social mechanisms is simply the combination of individuals and actions, not processes or systems.

Regularities underlying mechanisms. Whether as causal chains or patterns (Elster) or as the constellation of entities and activities (Hedström), the functioning

²¹ Whether this quick reconceptualization of Machamer’s definition is licit, should, in my opinion, be left as an open question. Although Machamer et al. do not deny the possibility of extending their definition of mechanisms to the social sciences (Machamer et al., 2000, 2), Hedström’s reformulation of the concepts of entity and activity seems to lack the same rigor and depth as the original, and clearly much more complex treatment found in Machamer et al. (2000) and Machamer (2004). It is not, however, the aim of this chapter to pursue this issue any further.

of mechanisms presupposes the existence of some deeper principles governing their inner workings. How do both authors explain them?

According to Elster, and mostly unnoticed by his critics (e.g., Bunge, 2004, 196–8), laws are needed to explain the functioning of mechanisms. Even if his defense of a mechanistic approach is basically an attack on the use of laws in explanations, Elster recognizes that the decomposition of phenomena in ever finer-grained causal sequences cannot go on indefinitely and must, eventually, bottom out in some nonmechanical principles. In his own words: “A causal mechanism has a finite number of links. Each link will have to be described by a general law, and in that sense by a ‘black-box’ about whose internal gears and wheels we remain ignorant” (Elster, 1990, 7). Hence, the principles underlying the regular functioning of mechanisms are, similar to the views of Bunge (1997, 2004) and Glennan (1996, 2002), mechanically-irreducible laws.

For Hedström, in contrast, it is not laws that are needed to explain the internal workings of mechanisms, but rather actors and actions. In his view, even if all phenomena may in principle be decomposable into their underlying mechanisms so that the regular functioning of a given mechanism is just the outcome of some deeper one, this decomposition need not be set forth indefinitely. Instead, mechanistic decomposition should be confined to disciplinary limits based on some “stopping rules” of substantive relevance. In sociology, he contends, such bottom-lines of mechanistic decomposition are individuals and their actions, the irreducible ontological starting point of all social phenomena (Hedström, 2005, 19). Consequently, even if it were possible to further decompose individual actions into deeper mechanisms (e.g., neuroscience) or into some deeper laws of nature, it would be, in his opinion, sociological irrelevant (Hedström, 2005, 25–6).

Types of mechanisms. Beyond the metaphysical aspects of defining mechanisms and the nature of their internal functioning, which, as will be shown below, are far from settled in the literature on the subject, Elster and Hedström provide very down-to-earth instances of social mechanisms, identifying both concrete and general *types*.

According to Elster (1999), mechanisms can be classified as either “atomic,” which are psychological mechanisms capturing very concrete patterns of individual action (p. 20), or “molecular,” which constitute arrays of combined atomic mechanisms explaining more complex psychic or social phenomena (p. 32). These mechanisms are not independent of each other; rather, they interact to produce the same outcome in ways that are mutually exclusive or reinforcing, depending on the triggering conditions of each (Elster, 1999, 7–8). To capture this interaction between mechanisms, Elster proposed a general typology: *type A* mechanisms refer to mutually exclusive mechanisms with unknown triggers, while *type*

B mechanisms refer to those with known triggers but unpredictable net effects; these can be further classified into *type B1* (if simultaneously triggered) and *type B2* (if successively triggered).

In his work, Elster provides a fairly comprehensive collection of examples of atomic (or psychological) mechanisms. Unfortunately, this is not the case for molecular mechanisms, which he does not elaborate in depth. Just to mention one example of the former, an individual's inability to have some desired object may trigger two competing atomic mechanisms that affect preferences: the "sour-grapes mechanism" (an adaptive preference to stop desiring what is not attainable) and the "forbidden-fruit mechanism" (an adaptive preference to desire something even more because it is forbidden or unattainable). Still other psychological mechanisms include spillover, compensation and crowding-out effects, contrast and endowment effects, and wishful-thinking (Elster, 1999, 20–32). All of them describe individual behavioral tendencies as a function of changes in desires, beliefs, and preferences.

Mirroring Elster's classification, Hedström distinguishes between "elementary" and "molecular" mechanisms. According to him, these two types of mechanisms denote differences not only in their constitutive entities and activities, but also in the phenomena they explain. Thus, while the entities constitutive of elementary mechanisms are beliefs, desires, and opportunities, the entities underlying molecular mechanisms are individuals. For elementary mechanisms, he does not define activities; for molecular mechanisms, activities are individual actions.²² Accordingly, whereas elementary mechanisms can be used to explain different individual actions, molecular mechanisms explain configurations of actors (Hedström, 2005, 26–7). Examples of molecular and elementary mechanisms are mostly provided in Hedström's book on analytical sociology (Hedström, 2005), particularly in Chapters 3 and 4. Like Elster's examples of mechanisms, the examples provided by Hedström mostly illustrate elementary mechanisms in the form of psychological patterns that underlie different behaviors, rather than molecular mechanisms that produce some configuration of actors. In fact, several of the concrete instances of mechanisms provided by Hedström, such as dissonance-driven or adaptive desire formation, are exactly the same mechanisms discussed by Elster (cf. Hedström, 2005, 59).

In addition to the distinction between elementary and molecular mechanisms, and departing from Elster's categorization of mechanisms in types A, B1, and B2, Hedström introduces three general types of mechanisms: *situational mechanisms* (macro to micro), *action formation mechanisms* (micro to micro), and *transforma-*

²² That Hedström does not specify the activities constitutive of elementary mechanisms and defines them solely in terms of their entities is surprising, to say the least, for it omits without any justification a central category of his own definition of mechanisms as constituted by activities and entities.

tional mechanisms (micro to macro). These three types of mechanisms are in line with Coleman's well-known macro-micro-macro model of explanation (Coleman, 1986). According to Hedström, situational mechanisms explain the reaction of an individual to specific social situations, action formation mechanisms account for the way individuals make decisions and interact among themselves, and transformational mechanisms aggregate individual actions into collective outcomes.

In the light of this discussion about the definition and classification of social mechanisms by Elster and Hedström, two additional relevant points should be briefly made. First, as may be evident already, both authors place individuals at the center of social mechanisms, so looking inside the black box of the covering-law model is the same as going to the level of individual action. This is hardly surprising given Elster's and Hedström's explicit adherence to the principles of methodological individualism and hence to the conviction that all social phenomena can be reduced to individuals and their actions (Elster, 2007, 13; Hedström & Swedberg, 1998b, 12-13). Hedström is especially emphatic in making clear that there are no mechanisms beyond individuals and thus no macro-level mechanisms (Hedström & Swedberg, 1998b, 24; Hedström, 2005, 28-9). To be sure, this emphasis on action does not necessarily imply a commitment to rational choice, from which both authors try to distance themselves. However, it certainly assumes a theory of action: the desire-belief-opportunity (DBO) theory in the case of Hedström (Hedström, 2005, ch. 3) and some sort of motivation-based, weak rational-choice theory in the case of Elster (Elster, 2007, ch. 3).

Second, it is also important to note how both authors draw the line between concrete and abstract mechanisms, that is, between real existing phenomena and abstractions of similar phenomena. Here a noteworthy difference can be observed. While Elster sticks to his definition of mechanisms as concrete and observable causal chains, Hedström makes a plea to depart from the concreteness of mechanisms, particularly in his earlier publications, in which he characterizes mechanisms as analytical constructs (Hedström & Swedberg, 1998b, 13). In later publications, although Hedström tends to characterize mechanisms as concrete phenomena (existing constellations of entities and activities), he still insists on abstraction as one central principle of his analytical sociology (Hedström, 2005, 2-3) and as a direct response to Elster, he doubts that mechanisms are always easily recognizable (Hedström & Ylikoski, 2010, 56).

Generality of mechanisms; laws and mechanisms. As concrete causal chains or constellations of entities and activities, the regularities produced by mechanisms are confined to their own concreteness. However, as discussed in **Section 1.1** on the philosophical literature on the subject, some degree of generality may be achieved beyond the mere observational level of particular instances by means of abstraction.

As already mentioned, it is Hedström who most explicitly advocates searching for analytical mechanisms of some generality. In his view, mechanistic explanations without generality would turn into mere ad-hoc story-telling limited to reconstructing contingent phenomena (Hedström & Swedberg, 1998b, 10). Yet, despite this plea for mechanisms of some generality, Hedström is not hoping to elevate mechanisms to the level of laws. Rather, his chief aim is to produce generalizations of a limited scope, much in the spirit of Merton's middle range theories (Hedström & Swedberg, 1998b, 25).

Unlike Hedström, Elster's position on laws is rather ambiguous and unstable throughout his writings, notably changing from one publication to the next. At times he argues that a mechanism is the decomposition of a law in its "cogs and wheels" (Elster, 1983), insisting that "In this context, the antonym of a mechanism is a scientific law" (Elster, 1999, p 5). Later, however, he describes the transition from laws into mechanisms as going from general laws at higher levels of abstraction to laws at lower levels of abstraction (Elster, 2007, 35), arguing that if the triggering conditions of mechanisms are identified (situations, individual traits, or previous outcomes), and if spurious mechanisms are sorted out, mechanisms may be transformed into laws of some restricted generality (Elster, 1999, 36–44; Elster, 2007, 44). However, still other passages reveal his indecision about mechanisms and laws: "To repeat, I am not advancing explanation by mechanisms as an ideal or norm. Explanation by laws is better—but also more difficult, often too difficult" (Elster, 1999, 10). All these changes considered, as Gorski (2009, 173–5) contends, Elster begins by trying to overcome positivism and laws, but he ends up recognizing their superiority, resorting to mechanisms as a second-best strategy needed to bypass the unsuccessful search for laws in the social sciences. Thus, one may conclude that what Elster initially presents as a fight between mechanisms and laws, with no quarter given, turns out to be, upon closer examination, a minor quarrel with a potentially amicable ending in which laws are not entirely dismissed but simply replaced by new ones of lower generality.

Table 1.4 summarizes the differences and similarities between Elster's and Hedström's treatment of social mechanisms. In a nutshell, while it is true that the reception of social mechanisms as put forward by the two authors share several aspects, such as methodological individualism and optimism about relying on mechanisms and mechanistic explanations to solve the limitations of black-box explanations and correlation-based causal inference, they differ in some other respects, in particular in the nature of the regularities underlying mechanisms, the classification of mechanisms, and the emphasis on concrete versus abstract mechanisms.

Table 1.4: Summary of Elster's and Hedström's approach to social mechanisms

	Elster	Hedström
Why mechanisms and mechanistic explanations?	To improve causal inference, intelligibility of explanations, and understanding of phenomena; to bypass search for laws.	To improve causal inference, intelligibility of explanations, and understanding of phenomena; to find middle course between grand theory and empiricism; to reduce theoretical fragmentation and promote interdisciplinary work.
Regularities underlying mechanisms	Laws connect links in causal chains.	Individual actions (stopping rule in sociology).
Types of mechanisms I	<i>Atomic</i> (psychological) and <i>molecular</i> (combination of atomic mechanisms).	<i>Elemental</i> (beliefs, desires, and opportunities) and <i>molecular</i> (individuals and actions).
Types of mechanisms II	Paired mechanisms: <i>Type A</i> (unknown triggers); <i>type B</i> (known triggers; unknown net effects), <i>type B1</i> (simultaneous), <i>type B2</i> (sequential).	<i>Situational</i> (macro-micro), <i>action formation</i> (micro-micro), and <i>transformational</i> (micro-macro).
Generality and laws	Mechanisms are easily recognizable causal patterns of restricted generality; however, they can be transformed into weak laws when triggers are identified.	Mechanisms are constellations of entities and activities that can be abstracted up to the level of middle-range generalizations.

1.2.2 Difficulties in implementing a mechanistic approach

Now that the central ideas of the debate on social mechanisms and mechanistic explanations have been extracted from the works of Elster and Hedström, this section addresses the difficulties of putting the mechanistic agenda into practice. Among the many challenges facing a mechanistic approach in sociology, three main issues have been selected for discussion: first, and the one most urgently calling for a solution, is the lack of consensus about the definition of social mechanisms; second, and closely related to the former, are the major hurdles that must be overcome to arrive at such consensus about the nature of mechanisms; and third, uncertainty about the appropriate way to identify, model, and test social mechanisms. To examine these three groups of issues, both specific articles on social mechanisms and reviews surveying the existing literature on social mechanisms will selectively be drawn upon where appropriate.

The selection of these topics for discussion reflects the fact that much of the doubt cast on a mechanistic approach in sociology refers to the problematic characterization of social mechanisms as existing phenomena, rather than to the po-

tential advantages of mechanism-based research as a way to produce more robust causal inferences, better explanations, and better theories. In other words, meta-physical controversies about the nature of social mechanisms have prevented a fruitful epistemological discussion about the type of theorizing and research that can be developed based on a mechanistic perspective.

Lack of consensus about what social mechanisms are. Anyone acquainted with the discussion on social mechanisms would readily agree that two of the most notorious difficulties hindering the implementation of the mechanistic approach in sociology are the widespread confusion about the definition of social mechanisms, and the resulting lack of rigor in employing the concept found in the literature.

(i) Far from making a mechanistic approach appealing for sociological research, the task of defining social mechanisms has proved to be rather self-defeating, so that anyone following the discussion will wonder whether the concept has any substance at all. As Mayntz (2004) remarks, “[...] a survey of the relevant empirical and methodological literature soon bogs down in a mire of loose talk and semantic confusion about what ‘mechanisms’ are” (p. 239). Some years later Brante (2008) confirmed this view by adding, “There are already embarrassingly large amounts of definitions, some of which even contradict one another” (p. 276). After reviewing the literature on social mechanisms Gerring (2007) is more pernicious in his comments, suggesting the possibility that “[...] since ‘mechanism’ means so many different things—often quite contradictory to one another—it means nothing at all” (p. 178).

This precarious situation in defining social mechanisms is hardly improved by the fact that central figures of the mechanistic approach, such as Elster and Hedström, have changed their definition of mechanisms more than once. In other words, it is not only the diversity of the many definitions of mechanisms so far produced but also their individual instability that makes the issue particularly worrisome. As a consequence of this definitional inflation and fluctuation there are currently more definitions than authors writing on the subject. In his first survey of the different definitions of social mechanisms in the social sciences (not only sociology), Mahoney (2001) counted a total of 24 different formulations from among 21 authors (see Mahoney, 2001, Table 1, pp. 579–80). In a later article, Mahoney (2003) once again reviewed the definitions of social mechanisms in the social sciences, but this time he grouped them according to their similarity, discerning a total of five different categories, some of which are barely comparable with the rest. Likewise, some 4 years later, Gerring (2007) found that social mechanisms are referred to in at least nine different, though not mutually exclusive ways. Most recently, Gross (2009) devised his own classification of the definitions

of social mechanisms and like Mahoney, came up with five different categories. **Table 1.5** summarizes the categories to classify the definitions of social mechanisms suggested by these three authors and shows the considerable disparity and diversity in the uses of this concept.²³

Table 1.5: Social mechanisms: Different groups of definitions

Mahoney (2003)	Gerring (2007)	Gross (2009)
1. Cause of an outcome.	1. Pathway or process by which an effect is produced.	1. Not necessarily observable structures or processes.
2. Intervening process, event, or variable.	2. Difficult-to-observe causal factor.	2. Observable processes that do not require the positing of motives.
3. Underspecified causal process.	3. Easy-to-observe causal factor.	3. Lower-order social processes.
4. Unobserved entity that generates outcome.	4. Context-dependent (tightly bounded) explanation.	4. Triggerable causal powers.
5. Other definitions.	5. Universal (i.e., highly general) explanation.	5. Transforming events.
	6. Explanation that presumes highly contingent phenomena.	
	7. Explanation built on phenomena that exhibit law-like regularities.	
	8. Distinct technique of analysis (based on qualitative, case study or process-tracing evidence).	
	9. Micro-level explanation for a causal phenomenon.	

Source: Mahoney (2001, Table 1, pp. 579–80); Gerring (2007, 177); Gross (2009, 360–2).

By the same token, and consonant with the diversity of definitions, there is already a long list of additional characteristics associated with social mechanisms. As reviewed by the same three authors in the publications cited in **Table 1.5**,

²³ In the case of Gerring (2007), categories 4 to 9 refer to mechanistic explanations or the mechanistic approach in general rather than to the definition of social mechanisms. To be sure, the author is not to blame for this confusion; it simply reflects the tendency found in the sociological literature to use the concept “social mechanism” indiscriminately to refer to mechanism (an ontologically distinct phenomena), mechanistic explanation (an explanation using social mechanisms to explain observed outcomes), and a mechanistic approach (the approach to science promoting the search for mechanisms and the formulation of mechanistic explanations).

mechanisms have been ascribed the most disparate attributes: they have been depicted among other things as both observable and unobservable, deterministic and probabilistic, macro and micro, hierarchical and non-hierarchical, reducible and non-reducible to lower levels, action based and non-action-based, and referring to concrete phenomena in bounded contexts or representing universal phenomena in a way similar to laws. Yet, if social mechanisms exist in the social world, they obviously cannot display all these attributes at the same time, for most of the pairs of attributes mentioned are mutually exclusive.

(ii) Aggravating this conceptual confusion, the diversity of views on social mechanisms and their properties has been accompanied by a pervasive carelessness in the use of the concept. The lack of conceptual rigor found in the literature on social mechanisms ranges from a more or less tolerable level of ambiguity to an outright negligent use of the word. Just to mention one example of the latter case, in his categorization of the social mechanisms underlying inequality, Therborn (2006) defines mechanisms as “a kind of social interaction that yields a certain distributive outcome” (p. 11). Having said that, on the page immediately following this, he describes the first of these mechanisms, “distantiation,” as a *process* that operates *independent* of interaction, interaction being the supposedly constitutive feature of his definition of social mechanisms (pp. 11–2).

Apart from such acute cases of conceptual imprecision, which probably pertain to only a small group of publications, a second, more widespread lack of rigor in employing the concept of social mechanism can be observed when sociologists try to identify or formulate concrete instances of mechanisms. As an example, when Tilly (2004) formulated his bundle of nine mechanisms “causing boundary change” and “constituting boundary change,” he not starts from an exceptionally obscure definition of mechanisms, which refers among other elements to the “transfer of energy among stipulated social entities” (p. 217), he also fails to provide a detailed definition of these “boundary change” mechanisms, let alone include any empirical evidence that differs from rather anecdotal remarks proving their existence or illustrating their functioning.

Tilly himself is aware of this criticism and openly concedes that his boundary mechanisms require further critical examination and empirical verification (p. 216). His article, however, was published and is now part of the literature on social mechanisms, adding to the general confusion surrounding the subject. Indeed, and confirming how harmful the mindless use of the word “mechanism” in published papers may be, Pickel (2006) adopted this disputable, if not merely preliminary, terminology from Tilly and defines a new set of “mechanisms causing property transformation” and “mechanisms constituting property transformation” (p. 37), which he then uses to explain post-communist transformation and globalization.

In short, when sociologists try to define social mechanisms as distinct social phenomena, they are evidently referring to something different. Although conceptual diversity itself is not necessarily negative, the lack of an even minimal consensus about the nature of social mechanisms and the careless use of the word may seriously impair the prospects of a mechanistic approach in sociology.

Factors making a consensus about the nature of social mechanisms difficult.

The many attempts so far undertaken to define social mechanisms show how difficult it is to arrive at a minimal consensus about some basic assumptions underlying the concept. As Gross (2009, 364) observes, authors writing on social mechanisms tend to avoid this minimal characterization of mechanisms, adopting rather abstract definitions without having to make any compromises about the concrete nature of social mechanisms. To be sure, the task of formulating a clear set of basic assumptions about social mechanisms is not a matter of philosophical whim or a capricious obsession with metaphysical questions. Quite the contrary; it responds to the logical necessity that only after having agreed upon a common understanding of the core elements describing social mechanisms is it possible to embark on the project of conducting mechanism-based research (Gerring, 2007, 178).²⁴

The difficulty of arriving at a minimal understanding of social mechanisms seems to be the consequence of two features of the mechanistic approach: first, the use of categories imported from the natural sciences, and second, the instrumentalization of the discussion on social mechanism as a way to put forward personal theoretical agendas that merely reproduce old and known debates in sociology without making any true contribution.

(i) Definitions of mechanisms frequently include ontological categories imported from other scientific disciplines that are difficult to translate into sociology in a meaningful way or without loss. This practice of borrowing categories that originally stemmed from other disciplines is hardly surprising for Gorski (2009, 166), who sees in the appeal to mechanisms in sociology nothing more than indulgence in a new form of scientism, one that has given up the search for laws as prescribed by physics and has turned instead to contemporary biology and their successful search for mechanism as the new role model to follow.

It is Hedström, who in his own work, most clearly exemplifies how problematic it can be to transfer categories from biology to sociology. While he defends an ontological individualism and defines mechanisms as a constellation of individuals and actions, he does not resist the temptation to introduce in his definition the categories of “entity” and “activity,” borrowed in a rather ad-hoc manner and

²⁴ An attempt to spell out these core assumption about social mechanism is found in **Section 1.3.2.**

with no further justification from the works of Machamer et al. (2000), which originate from biology and neuroscience. What makes the smuggling of conceptual contraband into sociology even more questionable, is Hedström's silence as to why it is necessary at all to endorse these concepts in order to understand social mechanisms. In fact, as already mentioned above, he even leaves out "activities" from his own definition of "elemental mechanisms," characterizing them only in terms of "entities" and giving the impression that his borrowed categories are mere accessories to be disposed of if necessary.

(ii) Further exacerbating the lack of a set of core features describing the nature of social mechanisms, the reception of mechanisms in sociology seems to be permeated by individual efforts to put forward personal theoretical agendas not necessarily bound to a general characterization of social mechanisms. This programmatic character of prominent contemporary views on social mechanisms in sociology makes it difficult to disentangle the essence of social mechanisms from other accessory assumptions reflecting individual theoretical or methodological orientations. As an example, both Elster and Hedström equate the mechanistic approach in sociology to methodological individualism. This must not necessarily be the case; on the contrary, as Mayntz (2004, 246ff.) argues in her justification of macro-level mechanisms, there may be corporate actors or structures whose complexity makes it misleading, if not impossible, to reduce them to individual actions. Others, like Sawyer (2004), defend a middle position between individualism and holism, which he calls "nonreductive individualism." Although Sawyer accepts (contrary to individualism) the existence of emergent properties with causal powers independent of individuals, he recognizes (contrary to holism) that those emergent properties are not ontologically autonomous but still composed of individuals; in other words, there is no primacy of individualism over holism or vice versa (pp. 266–7).²⁵

Still others, like many of the authors taking part in the essays collected by Hedström and Swedberg (1998a), condition the viability of the mechanism approach in sociology to some form of rational-choice theory. As an example, according to Boudon (1998, 172–3), the only way to make mechanistic explanations final, that is, to construct them in a way to avoid new unanswered questions or black boxes,

²⁵ The irreducibility of some social phenomena to the level of individuals is, according to Sawyer (2004, 266–9), due not only to *emergence* (higher-order properties not fully explicable by lower-order properties), but also to *supervenience* (the relation of higher-order properties to specific configurations of lower-order properties). In particular, two forms of supervenience are of relevance: *multiple realizability* (same higher-order properties produced, each time, by disparate combinations of lower-order properties), and *wild disjunction* (multiply realized lower-order properties that are not systematically related and yet produce the same higher-order properties). In all cases in which higher-order phenomena cannot be reduced to lower-orders, they possess equal causal efficacy as the one attributed to individual actions, or what Sawyer calls *supervenient causation* (p. 269).

is to resort to rational choice theory. This insistence on rational choice has been so consistent that many critics associate the mechanistic approach with this very particular theory of action (e. g., Abbott, 2007; Gorski, 2009). Not surprisingly, others have made similar strong cases in combination with social mechanisms for other theories of action. For instance, Hedström (2005, ch. 3) favors the DBO theory and Gross (2009, 366–9) a pragmatist theory of action.

So it seems like the discussion on social mechanisms has been, perhaps inadvertently, instrumentalized to fight numerous theoretical struggles not directly related to the mechanistic approach and, above all, not new in sociology.²⁶ Following this line of thought, Norkus (2005, 351) has pointed out that the discussion on mechanisms is but the mere reproduction of old debates in sociology and the social sciences in general, a restatement of known theoretical and methodological oppositions under a new “mechanistic talk.”²⁷ This is particularly evident in the discussion on individualism and holism, reductionism and hierarchies, and theories of action, topics that can be traced back to the beginnings of the discipline and are present in all major sociological works.²⁸

In short, defining away the discussion on the nature of social mechanisms by simple importing categories from other sciences will not do. Equally vain is the conflation of particular theoretical preferences with the definition of mechanisms, something which, at best, reduces the mechanistic approach to mere “mechanistic talk” that has no substance at all (Norkus, 2005).

Uncertainty about identifying, modeling, and testing social mechanisms. The ability to formulate mechanism-based explanations assumes that mechanisms are known, representable in some intelligible way, and empirically testable. The question thus arises: are there any methodological particularities that may be important to bear in mind in discovering, modeling, and testing mechanisms?

The mechanistic program in cell biology and neuroscience, as discussed in **Section 1.1**, offers an instructive example of how these three stages of mechanism-based research can be carried out.²⁹ To begin with, and before starting with the

²⁶ Still more theoretical and methodological oppositions in the mechanism debate in social sciences are discussed in Gerring (2007).

²⁷ Norkus makes this remark quoting the fractal theory of the evolution of scientific ideas proposed by Abbott, according to which disciplinary struggles around new ideas unfold in way that can be described as a “fractal distinction,” that is, the reproduction of existing oppositions along the same lines but using a new terminology or simply extended to a new context (Abbott, 2001, 10–15).

²⁸ For a general review of methodological individualism in social sciences, see Udehn (2001); a similar review on holism can be found in Phillips (1976).

²⁹ The text here provides a deliberately oversimplified account of the issues of discovery, modeling, and testing of mechanisms in neuroscience and cell biology and should be read merely as an illustration of what are meant to be methods for mechanistic research. More detailed discussions can be found in Bechtel (2006) and Craver (2007).

modeling, scientists in these disciplines must first *discover* mechanisms. This is usually done by observation and experimentation (Machamer, 2004, 28; Bechtel & Abrahamsen, 2005, 435), which primarily consists of localizing and identifying the constitutive parts of mechanisms (structural decomposition), their respective functions (functional decomposition), the interaction of both parts and functions, and the outcomes they produce (Glennan, 1996, 64; Bechtel & Abrahamsen, 2005, 432–6).

Once unveiled, the configuration of parts and functions, components and operations, or entities and activities (depending on the definition used; see **Table 1.1** in the previous section) that constitute a mechanism can then be represented or modeled in three different ways (Bechtel & Abrahamsen, 2005, 426ff.): (i) using a linguistic or propositional description of how mechanisms function; (ii) graphically representing parts, functions, and their interaction with the help of diagrams;³⁰ or (iii) recreating the system based on mathematical models and computer simulations. After choosing an appropriate model to represent mechanisms, their functioning can then be tested, usually through experimentation (Machamer et al., 2000, 17; Bechtel & Abrahamsen, 2005, 436–7), and the model can then be corrected if necessary. Finally, as Bechtel and Abrahamsen (2005, 436) point out, testing hypotheses resulting from a mechanistic model is no different from testing any other type of hypothesis, law-like or otherwise; it should follow the same rules and avoid the same pitfalls of confirmation and falsification as it is standard practice in science.

In sociology, these same three stages of mechanism-based research—identification, modeling, and testing—may not work in as straightforward as they do cell-biology and neuroscience. While the task of defining social mechanisms has received the most attention in the sociological debate on mechanisms and mechanistic explanation, methodological issues have, as Mayntz (2004, 256) puts it, been “sadly neglected”.

(i) *Identification*. So far, the methods used in mechanism-related sociological research are very diverse, and, in contrast to the natural sciences, usually non-experimental. That experimentation is not that common in sociology has certainly nothing to do with social mechanisms in particular; rather, its rarity is a consequence of the general difficulties and ethical restraints imposed on sociological experiments by the very object of study. Moreover, social mechanisms,

³⁰ As Machamer et al. (2000) remark, a diagrammatic representation of mechanisms is most commonly chosen. A diagram of a mechanism displays some setup or initial conditions, intermediate stages showing the functioning of the mechanism, and termination conditions indicating the production of a certain output (pp. 8–13). Two types of mechanism diagrams may be distinguished: a *mechanism schema* or a complete model of the functioning of a mechanism based on known properties and activities, and a *mechanism sketch* or a simplified and incomplete representation of a mechanism that contain black boxes or unknown properties and activities yet to be found (pp. 15–8).

however defined, are far from those dissectible objects that Glennan (1996, 2002), Machamer et al. (2000), Bechtel and Abrahamsen (2005), and Craver (2007) work with in their laboratories.

As to the diversity of methods associated with the identification of mechanisms, nothing different could have been expected given the numerous approaches to social mechanisms that have been taken and the highly disparate fields in which researchers are currently seeking such mechanisms. For instance, McAdam, Tarrow, and Tilly (2008, 310–11) have recently worked out a battery of four different types of methods to measure the presence or absence of mechanisms in the field of “contentious politics,” combining analytic tools that are both quantitative (e. g., statistical analysis) and qualitative (e. g., field ethnographic methods). Others like Steel (2004, 67–75) advocate “process tracing” as a qualitative way to uncover causality and mechanisms by sorting out spurious from valid causes and preparing the groundwork for statistical analysis. Still others, like Hedström (2005, ch. 6), champion the use of agent-based modeling or computer simulations.

In keeping with Gerring (2007, 171–3) and his recent review of the methods employed in mechanistic research in social sciences, the conclusion may be that the search for social mechanisms does not call for, nor is necessarily bound to, any particular methods beyond those quantitative and qualitative tools already being used in those same research fields that are now turning to mechanism. This should not imply that it is impossible or undesirable to develop methods tailored to the discovery of social mechanisms; these, however, have not yet been devised.

(ii) *Modeling*. After the social mechanisms have been identified, the next step is to represent their functioning, something on which the assumed definition of social mechanisms has no bearing at all. Indeed, because of their generality, the three alternatives discussed by Bechtel and Abrahamsen (2005)—propositional or linguistic descriptions, diagrammatic representations, and mathematical modeling combined with computer simulations—pretty much exhaust the possibilities of modeling any of the approaches to mechanisms discussed in sociology. There are, however, some differences among these three ways of representing mechanisms that may be important to bear in mind. According to Bechtel and Abrahamsen (2005, 428–32), diagrams are better suited than propositional descriptions to represent space, time, and the interconnectedness of various parts and functions of mechanisms. In addition, diagrams are much more intuitive to grasp than linguistic descriptions and thus advantageous for expositional reasons; they are, nonetheless, static pictures unable to show the dynamics of the mechanism and fairly limited when representing complex systems. Putting aside the possibility of animating diagrams, which would allow them to depict movement, representing both dynamics and complexity may be achieved most appropriately by means of mathematical modeling and computer simulations.

All this considered, diagrams may be preferable to linguistic descriptions to represent social mechanisms, unless of course dynamics are relevant or complexity is too high, in which case mathematical models and computer simulations may be the right modeling strategy. This conclusion may seem trivial, since this is what has already happened in sociology anyway: not only is the use of diagrams widespread, but some central figures in the discussion on social mechanisms, like Hedström, are making a plea for the use of computer simulations (e. g., Hedström, 2005, ch. 6).³¹

(iii) *Testing*. The last step in mechanism-based research is testing. Here, as in the natural sciences, the discussion can be kept short. In one word, there is no reason why testing mechanisms may differ from testing any other causal hypotheses. A model of a mechanism is simply a list of prepositions about social phenomena and as such may be tested in exactly the same way as other theoretical prepositions are usually tested.

To sum up this discussion on the methodological aspects of social mechanisms it can be said that first, there is no reason to bind the identification of social mechanisms to specific methodological tools; second, the best way to formally represent mechanisms may be diagrammatically, although dynamics and complexity may call for mathematical models and computer simulations; and third, the methods used to test hypotheses about mechanisms are the same as those used to test any other hypotheses. Thus, apparently, only the modeling of mechanisms poses an additional methodological challenge; the other two stages of mechanism-based research—identification and testing—seem to rely on the methodological practices already being used in sociology.

1.3 Taking stock: why and how mechanisms in sociology?

After reading the foregoing section on the difficulties of introducing mechanisms and mechanistic explanations into sociology, one may wonder about the pertinence of a mechanistic approach to the study of social phenomena in the face of its current fundamental shortcomings: there is no consensus about what mechanisms are or what their distinguishing characteristics are; no specific methods have been devised to identify or test them that differ from the ones already used in sociology; a covert programmatic character of mechanistic theorizing seems to be at work, furtively serving theoretical interests of particular authors and inadvertently reproducing old debates. All these things considered, it is difficult

³¹ For a review of the past, present and prospects of computer simulations as a methodological tool in sociology see Halpin (1999). See also **Chapter 4** and **Chapter 5** of the present study for examples of simulation-based modeling of social mechanisms.

to disagree with Norkus (2005) in the suspicion that the mechanistic approach to sociology has turned into innocuous “mechanistic talk,” barely accounting for something substantially new to address the issues it has set out to solve.

In view of these criticisms, it may seem rather adventurous to blindly vindicate the optimism shared by Elster, Hedström, and other champions of the mechanistic approach about the novelty and advantages of social mechanisms and mechanistic explanations in sociology. Instead, a more cautious position will be taken, one that focuses on core, substantive aspects of the mechanistic approach that can be safely defended irrespective of individual theoretical orientations. In the process of presenting this position, the two questions raised at the beginning of this chapter will be answered.

1.3.1 Which are the advantages of adopting a mechanistic approach?

Let us recall the alleged advantages of a mechanistic perspective in sociology as contended by Elster and Hedström: (i) making causal inference more reliable by minimizing the risks of spurious correlations, confounders, and endogeneity; (ii) improving causal explanations and deepening our understanding of social phenomena by abandoning laws and making explanations more transparent; and (iii) favoring interdisciplinary work, reducing theoretical fragmentation, and overcoming empiricism and the search for grand theories by concentrating on theories of some middle level of generality. In short, mechanisms and mechanistic explanations may improve the quality of causal inference, explanation, and theorizing in sociology.

As discussed in **Section 1.1**, the claims made based on the first of these alleged advantages (i) are highly contested issues in the philosophy of science. A mechanistic theory of causation seems to be limited in scope and not clearly superior to other ways of understanding causality, such as manipulation or counterfactual theories. It is also unclear to what extent the use of mechanisms can solve the problems of causal inference, making the risks of spurious correlations, confounders, and endogeneity disappear. After all, the search for mechanisms is as exposed to the methodological pitfalls that attend correlational analysis as any other attempt to uncover causality using statistical methods.

So leaving aside (i), the most plausible promises of the mechanistic approach appear to be the alleged advantages (ii) and (iii), that is, respectively, providing deeper explanations than those derived from law-based explanations, thereby improving our understanding of phenomena, and making theory building in sociology more productive and interdisciplinary by doing away with variable-based sociology and the search for grand theories. However, without being clear

about what a mechanistic approach exactly encompasses these promises are simply that, promises. This conclusion leads to the next question.

1.3.2 Which are the core elements of the mechanistic approach and how should they be put into practice?

Perhaps the most effective way to protect the mechanistic approach from its critics would be to show that beyond reproducing old debates, and on top of any particular assumptions made by different authors writing on social mechanisms, there still is a core of elements that positively identify the mechanism-based agenda and clearly distinguish it from other forms of theorizing and conducting sociological research.

As I will argue next, after extensively reviewing the literature on mechanisms and social mechanisms, there seem to be two alternative ways to characterize the mechanistic approach in sociology in a distinctive and substantive fashion. The first may be called a mechanistic approach *without* mechanisms and consists of thinking about mechanism-based research as a 'style of theorizing' committed to some principles of how to conduct research and develop theory. Such a solution is 'without mechanisms' because it is not necessary to define social mechanisms beyond a loose metaphor. By contrast, and articulating those same principles, a second alternative insists on the existence of social mechanisms, which implies that a mechanistic approach be considered not simply a metaphor signaling the commitment to some principles, but that social mechanisms be conceived of as distinguishable and existing phenomena. In this latter case, the mechanistic approach is not just a style of theorizing but rather the consequence of taking seriously the existence and prevalence of those very concrete parts of social reality, namely the mechanisms, that *call for* a style of theorizing. Only this second alternative requires a definition of social mechanisms.

After the two alternative approaches to a mechanistic agenda in sociology have been presented, a few words about the appropriate methodological tools to identify, model, and test social mechanisms will be offered before closing this chapter.

A mechanistic approach without mechanisms In his most recent publication, and after having provided a total of three different definitions throughout his works, Peter Hedström seems to have given up the whole project of defining social mechanisms. As though in despair, or simply realizing the philosophical difficulties that would have to be overcome in order to provide a positive account of social mechanisms, he concludes by withdrawing into the safety of his analytical sociology: "The key to future progress is the development of good exemplars of analytical sociology rather than, say, engaging in debates about the proper defini-

tion of mechanism" (Hedström & Ylikoski, 2010, 64). Surprising as it is that this claim comes from the very champion of the mechanistic approach in sociology, it shows how hopeless it seems to many, like Hedström himself, to find a quick fix for the introduction of mechanisms into sociology. In addition to that, it also confirms the suspicion that for Hedström the plea for mechanisms was nothing more than a prelude to, and a subordinate concept in his analytical sociology.

This reticence to define social mechanisms can be understood only if we take seriously Hedström's final remark, which can be found in one of his first and most quoted articles on mechanisms. There he contends that "[...] the essence of the mechanisms approach is to be found in a special *style of theorizing* rather than in any specific definition of what a social mechanism is" (Hedström & Swedberg, 1998b, p. 25; italics in original). To be sure, those principles Hedström is referring to are his own principles of analytical sociology: middle-range puzzles as well as action-based, abstract, and fine-grained explanations (Hedström & Swedberg, 1998b, 24–5). However, and irrespective of which principles are chosen, the idea of conceiving the mechanistic approach to sociology as a "style of theorizing" is a very clear statement. It resolves the confusion surrounding the definition of social mechanisms. Indeed, according to this view, social mechanisms *cannot* be defined simply because they are not a part of the social reality, they are not social phenomena *sui generis*, but a *metaphor* used to designate the commitment to some principles of conducting social research.

How can those principles be described without having to endorse Hedström's very particular approach to analytical sociology? As I argue next, the answer to this question consists of a bundle of three principles: deeper causal explanations, generative causality, and middle-range theorizing—all of which are implicit in the discussion on social mechanisms and mechanistic explanations. Of these three, only the first fully coincides with Hedström's idea of fine-grained explanations. The third one, middle-range theorizing, is partially compatible with Hedström's middle-range puzzles, but as will be seen, only partially. The second one, generative causality, is constitutive to the very idea of mechanism. To be clear what is here meant by these three constitutive elements of a mechanistic perspective in sociology, a short description of each will be provided, as follows.

(i) *Causal explanations*. The main thing driving the mechanistic approach to sociology is the conviction that improving the quality of causal explanations is the ultimate goal of sociology and the best way to deepen our understanding of social phenomena. This is to be achieved by formulating fine-grained explanations, or explanations that explicitly show how phenomena come about. The opposite of those explanations are "black boxes" or incomplete ways to explain these phenomena.

To be sure, explaining social phenomena is by no means the only possible approach to sociology. Reiss (2007, 171–3) is right when he criticizes the neglect of other relevant goals of social science, such as prediction or description, when promoting such narrow goals for sociology as improving causal explanations. However, this emphasis found in the mechanistic approach should best be understood, as Brante (2008) remarks, as *ultimate* and not as unique. The formulation of deeper causal explanations leaves room for other important aspects of sociology, like description or prediction.

Moreover, not only is it true that explanation must not necessarily be the goal of sociology, but explaining itself need not be causal. Committing to causal explanations puts the mechanistic approach nearer to the nomothetic, positivistic tradition in the social sciences, opposing it most directly to the ideographic, hermeneutical (*verstehende*) approach but also to the teleological tradition of functionalism (Bunge, 1997, 411–4).³² To say that the type of causal explanation championed by the mechanistic approach is rather positivistic does not imply a full commitment to other principles regarded as positivistic such as methodological monism or the belief in the existence of laws of nature (von Wright, 1971, 9). In fact, the mechanistic approach is fighting the positivistic or neopositivistic practice (as the covering-law model is labeled) of using laws to explain social phenomena, advocating instead for deep, transparent, and fine-grained causal explanations that show how social phenomena come about.

(ii) *Generative causality*. The commitment to transparent causal explanations calls for a deeper understanding of causality. As discussed in **Section 1.1** on the philosophy of mechanisms, even though mechanisms are not wedded to a specific theory of causation, they are consonant to a generative or productive understanding of causality that is diametrically opposed to Humean-type causation (constant conjunction).³³ In other words, according to the mechanistic approach, cause and effect are not merely cojoined, as correlational analysis suggests; rather, causes actively *produce* or effectively bring about their effects.

It is important to observe that a generative view of causation is defined without making any reference to mechanisms. In particular, and as mentioned already in **Section 1.1**, a generative view of causality is independent of a mechanistic theory of causation, which claims that a cause produces an effect *only* through a mechanism (cf. Glennan, 1996, 2002).

³² For a summary of the main traditions in social scientific explanations see von Wright (1971, ch.1).

³³ Goldthorpe (2001) offers a thorough justification of the advantages of generative causality over alternative views on causation in sociology. For a short history of causality in sociological research, see Abbott (1998). A comprehensive collection of articles surveying the most relevant conceptions of causality in philosophy and science, in both the natural and the social sciences, can be found in Beebe et al. (2009).

(iii) *Middle-range theorizing*. On top of causal explanation and generative causation, the mechanistic approach seems to advocate a type of theorizing that closely resembles Merton's idea of theories of the middle range. The reason for this affinity to Merton is not because of the limited generality of mechanistic explanations, as many argue, but rather because of their potential use as building blocks for more general theories.

In his widely quoted article of 1949, Robert Merton (1965) defines middle-range or special theories as those theoretical generalizations which are "intermediate to general theories of social systems [...] and those detailed orderly descriptions of particulars that are not generalized at all" (p.39); moreover, they "enable us to transcend the mock problem of a theoretical conflict between the nomothetic and the idiopathic, between the general and the altogether particular, between generalizing social theory and historicism" (p. 44).

Normally the references found in the literature on social mechanism about middle-range theories stop here, suggesting that theories of middle range or limited scope of generalization are ends in themselves, making it undesirable to move further in the direction of greater levels of abstraction or grand theories (e. g., Hedström & Ylikoski, 2010, 61). However, that is not quite the complete story. Indeed, Merton's criticism is not directed against grand theories *per se*, but rather against *prematurely* attempting to produce such theories without having provided the pertinent building blocks. For this preparatory work he envisions middle-range theories arguing for "a developmental orientation" (p.50), compelling sociologists to "look [...] toward progressively comprehensive sociological theory which [...] gradually consolidates theories of the middle range, so that these become special cases of more general formulations" (p.51). To fulfill this task, middle-range theories must be compatible with different general theories (p. 43). His conclusion is worth quoting in full:³⁴

"Which shall have the greater share of our collective energies and resource: the search for confirmed theories of the middle range or the search for an all-inclusive conceptual scheme? I believe—and beliefs are of course notoriously subject to error—that theories of the middle range hold the largest promise, *provided that* the search for them is coupled with a pervasive concern with consolidating special theories into more general sets of concepts and mutually consistent propositions" (Merton, 1965, 52, italics in original).

Hence Merton is not pleading solely for the search for special theories of middle scope to replace the formulation of very general theories; instead, he is making a case for the articulation of such grand theories *based* on middle-range theories.

³⁴ All these quotes are needed, because it seems like many authors who refer to Merton when discussing social mechanisms have omitted these very central passages, thus changing the whole notion of middle-range theories to mean theories of narrow scope without any reference to more general theories.

It is not difficult to see how Merton's criticism to the premature formulation of grand theories resembles the criticism to the search for laws behind the mechanistic approach. It is also easy to imagine the role of mechanistic explanations in Merton's bottom-up strategy of theory building. Mechanism-based explanations could be those special theories of limited scope compatible with different general theories of society; they are indispensable to be used as building blocks, articulating and gradually constructing those general theories.

In a nutshell, a mechanistic approach *without* mechanisms is nothing more than the commitment to three core principles: transparent and deep causal explanations, generative causality, and middle-range theorizing. To be sure, these ideas existed before the mechanistic approach bundled them under a single name and have been pursued in the past without any reference to social mechanisms.

A mechanistic approach based on mechanisms: a core definition of mechanisms. Besides endorsing the principles mentioned, and Hedström's opinion notwithstanding, defining social mechanisms still is the logical, if not fundamental, first step toward conducting mechanism-based research. Then, how can we explain social phenomena and construct theories labeled "mechanistic" without committing to the existence of social mechanisms?

The need for a minimal consensus about the definition of social mechanisms is justified by Gerring (2007), after thoroughly reviewing the literature on social mechanisms, as follows: "[...] for general methodological purposes it is important that a key word like mechanism be employed in a recognizable fashion. There must be some degree of consensus; otherwise, the term serves to confuse, rather than clarify, methodological issues—as has happened, arguably, over the past several decades of this term's ascendance" (p. 178). What Gerring pleads for is a "core definition," a common starting point about the nature of mechanisms from which specific approaches or sub-types can eventually be derived or 'branched out' by means of additional assumptions.

But, one may ask, how do we formulate a core definition of mechanisms without making problematic ontological assumptions and, at the same, avoiding the shortcomings of previous definitions in being unclear about their underlying ontology? In other words, how do we describe a social mechanism without referring in any way to systems, processes, individual actions, or any other particular social ontology used in the literature to define social mechanisms and nonetheless provide a clear account of the nature of social mechanisms? Simply adhering to an existing definition of mechanism would certainly not do, since most of these definitions seem to carry additional accessory assumptions that merely reflect the theoretical or methodological preferences of the authors who advocate them.

A pragmatic solution to this definitional problem was recently suggested by Demetriou (2009). While his argument most directly refers to the branch of the philosophy of science known as critical realism, the solution he suggests can be restated in more general terms so as to be applied to the reception of mechanisms in sociology as a whole.³⁵ According to Demetriou (2009), two different research programs may be developed around the notion of mechanisms as actual existing phenomena from a philosophical, critical realist perspective (pp. 447–51): a *strong program* with the goal of articulating a complete ontology of mechanisms and the social world, and a *weak program* committed to explain concrete social phenomena using mechanism-based models but refraining from any discussion about the ontology of mechanisms as real phenomena.

Demetriou is suspicious of both programs. While he fears that a strong program may compromise the credibility of any premature reference to social mechanisms if it takes too long to fully materialize, a weak program alone without any clear ontology may most likely run astray of the very idea of the existence of mechanisms. In view of this dilemma, he advocates for a pragmatic middle course that reconciles the limitations of both the strong and the weak programs (pp. 456–7). Accordingly, the strong program should be pursued and the formulation of a complete ontology of the social world and of social mechanisms should remain the chief goal of the mechanistic program, although the results will not become evident right away; it is a long-run project. In the meantime, and oriented by that long-term commitment to the articulation of social ontology that includes mechanisms as a constitutive part, the weak program may further be advanced to inform research and explain social phenomena in terms of a *heuristic*.³⁶ Hence social mechanisms can safely be used in a loose, heuristic way to explain social phenomena until a full-fledged social ontology has been spelled out describing their real nature.

It is not difficult to see how Demetriou's solution can be extended beyond critical realism to solve the problem of defining social mechanisms in sociology. Taking sociology as a whole, the question is not how much mechanism-based research can be conducted without a fully developed ontology of the social world and of social mechanisms, but instead how can we make sense of mechanisms given the diversity of competing social ontologies available—e. g., individuals and their actions (Hedström, 2005), processes (Reskin, 2003), processes in systems (Bunge, 1997, 2004), parts of processes (Tilly, 2001), or entities in systems (Gorski, 2009). For, taken as a whole, the problem of the mechanistic approach in sociology is not the lack but rather the abundance of ontologies underlying so-

35 For a general overview of critical realism see Archer, Bhaskar, Collier, and Lawson (1998).

36 Following Kuorikoski (2009), a heuristic can be defined as “an informal method or rule of thumb for how to carry out research in some loosely defined context” (p. 146).

cial mechanisms. To be sure, the middle course traced by Demetriou for critical realism still applies to each of the distinct social ontologies taken separately. Put differently, to say that there are many ontologies does not exclude the possibility that each of them is still underdeveloped, as Demetriou contends in the case of critical realism.

The middle way charted by Demetriou as a critical realist approach to mechanisms reconciled the lack of a clear ontology of mechanisms with their use as a heuristic for explanatory purposes. This approach can be restated to apply to sociology in general as follows. Since there is more than one ontology of the social world and of social mechanisms, the possibility of reaching an agreement about the nature of social mechanisms is remote; on the other hand, given that a weak program alone, with no clear ontology, may run astray of the very idea of the existence of mechanisms, a middle course may be taken to find a core definition of mechanisms that can be used irrespective of single ontologies. Accordingly, while everyone is free to choose and develop any particular ontology of the social world and of social mechanisms, a heuristic conception of social mechanisms is needed that will inform research that is independent of ontological controversies or, by the same token, research that is compatible with different social ontologies.

Understood in these terms, a heuristic definition of social mechanisms is not merely a pragmatic solution to overcome the immature stage of any particular social ontology but a way to cope with the theoretical plurality of sociology without having to give up the whole project of defining social mechanisms, as Hedström has suggested with his mechanistic approach as a “style of theorizing.” Thus, the question of whether mechanism *are*, for example, constellations of individuals and their actions, processes, processes in systems, parts of processes, or any other ontological category, must not be answered prior to introducing a heuristic definition of social mechanisms. Needless to say, as Demetriou (2009, 457) points out, the strong program or formulation of an ontology of social mechanisms should be pursued further and orient such a heuristic perspective until agreement concerning an ontology has been achieved. The advantage of this strategy is that mechanisms may continue to be used as a concept to inform and orient research irrespective of the controversies over ontological issues.

But how should we define social mechanisms as a heuristic? For Demetriou (2009), an “explanatory mechanism” is “the concatenation of (pertinent) outcomes, [i.e.] the way the outcome combines with other outcomes to account for an explanandum” (p. 458). In other words, a (model of a) mechanism is the combination of outcomes explaining some phenomenon. Demetriou’s definition is fairly general, capturing some core characteristics of social mechanisms and displaying some other desirable characteristics:

- The exact nature of “outcomes” is indeterminate and deliberately ambiguous. This makes it flexible enough to allow for different theoretical underpinnings and social ontologies and distinguishable enough to capture the intuition about mechanisms.
- It avoids making problematic ontological assumptions. In fact, only one ontological assumption is implied by this definition, namely that regular phenomena exist that can be described as the result of the concatenation of outcomes or mechanisms.
- The idea of concatenation captures two defining characteristics of social mechanisms: they exhibit some extension in time and consist of more than one intermediate step or more than one single outcome (Mayntz, 2004, 242; Gross, 2009, 362).
- The principles underlying the inner workings of mechanisms must not be defined. Demetriou accepts that outcomes constituting mechanisms may be the result of other mechanisms. This distinction, however, may or may not be of explanatory relevance and thus need not be spelled out in order to identify a mechanism.

Demetriou does not mention any of the other characteristics that are usually attributed to mechanisms as found in the literature on social mechanisms and discussed by critical realists themselves (Gorski, 2009). This is understandable not only because he is mainly concerned with the use of mechanisms as a heuristic, but also because he counts on the “strong program” yet to be completed to deliver precisely that complete characterization of the nature of mechanisms. It is evident from this short discussion that without the orientation of a strong program, that is, without some further substantive ontological premises about the nature of mechanisms, an heuristic definition sounds vague and incomplete. However, anyone who is not acquainted with any particular social ontology may understandably find such a heuristic definition too oversimplified to guide research. In view of this plausible objection, a further question arises: is it possible to elaborate on Demetriou’s heuristic definition in order to gain more substance without losing generality or making problematic ontological assumptions? I believe it is.

Even if the different social ontologies used to describe mechanisms are not fully compatible (e. g., Elster’s individualism and Bunge’s systemism), there may be some very basic additional features attributable to mechanisms that are not at odds with any particular ontological position on social phenomena yet help clarify what is meant by this concept. Arguably, and after reviewing the literature on social mechanisms, including summary articles, there are four core characteristics of mechanisms that everyone seems to agree upon. (1) the idea that mecha-

nisms *produce* an outcome; (2) the condition that mechanisms are recurrent, that is, they produce that same outcome more than once; (3) their functioning is contingent upon some initial conditions; and (4) they are robust despite changing conditions. It is true that if these elements are added to Demetriou's definition of explanatory mechanisms, it could no longer be regarded as purely heuristic. Instead, the resulting definition would be a kind of 'enriched heuristic,' keeping its generality and its compatibility with different ontologies of social phenomena but at the same time including some minimal substantive ontological assumptions about the nature of mechanisms that seem to be shared by most sociologists and philosophers who have contributed to the debate on mechanisms and providing a more precise characterization of the type of phenomena social mechanism are supposed to be.

These four substantive characteristics of mechanisms mentioned are addressed by Mayntz (2004) in her account of social mechanisms. She defines mechanisms as "recurrent processes linking specified initial conditions and a specific outcome," or as "sequences of causally linked events that occur repeatedly in reality if certain conditions are given" (p. 241). Compared with Demetriou's heuristic definition, Mayntz's account of social mechanisms is more explicit about a basic ontology of mechanisms (pp. 241–5). First, the idea that the mechanism is *producing* the outcome, hence the notion of generative causality, is more evident. Second, mechanisms are characterized as recurrent phenomena; they are not unique or contingent, but regularly occurring.³⁷ Indeed, as others have already remarked, referring to mechanisms as unique sequences of events would reduce them to "story-telling" (Elster, 2007, 21; Hedström & Swedberg, 1998b, 10). Third, Mayntz stresses that outcomes produced by a given mechanism are contingent upon different initial conditions and other possible intervening causes affecting the same outcome, including interactions with other mechanisms. This implies, on the one hand, that the functioning of mechanisms cannot be separated from their initial conditions or other intervening factors. Contingency in the functioning of mechanisms is an important difference between them and laws. As Gorski (2009, 182) explains, mechanisms differ from laws not so much in their generality, but rather in the variability of outcomes they produce as a result of changing conditions and interaction with a complex reality. A logical consequence of this argument is that in very simple or closed systems, where conditions are stable and interaction with other factors is limited or otherwise predictable, a mechanism would behave exactly as a law, always producing the same outcomes. Fourth, and as a consequence of the previous point, contingency poses a minimal stability assumption on the structure of a mechanism. Hence,

³⁷ Demetriou (2009) also mentions this issue. However, these are properties of 'real' mechanisms and should not be included in a heuristic definition. In fact, robustness is for him an empirical question: "[...] the more such concatenations show regularity, the more reason we will have to suspect that real mechanisms are involved" (p. 459).

mechanisms not only preserve their structure in the face of changing conditions, but also consistently bring about a certain outcome provided conditions remain stable. Although Mayntz does not use any label to refer to this property, one could think of it as *robustness*.

One may wonder about the advantage of elaborating on Demetriou's definition given Mayntz's more substantive definition. After all, her description of the nature of mechanisms seems to be everything that is needed to improve Demetriou's heuristic account of mechanisms. The reason not to adopt Mayntz's definition is fairly simple: she uses the concept of *process*, a specific social ontology, as part of the definition. While loosely describing mechanisms as processes is intuitively appealing and has already been done in the philosophy of science (e. g., Glennan, 2009, 323; Salmon, 1984), the concept of process may be far more complex than Mayntz's definition of "sequences of causally linked events" suggests (Rescher, 1996). Moreover, given that the chief goal of formulating a core definition of mechanisms is precisely to avoid making compromises with any particular social ontology, the inclusion of the concept of 'process' in the definition is likely to preclude alternative ontologies that are not directly compatible with processes. In other words, although it is entirely valid to use a process ontology to describe the nature of social mechanisms, processes need not necessarily be included in a general definition meant to be broad enough to accommodate different ontological categories and not limited to any one of them.

By combining the convenient ambiguity of Demetriou's heuristic definition with the four core substantive ontological elements described in Mayntz's work, it is possible to formulate an enhanced core definition of social mechanism as *a robust and recurrent concatenation of outcomes that, given certain initial conditions, causally produces the explanandum*. This definition exhibits the following characteristics:

1. *Minimal ontological assumptions*. While the definition is not strictly heuristic, it makes only a few ontological assumptions that should not be at odds with any particular social ontology. In addition to accepting the existence of mechanisms as regular phenomena with some extension in time, the definition includes only four basic properties of mechanisms: generative causality, recurrence in time, dependence on initial conditions, and robustness to these conditions. These four properties provide more substance about the nature of mechanisms than a simple heuristic can.
2. *Open-endedness*. The idea of 'concatenation of outcomes' is deliberately ambiguous and open to additional assumptions or interpretations. It may be qualified as needed and used as place holder to be filled in or replaced with further substantive categories or additional theoretical assumptions. As

Gerring (2007) suggested, such general definitions can be “branched out” to include additional, more specific attributes. In particular, the definition can be elaborated in terms of regarding four different aspects:

- (i) *Exact nature of ‘outcomes’ and ‘concatenations of outcomes.’* Outcomes may be understood as any constituent of sociologically relevant phenomena thought to have any causal efficacy. This can vary depending on the theoretical preferences of researchers and may range from somewhat psychological categories, such as desires or beliefs, to individuals and their actions, or even to holistic social entities or components of processes or systems. Perennial controversies in sociology regarding, for instance, theories of action or individualism versus holism, are not addressed by the definition and must therefore be addressed in the form of additional assumptions. Accordingly, a concatenation of outcomes may be as diversely construed as structural configurations of individual actions (Hedström, 2005, 26), events changing some set of relations (Tilly, 2001, 25–6), processes in systems (Bunge, 1997, 414), or related entities within a system (Gorski, 2009, 157–66), just to mention a few of the different ontologies of social mechanisms discussed so far in the literature.
- (ii) *Principles underlying the inner workings of mechanisms.* Specifying the principles governing the inner workings of mechanisms may require resorting to laws (Elster, 1990, 7; Bunge, 2004, 196–7) or any other alternative mechanically irreducible principle such as those discussed in the philosophy of science (e. g., Machamer, 2004; Woodward, 2002). Alternatively, the question about the inner functioning of mechanisms can be assumed away by drawing upon discipline-specific stopping rules of mechanistic decomposition (Hedström, 2005, 25–6).
- (iii) *Generality and stability of mechanisms.* As it stands, the definition refers to robust and recurrent concatenations of outcomes producing phenomena. However, it is left open whether mechanisms are regarded as immutable or have the ability to change and evolve in time, and whether they are constrained to some spatial and temporal boundaries; in other words, the definition does not fix the temporal or spatial boundaries in which the robustness and recurrence of mechanisms hold true.³⁸ Similarly, the definition does not indicate how abstract and general or concrete and specific these concatenations of outcomes may be construed.

³⁸ Gorski (2009, 165–6), for example attributes to social mechanisms the properties of “mutability,” or the capacity to change and evolve, and “time-space dependence,” or their historical and geographical dependency.

- (iv) *Additional attributes.* Further properties attributed to social mechanisms that are also not fixed by the definition include, among others, observability, levels or hierarchies, and interactions between mechanisms and between levels (Gerring, 2007; Gross, 2009; Hedström & Ylikoski, 2010).

The advantages of such an open-ended definition are many. First, the definition reflects a minimal consensus on the nature and core elements of social mechanisms, thus offering a solution to Gerring's concern about making the concept distinguishable.³⁹ Second, the reduced number of assumptions is compatible with alternative social ontologies that currently focus on the nature of social mechanisms as well as other theoretical issues already known in sociology such as levels or theories of action. This in turn does justice only to theoretical pluralism, allowing for a great degree of eclecticism, but also, in the spirit of middle-range theorizing, opening the door for the accumulation of empirical evidence based on mechanisms irrespective of particular theoretical orientations. Third, since the definition is deliberately incomplete, it forces sociologists who make use of it to be explicit about the additional theoretical assumptions they appeal to. In so doing, it prevents the mechanistic approach to sociology from being associated with inessential assumptions (e. g., methodological individualism or rational choice) and forces authors committed to those additional assumptions to be transparent about them.

Identifying, modeling, and testing social mechanisms. Beyond the definition of social mechanisms, still other issues regarding the identification, modeling, and testing of mechanisms must be addressed. However, and in order to keep these last remarks brief, there is nothing much that can be said about mechanism-based research that has not already been mentioned. The only particularities of mechanisms-based research may be the use of diagrams or computer simulations to represent mechanism. Aside from these two methodological particularities, no 'mechanism-based methods' of research have as yet been devised (or may be needed) that depart in any significant way from the methodological tools already used in sociology for causal analysis and causal inference, including both quantitative and qualitative methods.

³⁹ Gerring (2007) has a suggestion of his own on how to define social mechanisms in a minimal way. His definition is "the pathway or process by which an effect is produced or a purpose is accomplished" (p. 178). Although the definition captures some of the intuition about mechanisms, it does include some important elements like robustness, recurrence, or contingency to initial conditions.

1.4 Summary

Based on the review of both the philosophical and the sociological literature on mechanisms and mechanistic explanations, an essential difference between the two disciplines in the way they deal with the subject becomes evident. While philosophers are aware of and actively work to solve the deep metaphysical and epistemological complexities of characterizing mechanisms as objects *sui generis* that produce observed phenomena, some sociologists were quickly seduced by the idea of a mechanistic approach, and without knowing much about its existence in the social world, enthusiastically started preaching its virtues for solving various methodological and theoretical issues. The advantages of such an approach, their advocates allege, are many: resolving the pitfalls of causal inference; overcoming black-box, law-based explanations and replacing them with deep, transparent, fine-grained explanations; and making theorizing more productive than mindless variable-based sociology or fruitless efforts to formulate grand theories by generating theories of narrow scope that reduce theoretical fragmentation and encourage interdisciplinary work.

However, the initial enthusiasm toward mechanisms in sociology seems to rest on a rather shaky foundation. The discussion has degenerated into vacuous “mechanistic talk,” one that reproduces old theoretical and methodological debates and serves individual programmatic interests without being conclusive about the nature of the very phenomena it is trying to call attention to or the distinct character of the approach it is promoting. This is why the controversy surrounding the definition of mechanisms is still far from settled. Most advocates of mechanisms in sociology are sailing without a map, or rather are using an old map to sail in uncharted waters: the definition of social mechanisms is chiefly couched in terms of known jargon or along the lines of long-standing theoretical oppositions in sociology. The paradoxical fact that widespread support for the advantages of a mechanistic perspective coexist with equally widespread confusion about the nature of social mechanisms best summarizes what the mechanistic approach to sociology has become.

To be able to give credence to the promises of the mechanistic approach and to justify the introduction of mechanisms into sociology, a clear characterization of such a perspective is needed. The two alternatives devised in this chapter are intended to give the mechanistic approach the substantive foundation it desperately needs. The first alternative, a mechanistic approach *without* mechanisms, is conceived as a ‘style of theorizing.’ According to this view, more than defining mechanisms, the most crucial element of the mechanistic approach is the commitment to deeper and more transparent causal explanations, generative causality, and middle-range theorizing. The second alternative goes one step further by in-

sisting that a mechanistic approach in sociology should be committed not only to a 'style of theorizing,' but also to an ontology of social mechanisms. To this end, an open-ended, minimal definition of social mechanisms, an 'enriched heuristic,' was provided. According to this definition, social mechanisms are *robust and recurrent concatenation of outcomes that, given certain initial conditions, causally produces the explanandum*. The mechanisms are attributed a core set of characteristics—extension and recurrence in time, generative causality, and dependence on and robustness to initial conditions—while at the same time leaving enough room for further elaborations depending on the preferred social ontology. In the present work, the second alternative is followed. Therefore, the challenges are not only to define 'closure' in a way that complies with the principles of causal explanations, generative causality, and middle-range theorizing, but also to identify those processes, that given initial conditions, causally bring about inequality across contexts.

II. Defining social closure

Chapter 2

Weber's definition of closure

The condition that is needed to use closure as a social mechanism to explain social inequality is conceptual clarity. The present chapter takes the first step in this direction by reviewing Max Weber's original definition of closure in its two meanings as market closure and group closure.¹ The next chapter will elaborate on this concept, expanding the scope of closure while keeping its action-based character intact.

Given the widespread use of the concept of closure in inequality research, one could argue that discussing Weber's definition is redundant. However, the opposite is the case. The popularity of the concept and its use in both theoretical and empirical works have unfortunately been accompanied by conceptual inattention. The problem, pointed out over 30 years ago by Giddens (1980, 887) in a critical appraisal of the work of Parkin (1979), consists of ignoring the very distinction drawn by Weber between the collective efforts to close markets by excluding rivals from competition and the process of closing the group by erecting boundaries against outsiders. Some, like Parkin, have done this knowingly, claiming that market closure and group closure are the same processes (Parkin, 1980).² Others, mainly those working with the concept empirically, appear to have drawn selectively from Weber's writings on closure, using one of the two meanings of the word and ignoring the second meaning. For example, while some use the concept to denote closing the market (e. g., Weeden, 2002), others refer to closing the group (e. g., Brubaker, 1992; Macdonald, 1985), and still others merge both phenomena into one term (e. g., Elliott, 2001; Tomaskovic-Devey, 1993b). This is the reason why revisiting Weber's original definition is an important first step to avert further conceptual confusion.

1 This chapter can be found as part of a working paper in Cardona (2013a).

2 In Parkin's reply to Giddens' critical assessment of his *Marxism and Class Theory: A Bourgeois Critique* (Giddens, 1980), Parkin concludes: "It simply does not make sense to say, as Giddens does, that the attempt by one group to monopolize resources to the exclusion of another is a separate phenomenon from group closure against outsiders. They are merely different ways of saying the same thing" (Parkin, 1980, 892).

To begin with, a short summary of Weber's discussion on open and closed relationships will be provided (Weber, 1978, 43–6), in which the term closure is introduced to refer to closing group boundaries (**Section 2.1**). Next, a widely quoted fragment of his text on the economic relationships of organized groups will be commented on (Weber, 1978, 339–48), in which he describes closure as strategic collective efforts to neutralize competition, or market closure (**Section 2.2**). The two meanings of the word are illustrated with an example taken from the history of the professions (**Section 2.3**). The last two sections briefly discuss the possible interaction between group closure and market closure (**Section 2.4**) and some translation slips between the original German version and the English version are revealed (**Section 2.5**).³ The relationship between group closure and market closure will be further explored in **Chapter 4** using an agent-based model.

2.1 Group closure

A social relationship, regardless of whether it is communal or associative in character, will be spoken of as “open” to outsiders if and insofar as its system of order does not deny participation to anyone who wishes to join and is actually in a position to do so. A relationship will, on the other hand, be called “closed” against outsiders so far as, according to its subjective meaning and its binding rules, participation of certain persons is excluded, limited, or subjected to conditions (Weber, 1978, 43).⁴

The process of closing a relationship, Weber adds, may be driven by tradition, affectual bonds, or rational considerations.⁵ Thus, even if, for example, families, erotic relationships, or economic groups all draw boundaries against outsiders, the logic underlying the emergence of those boundaries varies. The numerous motives for relationships to be closed or open (traditional, affectual, or rational) combines with the wide range of collective phenomena subsumed by Weber under his concept of relationship to produce a myriad of possible conditions of participation (p. 45). At one end of the spectrum, formally constituted groups such

3 For the sake of precision and comparability, the English version of Weber's works referred to in the following pages (Weber, 1978) is the same as that used by Parkin (1979) and Murphy (1988).

4 Sørensen (1983) uses this same notion of open and closed relationships to discuss what he calls ‘closed positions.’ Closed positions, such as jobs with tenure, are those to which individuals have access only when the positions have been vacated by previous incumbents (p. 206). Although Sørensen's starting point is Weber's passage on open and closed relationships, the two definitions should not be confused. While Weber is referring to the emergence and permeability of group boundaries, Sørensen is interested in positions in organizations and the dynamics of vacancy chains in labor markets and educational systems.

5 While communal relationships (*Vergemeinschaftung*) refer to individuals held together by affectual or traditional bonds, associative relationships (*Vergesellschaftung*) describe individuals brought together by rational agreements or mutual consent (Weber, 1978, 40–2).

as private clubs may screen new members through formal membership rules attached to achieved or ascribed individual characteristics. At the other end, more diffusely bounded groups might be found, such as "a party rally to which the largest possible number has been urged to come" (p. 45).

In fact, closing a relationship in the Weberian sense, or, to use a more generic word, closing a group can be understood as a special case of the more contemporary notion of 'boundary making.' As Lamont and Molnár (2002) summarize, boundaries are not only drawn by clearly identifiable groups using formal or informal membership rules to keep unwanted non-members at bay as in the Weberian version; they might also be symbolic. Symbolic boundaries segregate individuals in diffusely defined categories, such as ethnicity or class, and are constantly renegotiated through ever changing patterns of interaction within and across boundaries.

2.2 Market closure

As well as in the discussion on group boundaries, Weber also uses the word 'closure' to designate the type of collective, exclusionary action practiced by groups when pursuing common economic interests. Compared to the process of drawing boundaries or group closure, which, Weber argues, might follow affectual, traditional, or rational motives, according to this second definition, 'closure' denotes rationally driven, economically motivated collective behavior. He describes this very particular form of economic action as follows:

One frequent economic determinant is the competition for a livelihood—offices, clients and other remunerative opportunities. When the number of competitors increases in relation to the profit span, the participants become interested in curbing competition. Usually one group of competitors takes some externally identifiable characteristic of another group of (actual or potential) competitors—race, language, religion, local or social origin, descent, residence, etc.—as a pretext for attempting their exclusion. It does not matter which characteristic is chosen in the individual case: whatever suggests itself most easily is seized upon (Weber, 1978, 341-2).

Hence, groups practicing market closure as a strategy for accumulating resources and economic opportunities may avoid the uncertainties and difficulties of becoming better competitors by redirecting their efforts to exclude adversaries from the competition altogether. Not surprisingly, as Weber points out, the best way to secure group-related preferential access to markets is by mobilizing the support of the state. This is the case with successful professionalization projects which grant a small circle of specialists, such as lawyers or doctors, the exclusive right to offer specialized services. It also applies to trade protectionism driven by

industry lobbying which excludes foreign competitors from domestic markets by means of prohibitive tariffs and restrictive non-tariff regulations.

This is not to say, however, that neutralizing competition from a particular group always requires the support of the state and the legal system. Excluding rival groups from the market can also be achieved through informal means such as bad publicity, as in the case of western medical practitioners calling alternative practitioners unscientific. It can also be done by other less subtle yet highly effective means such as those used by the Sicilian mafia to protect the territorial claims of their clients' businesses from unwanted competition (Gambetta, 1996, ch. 8). In any case, the crucial precondition for market closure practices is the existence of a group capable of collective action. To speak about closure practices of bounded groups not capable of concerted action would be to commit the fallacy of "groupism" (Brubaker, 2004). As Brubaker (2004, ch. 1) warns, not all groups or categorically bounded collectives, such as those defined along the lines of ethnicity and religion, can be assumed to act concertedly the way professional organizations or firms do when pursuing their common economic interests.

Although Weber provides some historical examples of market closure practices, such as professional organizations lobbying the state for the legal privilege to offer their services, he does not discuss in any detail the outcome of such acts of strategic exclusion of competitors. Complementing Weber's definition of market closure, two main outcomes can be expected to follow from a group acting collectively to exclude rivals from the market. First, closing the market should, by definition, lead to a new market situation where market participation is a function of group membership. To close a market is to change its allocation rules from a free-for-all contest where the best contender wins, irrespective of group membership to an administered competition in which some groups but not others, and certainly not all, have the privilege of participating. Second, and as consequence of the first, closing a market, if done successfully, should translate into a process of unequal accumulation of resources and economic opportunities favoring the excluding party at the expense of those against whom exclusionary action was directed. Market closure then produces both a closed market and intergroup inequality.

It is very important to note that Weber's second definition of closure refers to the act of collectively excluding competitors from the market and not to any of its two outcomes—a closed market or intergroup inequality per se. It would be misleading to assume that the mere existence of inequality in a market, for instance, the observed dominant position of one group compared to other groups, should always be attributed to closure practices, a confusion found in prominent works such as Murphy's theory of monopolization and exclusion (e. g., Murphy, 1988, 71–2). Just as a group may achieve a dominant position by disrupting compe-

tition, acting against the market through concerted exclusionary action directed against rival groups, it can also bring about the same result by being a better competitor and playing by the rules (Weber, 1978, 936–7). The same caveat applies to closed markets. The existence of a monopoly benefiting a group should not be taken at face value as evidence of market closure practices. Legally protected group monopolies may also result from broader societal processes which are to a large extent unrelated to the economic interests of the group enjoying the privilege. For example, even if the state passes laws to regulate certain occupational groups through exclusionary instruments such as licenses, the capacity of professional groups to influence the state cannot always be assumed to be the catalyst for such regulations (Adams, 2008). Moreover, a closed market might also be the result of group-related discrimination, such as racism or sexism, where categorically-biased cognitive rules of thumb and non-concerted collective action are responsible for undermining the capacity of individuals to compete in the market (Rosigno, Garcia, & Bobbitt-Zeher, 2007).

2.3 An example: Accountants in UK between 1957 and 1970

One of the many possible instances of group and market closure that can be cited is a case study stemming from the history of professions.⁶ This study was conducted by Walker and Shackleton (1998) and deals with the failed attempt of the accountancy profession in UK to secure a state-sanctioned monopoly between 1957 and 1970. The main drive behind these efforts was to exclude unqualified practitioners from the market through the creation of a unified professional body whose members would hold a legal monopoly on the provision of accounting services. For this purpose, proponents of the initiative agreed on two main strategies (pp. 44ff.):

- i) An umbrella organization was to be created to integrate competing professional bodies and offer standardized training for its members with clearly defined entry requirements based on several criteria such as education and training, work experience, employment status, location, and type of service. Not all accountants were to be included in this unified organization, and particularly not those regarded as lowering the standards of the profession.

⁶ The selection of this study was not entirely arbitrary. There are two good reasons for choosing it: first, the literature on professions is one of the most prolific fields in sociology empirically applying the concept of closure (see the Summary section, **Table 0.1**); and second, this particular case offers a clear example of both group closure and market closure practiced by the same group.

- ii) With the support of the legislator, the members of this newly formed organization were to be granted a legal monopoly on accounting services. The creation of competing accounting organizations in the future was to be prohibited.

With i), accountants expected to unify their organization by setting training requirements and by keeping out unqualified accountancy practitioners from their group. This, however, would not have stopped non-members from offering accounting services, or prevented the formation of new organizations claiming to train and certify accountants. In other words, i) would simply have regulated who could offer his or her services as a certified member of the new organization of professional accountants. The market would have still remained formally open to competitors offering accounting services and would also have allowed clients to choose freely among alternative practitioners regardless of their credentials. With ii), on the other hand, not only was the new organization to be made exclusive, but, in addition, taking part in the market would have become the sole privilege of its members. Had the law been introduced and effectively enforced, accountants outside the new umbrella organization would not have been able to offer their services. Even if achieving i) would have granted members of the group the privileges of membership in a consolidated professional body, access to the market could only have been closed after having successfully accomplished ii).

It can easily be seen how each of these two strategies fits into the concepts of group closure and market closure. While i) can be regarded as rationally driven group closure, ii) is a prototypical case of attempts at closing the market. Although, as it turned out, accountants did not succeed in convincing state agencies of the benefits of their plan and abandoned their efforts before seeing any results, the two intended strategies clearly show the difference between closing the group through membership rules and closing the market by conditioning market participation to group membership.

2.4 Is closing the market independent from closing the group?

To draw a distinction between market closure and group closure is not to deny that, under certain conditions, the two processes might respond to the same motives and reinforce each other. In cases where making the group more exclusive responds to the same economic considerations pursued through market closure practices, closing the group might correlate or even be consciously aligned with

collective attempts to reduce competition from rival groups. Regarding this particular overlap of market closure with rationally driven group closure, Weber remarks:

If the participants [in a relationship] expect that the admission of others will lead to an improvement of their situation, an improvement in degree, in kind, in the security or the value of the satisfaction, their interest will be in keeping the relationship open. If, on the other hand, their expectations are of improving their position by monopolistic tactics, their interest is in a closed relationship (Weber, 1978, 43).

Therefore, according to Weber, protecting or enhancing the privileges enjoyed by a group might indeed be a reason to tighten group boundaries. Religious sects or craft guilds closing their boundaries with the overt purpose of maintaining ethical standards or protecting their monopolistic position in the market are two examples given by Weber to illustrate rationally driven group closure (Weber, 1978, 45).

It would be tempting to conclude that when groups pursue their collective economic interests, a combination of market and group closure leads to the most favorable results. Market closure could be deployed to accelerate the accumulation of resources and economic opportunities, while group closure could be used to protect accumulated resources. As Weber observes, however, this combined tactic is neither infallible nor always desirable. Instead, groups may oscillate between openness and exclusivity depending on their priorities (Weber, 1978, 45). Keeping group boundaries open might well be necessary to expand the group's influence through the effect of sheer size. On the other hand, restricting the number of members through stronger boundaries becomes essential when the goal is to keep or increase the value of privileges already accumulated. Hence, even when group closure complements market closure in securing acquired privileges, the very process of collective accumulation probably entails periods of expansion and permeable group boundaries as well as periods of consolidation and tight group boundaries.

2.5 Why were the two meanings of closure conflated in the first place?

So far, the two meanings of the word 'closure' have been discussed and illustrated with an historical example. Yet, despite the palpable differences between these two phenomena, research and theorizing on closure tend to ignore the distinction. Why is this so?

There are at least three possible answers to this question. First, Weber's readers may be guilty of reading *Economy and Society* selectively, quoting the passages on closure without being aware of the two meanings of the word. This also includes instances in which, as mentioned by Parkin, they were aware of the two meanings of the word but saw no point in differentiating between them. A second possible explanation for this conceptual confusion is to blame the author, Max Weber. In fact, he used the word 'closure'—*Schließung* in German—in two different contexts. As summarized above, in Weber's original version of the text, the word *Schließung* first appears under the heading "open and closed relationships" (Weber, 1922, 23–5); once to describe the exclusion of outsiders from participating in a group through membership rules (*Schließung nach außen*) and again to indicate the exclusion of members from privileges *within* the group (*Schließung nach innen*). In a later chapter, the word *Schließung* appears once more, this time as part of the discussion on "open and closed economic relationships" (Weber, 1922, 201–3). But besides Weber and his readers, the third possibility is to blame the translators of Weber's original text. The slippery conceptual choice made by Weber when using the word 'closure' was further obscured by slight inconsistencies in its translations into English.⁷ Thus, for instance, in one passage, what Weber terms "*Regulierung und Schließung*" was translated as "regulation and exclusion" (*Schließung* = exclusion), while "*Reguliertheit und Geschlossenheit*" became "regulation and closure" (*Geschlossenheit* = closure). Yet, after introducing the translations of the two terms, the text refers in a later passage to *Schließung* no longer as 'exclusion' but as 'closure.'⁸ As summarized in **Table 2.1**, while *Schließung* can mean both 'exclusion' and 'closure,' the word 'closure' is used in the translation to refer to both *Schließung*, the active act of 'closing,' and *Geschlossenheit*, which could be translated as 'closedness' and describes the resulting state of being 'closed.'

A more reasonable position is to attribute the confusion surrounding the concept of 'closure' to the composite effect of readers' inattention, multiplicity of meanings in Weber's original text, and small but consequential inconsistencies in the English translation of the concept. The result is a word with not only two, but even three meanings: the first two, as explained above, are genuine distinctions drawn by Weber between closing the market and closing the group that can be

7 Again, this applies to the English translation of Weber's *Economy and Society* by Guenther Roth and Claus Wittich (Weber, 1978), the version usually quoted in subsequent discussions on closure and the one used by Parkin (1979) and Murphy (1988).

8 The exact passages referred to here are the following, quoted in German and English, respectively. (i) German: "*Das Maß und die Mittel der Regulierung und Schließung nach außen können sehr verschieden sein, so daß der Übergang von Offenheit zu Reguliertheit und Geschlossenheit flüssig ist*" (Weber, 1922, 24). (i) English: "Both the extent and the methods of regulation and exclusion in relation to outsiders may vary widely, so that the transition from a state of openness to one of regulation and closure is gradual" (Weber, 1978, 45). (ii) German: "*Motiv der Schließung kann sein...*" (Weber, 1922, 24). (ii) English: "The principal motives for closure of a relationship are.." (Weber, 1978, 46).

Table 2.1: Different translations of the words *Schließung* and 'closure'

Section in <i>Economy and Society</i>	Original text and translations
Open and closed relationships (Weber, 1922, 23-5; Weber, 1978, 43-6).	<i>Schließung</i> : closure, exclusion. <i>Geschlossenheit</i> : closure.
Open and closed economic relationships (Weber, 1922, 201-3; Weber, 1978, 341-3).	<i>Schließung</i> : closure.

traced back to the word *Schließung*. The third meaning was gained in translation and refers to the *outcome* of a group closing its boundaries to outsiders, or internally for the distribution of privileges within the group. It is termed *Geschlossenheit* by Weber, meaning the *state* of being closed. The third meaning of closure, artificially created in translation, must have been a challenge for readers of the English version of the text who were confronted with the seemingly incomprehensible assertion that closure (*Schließung*; the act of closing) produces closure (*Geschlossenheit*; the state of being closed).

To avoid any misunderstandings, Weber's two forms of closure (*Schließung*) can be easily distinguished by explicitly naming the object of the action of 'closing,' as has been done so far in the present chapter: group closure or the collective exclusion of individuals from the group and market closure or the collective exclusion of rival groups from competition. Furthermore, to improve the inaccurate translation of the word *Geschlossenheit* (literally meaning 'closedness'), the word 'exclusivity,' the adjective 'closed' or the expression 'degree of closure' might be used instead. The level of exclusivity of a group or its degree of closure is nothing more than the permeability of its boundaries to outsiders. If boundaries are impenetrable, the group might be described as being 'closed.' Moreover, just as group closure leads to group exclusivity or to a closed group, a market that is only accessible to members of a certain group can be described as an exclusive market, a closed market, or a market with a high degree of closure. Arbitrary as it may seem, 'exclusivity,' 'degree of closure,' and being 'closed' appear to be distinct enough from 'closure' to reduce the risk of confusing the phenomena they describe. More importantly, making this distinction allows us to refer separately to the action of closing and the outcome or state following that action.

2.6 Summary

In revisiting Weber, two forms of closure were identified. Market closure denotes collective action aimed at excluding rival groups from competition, and group closure refers to groups drawing boundaries against outsiders. The acts of closing the market and closing the group (*Schließung*), which necessarily imply the

existence of collective actors and agency, were in turn distinguished from their outcomes: the mere existence of a closed market, or a market where allocation is conditioned by group membership, and a closed group, or the mere existence of membership rules. To refer to the latter, the concept of degree of closure was introduced (*Geschlossenheit*). **Table 2.2** summarizes the core aspects of Weber's definition of closure and its two meanings as group closure and market closure. Four dimensions are compared: action, actors, motive of action, and outcome.

Table 2.2: Weber's two meanings of closure

	<u>Group closure</u>	<u>Market closure</u>
Action	Groups draw boundaries against outsiders.	Groups influence resource allocation rules in a market to limit or eliminate competition from rival groups.
Actors	Any group with clearly defined boundaries and the capacity to modify its membership rules.	Group capable of concerted collective action and the power to modify market allocation rules. The latter can also be effected indirectly through a third party (e.g., the state).
Motive	Economic interests or also shared values, tradition, and affectual bonds.	Economic interests.
Outcome	Exclusive group. Participation in the group regulated by membership rules.	Closed market. Market allocation conditioned by group membership.

Chapter 3

A new definition: closure as exclusionary action

The popularity of the two meanings of the Weberian definition of closure in the study of inequality has been counterproductive in keeping the concept explanatory. Attempts to fit the narrow Weberian definitions of group closure and market closure to a larger set of theoretical propositions, as was the aim of the so-called neo-Weberian theories of Parkin (1979) and Murphy (1988), or to accommodate their meaning to a wider collection of empirical phenomena, as was sought by Tilly (Tilly, 1998) and Roscigno (Roscigno, 2007; Roscigno, Garcia, & Bobbitt-Zeher, 2007; Roscigno, Hodson, & Lopez, 2009; Roscigno, Karafin, & Tester, 2009; Roscigno, Mong, et al., 2007), have put too much strain on the concept. In particular, the overstretching of the scope of closure has diverted much attention from the importance of agency and the central role played by actors, motives, and modes of interaction in explaining processes of collective accumulation of advantage.

The goal of this chapter is therefore twofold. First, it briefly reviews the extensions of the Weberian concept of closure as found in the theoretical works of Parkin and Murphy and in the empirically oriented contributions of Tilly and Roscigno. Second, as a way of synthesis, a general definition of closure as exclusionary action is offered that effectively extends the scope of the concept to include related phenomena other than market and group closure while keeping its action-based core intact.

Defining closure at the level of individual action is not just a matter of definitional precision. Above all, it is an attempt to make the concept well-suited for the study of intergroup inequality from a mechanistic perspective. As discussed in **Chapter 1**, the common denominator in the debate on mechanisms, besides a focus on casual explanation, generative causality, and middle-range theorizing, has been the goal of identifying concatenated phenomena that are robust to given initial conditions across contexts and levels of analysis. From this perspective, and as will be argued below, closure can be understood as a ‘transformational

mechanism' (Hedström & Ylikoski, 2010, 59), a micro-macro link (Raub, Buskens, & Van Assen, 2011) that causally connects exclusionary action at the level of individual or collective actors to processes of unequal accumulation of economic resources and opportunities among groups or categories at the societal level.

In order to keep the argument as tractable as possible, the chapter has been divided into three main sections. The first two sections deal with the modifications and extensions of the original Weberian formulation of closure that have been suggested so far by sociologists. **Section 3.1** summarizes the theoretical efforts of Parkin and Murphy to expand the reach of the concept of closure, while **Section 3.2** turns to the mostly empirically oriented works of Tilly and Roscigno and their attempts to make closure compatible with their findings. **Section 3.3** offers a new definition of closure as exclusionary action. Forms of closure are classified depending on the motives of the excluding party and the form of interaction involved. Examples of each form of closure taken from published works are provided and commented. Further examples of closure in markets, families, and networks are developed in the third part of this work (**Chapters 4, 5 and 6**).

3.1 The neo-Weberian conceptual expansion: Parkin and Murphy

Two of the most influential neo-Weberian extensions to the concept of closure have been advanced in the works of Parkin (1979) and Murphy (1988) (Manza, 1992). Rather than presenting a comprehensive review of their theories, I will comment, briefly, Parkin's and Murphy's suggested modifications to the definition of closure.

3.1.1 Parkin: the role of unintended consequences

In his book *Marxism and Class Theory: A Bourgeois Critique* (Parkin, 1979), Parkin embarks on the ambitious intellectual enterprise of revising Marxist class theory by developing a comprehensive framework for the study of social inequality (p. 42). For this purpose, he adopts and further elaborates Weber's definition of closure, which he describes as follows:¹

[...] the attempt by one group to secure for itself a privileged position at the expense of some other group through a process of subordination. That is to say, it is a form of collective social action which, intentionally or otherwise, gives rise to the social category of ineligibles or outsiders (p. 45).

¹ To what extent Parkin's efforts to build a general theory of stratification successful were is not the main concern here. Others have already reviewed his work critically and extensively (Barbalet, 1982; Giddens, 1980; Mackenzie, 1980; Roth, 1980).

He complements his definition with the related concept of 'usurpatory closure,' or:

[...] that type of social closure mounted by a group in response to its outsider status and the collective experiences of exclusion (p. 74).

To the extent that exclusionary and usurpatory forms of closure are collective action (p. 108), Parkin's definition closely resembles Weber's: a collective actor excludes outsiders from valued resources. Yet, despite the similarities, Parkin introduces a novel element to the definition that goes beyond Weber's original formulation. He allows closure to emerge as an unintended consequence of collective behavior, lifting the assumption that collective actors behave intentionally with the purpose of excluding rivals. Thus, what Weber denotes as strategic collective acts of exclusion from the group or the market is reframed by Parkin to include any form of collective action that gives rise to marginalized groups, even if only unintentionally.

3.1.2 Murphy: from explanation to mere description

In line with Parkin's pretension to expand the scope of the concept, Murphy (1988) stretches the meaning of closure even further (p. 38).² As part of his theory of exclusion and monopolization, two concepts that he uses as synonyms for closure in his works, Murphy introduces the notion of closure "rules," "codes," or "forms," which are nothing more than dimensions, such as gender or race, along which exclusion occurs (ch. 4). In general, Murphy claims, the social structure of any society can be understood as a combination of principal, derivative, and contingent forms of exclusion or closure (pp. 70–2). If, for example, private property is the principal form of exclusion in a given society (that is, groups are defined by their control of or exclusion from private property), and if in addition, those in possession of private property happen to constitute an ethnically homogeneous collective, then ethnic discrimination could be regarded as deriving from the first, principal form of closure. Gender, on the other hand, not being directly related to private property in this hypothetical case, would be contingent upon the principal form.

Thus, by spelling out his analytical framework Murphy seems to forget about collective action altogether and gives the concept a descriptive connotation, even if his starting point remains Weber's and Parkin's action-based definition of closure. His own definition of closure can be inferred from different passages ex-

² Murphy (1988) presents his previous articles published on the subject in various journals between 1983 and 1986 (Murphy, 1983, 1984, 1985, 1986a, 1986b).

plaining his theory (ch. 4, in particular). For instance, when describing “derivative forms of exclusion,” Murphy writes the following:

Derivative forms of exclusion can be formally written into law—as, for example, when those who owe their power to the legal guarantees of private property use that power to enact slavery laws and racial exclusion laws—but usually, and increasingly, they are not. [...] much of the stratification of racial, ethnic, linguistic, and religious groups in contemporary capitalist society does not have a distinct legal basis of racist, ethnic, linguistic, or religious discrimination. Rather it is based upon their differential historical accumulation of private property (a differential itself having its origin in military conquest and migration) and upon resulting monopolization of opportunities in the market through formation of networks, alliances, and the imposition of the owners’ language and cultural assumptions concerning competence for positions and careers (pp. 71-2).

According to this passage, derivative forms of closure are not what explain inequality among racial, ethnic, linguistic, and religious groups. Rather, closure designates the mere existence of inequalities among groups that can be traced back to other causes: the differential accumulation of property and market opportunities due to conquest and migration, differences in network formation, the imposition of language, and the cultural assumptions of private property owners. In other words, instead of keeping the definition of closure at the level of collective action, as groups acting against rivals to exclude them from accessing resources, Murphy simply redefines categorical inequality as closure and seeks its real causes in other phenomena. This transforms the idea of closure from an action-based explanans for group-related inequality into a static explanandum describing the existence of intergroup inequality.³ Accordingly, instead of looking first for collective actors and their acts of exclusion, intentional or not, the whole empirical enterprise is turned on its head: if resources and opportunities are found to be unequally distributed among groups or categories, with some groups or categories consistently being privileged and others remaining deprived, closure is assumed to have occurred. This, of course, need not necessarily be the case.

Put briefly, the neo-Weberian modifications of the concept of closure led by Parkin and Murphy left mixed results. First, and mostly due to Parkin, the concept was extended to the unintended consequences of collective action. This is a welcome extension of the concept because it provides additional analytical leverage for understanding processes of collective accumulation in which the motives of action are not clearly exclusionary or simply not observable. Unintended forms of closure are discussed further below. Second, however, and mostly due to Murphy, the concept moved away from an action-based notion and was transformed

³ Manza (1992) already observed this shift in meaning away from explanation and towards description in the neo-Weberian reception of closure (see p. 288).

into a mere reconceptualization of inequality as closure, a descriptive restatement of the phenomenon to be explained. Thus, in terms of explanatory power, the concept gained in breadth but lost in precision.

3.2 The demands of empirical research on the concept of closure: Tilly and Roscigno

Aside from the efforts of Parkin and Murphy to give the concept of closure an extended meaning, two further modifications of the concept have been brewed in the empirical works of Charles Tilly (Tilly, 1998) and Vincent Roscigno (Roscigno, 2007; Roscigno, Garcia, & Bobbitt-Zeher, 2007; Roscigno, Hodson, & Lopez, 2009; Roscigno, Karafin, & Tester, 2009; Roscigno, Mong, et al., 2007). In contrast to the neo-Weberians, who were more interested in expanding the scope of the concept to make it amenable to their theoretical agendas, Tilly and Roscigno were compelled to modify Weber's definition to cope with the demands posed by substantive empirical research on categorical inequality and discrimination.

3.2.1 Tilly's relaxation of collective actors

In his ambitious book on social inequality (Tilly, 1998), Tilly sets out to understand and explain categorical inequality in all its guises, including gender, ethnic, and political inequality (p. 6).⁴ In spelling out his explanatory agenda, and as a direct extension of Weber's notion of closure, Tilly advocates two fundamental changes in thinking about categorical inequality: relaxing the existence of clearly defined groups and, as Parkin had already suggested years before, lifting the assumption of intentional collective action.

According to Tilly, the creation and maintenance of categorical inequality is not limited to the action of neatly demarcated groups such as firms or professional organizations (p. 99). Instead, mechanisms generating inequality operate among "[...] all sorts of well-bounded clusters of social relations in which occupants of at least one position have the right to commit resources to activities reaching across the boundary" (p. 9). Aside from formal organizations, which Weber suggested would be the likely constitution of collective actors involved in closure (Weber, 1978, 342–3), Tilly's "bounded networks" include loosely defined collectives such as "corporate kin groups, households, religious sects, bands of mercenaries, and many local communities" (p. 9–10). This flexibilization of the definition of collective actor is further accompanied by a broader view of purposeful action in-

4 Laslett (2000), Morris (2000), and Wright (2000) provide a general review and discussion of Tilly's *Durable Inequality* (1998). The main theoretical propositions of the book are summarized in Tilly (2000).

volved in the creation of categorical inequality. Contrary to the Weberian version of closure, in which deliberate exclusionary action drives collective accumulation processes, Tilly makes a plea for freeing agency from the straitjacket of intentionality. In his view, inequality is created by the necessity of bounded networks to solve organizational problems, such as the creation of a bureaucracy in a newly created nation-state or the gendered division of labor inside firms (see ch. 5), and not by the overt purpose of producing inequality.

From this general plea for a broader understanding of collective actors and actions involved in the production of inequality, Tilly transforms the concept of closure into the broader notion of 'opportunity hoarding,' which he defines as follows:

When members of a categorically bounded network acquire access to a resource that is valuable, renewable, subject to monopoly, supportive of network activities, and enhanced by the network's *modus operandi*, network members regularly hoard their access to resources, creating beliefs and practices that sustain their control (p. 91; see also p. 154).

According to Tilly, networks can be bounded along categorical lines, including race, gender, schooling, professional training, and political affiliation (p. 155). Resources may include both material resources, such as access to mineral deposits, and nonmaterial resources such as shared knowledge, access to clients, or reliable suppliers (p. 158). As can be taken from this definition, besides the conditions imposed on the characteristics of the network and the resources, opportunity hoarding comprises two processes: (i) the accumulation of resources by network members, and (ii) the protection of accumulated resources by the network through the creation of beliefs and practices.

Is opportunity hoarding still closure in the Weberian sense? While opportunity hoarding describes the dual process of collective accumulation and protection of resources in all its manifestations (Tilly, 1998, p. 91; see also p. 154), Weber's market closure and group closure designate concrete strategies followed by collective actors to set in motion each of those two processes. Hence, acting collectively to exclude rivals from competition (market closure) is but one possible strategy among others to collectively accumulate resources, just as excluding outsiders from the group (group closure) is merely one way to keep control over accumulated resources. However, according to Tilly's definition of opportunity hoarding the collective accumulation of resources can be achieved through means other than market closure (e. g., market competition), just as the protection of controlled resources can be accomplished by following strategies other than tightening group boundaries through membership rules (e. g., ingroup information sharing). While these other strategies, such as market competition or ingroup in-

formation sharing, fall under the broader category of opportunity hoarding, they go beyond the scope of Weber's original definitions of market closure and group closure. As a consequence, the concept of "opportunity hoarding" should not be used as a synonym for the Weberian notion of closure because the latter can in fact be subsumed and be understood as a special case of the former.

3.2.2 Roscigno's emphasis on individual agency and interaction

Recent empirical work on discrimination led by Vincent Roscigno offers further valuable insights into how Weber's original concept of closure can be expanded (Roscigno, 2007; Roscigno, Garcia, & Bobbitt-Zeher, 2007; Roscigno, Hodson, & Lopez, 2009; Roscigno, Karafin, & Tester, 2009; Roscigno, Mong, et al., 2007). Although discrimination is by no means a new subject in sociological research on inequality, the data collected and analyzed by Roscigno and his collaborators certainly are. They consist of thousands of cases of racial and sex discrimination in labor and housing markets brought to court in one U.S. state during a period of 25 years.⁵ Putting aside the vivid results regarding the reality and consequences of race and gender discrimination in housing and employment in the U.S. as portrayed in legal disputes, what is relevant for the present discussion are the theoretical lessons Roscigno draws from his data. As the hundreds of cases studied illustrate, gender and race discrimination in employment and housing is performed by individuals who, even if restrained by a specific institutional and organizational setting and influenced by society-wide beliefs and stereotypes, bring about an unequal distribution of privileges between groups at the place of work and residence through their actions (Roscigno, Garcia, & Bobbitt-Zeher, 2007, 214–7). From this finding Roscigno concludes that closure

[...] also comes about, consciously and unconsciously within the context of everyday interaction—interaction that, through language, symbolic acts, and/or physical control or force, has as its aim status-hierarchy preservation and the various advantages/disadvantages it affords (Roscigno, Garcia, & Bobbitt-Zeher, 2007, 8)

According to this view, individual acts of discrimination against certain out-group members are enough to produce exclusion and set in motion a similar process of collective accumulation of privileges favoring the excluding party as described by Weber. Here, however, closure is not performed by economically motivated collective actors or aimed at the strategic exclusion of rivals from the

5 Cases were obtained from the Civil Rights Commission of the state of Ohio (OCRC) and amount to roughly 60,743 cases of employment discrimination and 3,941 cases of housing discrimination related to gender and race between 1988 and 2003 (Roscigno, Garcia, & Bobbitt-Zeher, 2007, 14ff).

market. In contrast, it is practiced by individuals acting nonstrategically who bring about inequality among groups unintentionally, just as Parkin and Tilly point out in their works.

In conclusion, the works of Tilly and Roscigno, taken together, suggest two illuminating prescriptions on how to expand the concept of closure. First, actors need not be clearly defined collectives; loosely bound groups and even individuals are capable of excluding rivals from access to valued resources along categorical boundaries too. Second, and echoing Parkin, exclusionary behavior need not be conscious or purposeful. Unintended action might be just as effective in excluding other groups or individuals who belong to a category from accessing valued resources.

3.3 Closure as exclusionary action

As discussed so far, attempts to stretch the concept of closure have brought both losses (leaving out agency) and valuable new insights (lifting restrictive assumptions about agency). From these attempted revisions of the concept at least two conclusions can be drawn. First, there is a significant discrepancy between the narrowness of Weber's original formulation of closure as market and group closure and the rather broad uses to which the concept has been put by neo-Weberians and contemporary empirical researchers. Second, and as a consequence of the first, fitting the narrow Weberian definition of closure to a larger set of theoretical propositions and empirical phenomena has put too much strain on the concept and has threatened to divest closure of much of its explanatory power, which resides in its emphasis on agency.

A new definition of closure should profit from past efforts to modify the concept by avoiding the pitfalls of reducing it to a description of inequality, while at the same time being able to accommodate related phenomena in which loosely defined collectives and even individuals acting non-strategically can bring about the same outcomes as the collective actors described by Weber in his original definition. In the following, such a definition of closure is proposed and illustrated with examples taken from existing published works and from the articles belonging to this dissertation (see the Summary section, **Table 0.1**). In addition, a 'closure space' is introduced as a way to categorize different forms of closure and to orient empirical research.

3.3.1 A general, action-based definition of closure

In order to expand the scope of closure while keeping the core of Weber's definition intact, the concept can be generalized in terms of I denote 'exclusionary

action.' Irrespective of the type of actor, motives, and forms of interaction, closure as exclusionary action encompasses *all forms of preferential or discriminatory interactions and transactions among groups or categorically bounded individuals that accrue or secure benefits to one group or category by excluding others, both intentionally and unintentionally.* Closure is 'exclusionary' in its consequences and not necessarily in its motives. Actors may be aware about the exclusionary character of their actions and even pursue exclusionary goals consciously. Yet, the marginalization of groups or categories of individuals from accessing desirable resources and opportunities may also be brought about unintentionally. Thus, to assert that interaction or transactions are preferential or discriminatory is a mere description of an action and not an assumption about consciously perceived motives of the actor involved. At the same time, closure crucially depends on action, since exclusion is brought about through individuals or groups acting to bring about the marginalization of outgroups or members of other categories. In other words, closure is not merely about the emergence of 'outsiders' as Parkin puts it, but rather about acts of exclusion by a benefiting group or category of individuals that *actively*, though not necessarily purposefully, carve out a gulf between them and the rest in terms of access to valued resources. This new definition of closure as exclusionary action incorporates Weber's original concept of closure as practiced by a group acting intentionally to exclude rivals from valued resources as a special case. In addition, it comprises exclusionary acts undertaken for motives different than exclusion and by actors other than clearly defined collectives, including individuals in categories such as gender or ethnicity. To avoid confusion and to be able to subsume all previous definitions of closure under this new general definition, a more detailed characterization of closure as exclusionary action is provided in the following.

3.3.2 Forms of closure as exclusionary action: motives and forms of interaction

Actor's *motives* are a first dimension that can be used to further typify forms of closure as exclusionary action. At one end of this dimension, *intentional forms* of closure designate instances of exclusionary action in which the motive of excluding outsiders from accessing resources is explicit and consciously known by the excluding party. This would be the case for collective actors, such as professional associations, that act strategically to exclude rivals from the market and corresponds most directly to Weber's original definition of closure. At the other end, *unintentional forms*, refer to exclusionary action that is not undertaken with the purpose of excluding a whole category of rivals from accessing resources but instead emerges as an unintended consequence of individual or collective action.

For example, individual short-sighted, categorically biased interactions hostile to outgroups, as in the case of discrimination (Fiske, 1998), may be equally sufficient to bring about unequal access to resources for whole categories of individuals (e. g., 'men') as if these actions were consciously carried out to bring about the same outcome.

A further dimension besides motives to help characterize exclusionary action is the *form of interaction* involved. Preferential or discriminatory interactions and transactions between groups and individuals can be roughly divided into direct and mediated. *Direct forms* of closure are face-to-face. They constitute immediate interaction between the excluding and the excluded party, such as when landlords ask higher rental prices from ethnic minorities, employers offer lower salaries depending on the gender of the applicant, or parents give more attention to the firstborn than to other siblings. Actors involved in direct forms of closure are individuals, even if some of them act as representatives of a collective actor, such as gatekeepers controlling entry to an organization. In contrast, *mediated forms* of closure regulate direct exclusionary action through institutional arrangements, including laws, which bring about the same result as direct forms of closure without the necessity of repeated face-to-face interaction. Thus, instead of individual landlords asking higher rental prices from ethnic minorities, laws can be enacted that regulate housing markets in terms of ethnicity, such as those observed in segregationist regimes like South Africa under apartheid. To some extent, mediated forms of closure still require some degree of face-to-face interaction. This, however, is outsourced to a third party, such as police or judges, to perform the same exclusionary act otherwise required by a direct form of closure.

When it comes to mediated form of closure, it is critical to note that in order to classify as exclusionary action, institutional arrangements and laws regulating closure have to originate in collective action carried on by the excluding party. Failing to demonstrate the connection between mediated forms of closure and the party that benefits from them would reduce the concept to a descriptive notion, a mere characterization of institutional arrangements as benefiting or negatively affecting the access to resources of groups or categories of people that ignores the actions that led to those institutional arrangements in the first place. Rules exist that are exclusionary without necessarily constituting an instance of closure. For example, age-specific enrollment rules such as those found in organizations or activities structured around age have been demonstrated to be responsible for the so-called 'relative age effect' extensively documented in schools (Sprietsma, 2010) and competitive sports (Musch, 2001). The relative age effect refers to performance gaps between older and younger children inside the same cohort that can be traced back exclusively to being born closer to the cutoff date, which explains small but decisive differences in terms of physical and mental development

at young ages. Thus, even if it is true that younger children in a given cohort tend to fare worse than older children because of age-based enrollment rules, to call these rules a mediated form of closure requires an additional condition: it is necessary to show that older children, as a group or as members of the category defined by their age, not only benefit from the rules, which they in fact do, but also to show that they or someone acting on their behalf was actively involved in the design and instauration of such particular membership rules, either consciously with the purpose to benefit older children and exclude younger children or unconsciously by pursuing other goals other than the exclusion of their younger peers. Only after providing evidence for agency on the side of the 'older children,' would the case for a mediated form of closure be credible. In other words, mediated forms of closure substitute direct interaction and regulate exclusionary action that would have otherwise been undertaken by the excluding party. They, however, neither replace agency nor obviate the existence of an actor responsible for exclusionary action, which by definition underlies all forms of closure, direct and mediated alike.

It bears emphasizing that despite the differences between intentional and unintentional motives and between direct and mediated forms of interaction, all types of exclusionary action bring about the same *outcome*: intergroup inequality. In this sense, closure can be understood as a transformative mechanism, as defined by Hedström and Ylikoski (2010). Exclusionary action translates individual or group interactions at the microlevel into an unequal distribution of resources among groups or categories of individuals at the societal level (**Figure 3.1**). Where such unequal processes of collective accumulation, set in motion by exclusionary action, endure, a persistently unequal distribution of economic resources and opportunities between groups or categories will necessarily emerge.

To repeat, closure should not be equated with the unequal process of accumulation it engenders. The latter is an *outcome* of closure, one that can be brought about by causes different from exclusionary action. For example, processes of cumulative advantage that produce an unequal distribution of resources among groups or categories of individuals in which no interaction or transactions among groups take place and hence no exclusionary action is involved (DiPrete & Eirich, 2006) should not be confused with closure. Also, processes of self-selection into occupations or place of residence can produce inequality in the form of segregation patterns, such as men-dominated occupations or high-income neighborhoods, which could be wrongly attributed to exclusionary action by men or high-income individuals, respectively. Closure is interaction.

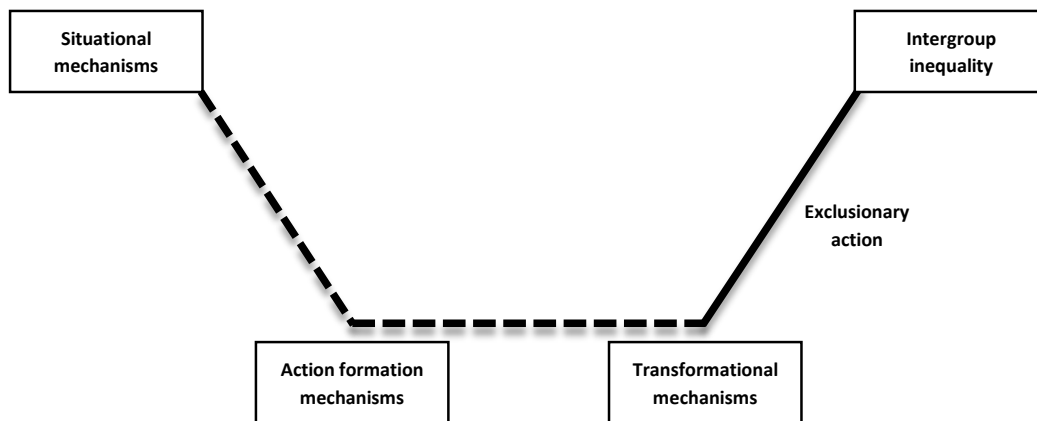


Figure 3.1: Closure as a transformative mechanism

3.3.3 Further examples

To complement the conceptual distinctions introduced so far, additional examples of closure are listed and classified along the dimensions of intentional/unintentional motives and direct/mediated forms of interaction.⁶

Intentional forms. (i) The exclusion of competitors from the market is a prototypical intentional form of closure, practiced in both a direct and a mediated form by collective actors. Of the many possible instances of market closure that can be cited, the history of professions offers perhaps the most eloquent examples of conscious exclusionary action mediated by market regulations. Lawyers and medical doctors, but also related professions such as accountants or nurses, have been shown to practice closure by mobilizing state control to protect their economic interests in the form of licenses or other legal dispositions that restrain competition (Macdonald, 1995). In those cases where professional bodies enjoy full autonomy in regulating market entry, closure can even be tuned on short notice according to the necessities of the profession. For example, as documented by Kidder (2004),

⁶ Refer to Tilly (1998) and Roscigno (2007) and their list of references for more examples of exclusionary action.

bar examination standards for lawyers in the US seem to have been modified systematically to control wage levels by organized lawyers according to perceived oversupply of practitioners. To be sure, professional associations are not the only interest groups trying to gain state support on their side. What professions do can be subsumed under the more general processes of rent-seeking (Rowley, 1991) and regulatory capture (Dal Bo, 2006), two related phenomena studied by economists, which encompass all efforts undertaken by interests groups to secure rents or economic advantages by securing state-sanctioned monopolies or by tilting market regulation in their favor. A well-known and extensively documented example is lobbying by agricultural producers of high-income countries to secure subsidies and tariff protections that thwart participation by farmers from low-income countries in international trade, one of the most blatant distortions of global agricultural markets (Hoekman, 2004).

Exclusion from the market can also be effected through direct forms of exclusionary action. The study by Hollenberg (2006) of integrated health care hospitals in Canada demonstrate how biomedical practitioners exclude their alternative medicine counterparts from fully treating patients in day-to-day interactions by controlling patient charting, referrals, and access to diagnostic tests. Thus, even if both groups of specialists are formally supposed to be on equal footing in offering their services, which is the explicit aim of integrated health care centers, biomedical practitioners manage to turn the playing field in their favor through direct exclusionary action. Outside hospitals, excluding rivals from the market can also be achieved directly through illegal means, as demonstrated by the Sicilian Mafia and the shady services they offer to their clients. Instead of lobbying for a law that regulates the market in favor of one's group, firms resort to intimidation and blackmailing with the help of Mafia henchmen to protect territorial control over businesses by chasing away competitors from the market one at a time (Gambetta, 1996, ch. 8). The effects on inequality of market and group closure are illustrated in **Chapter 4** using an agent-based model of individual and group competition in labor markets.

(ii) Exclusion from groups through membership rules is another common intentional form of closure. Membership rules to enter formally constituted collectives such as religious, political, educational, and productive organizations, unions, and corporate groups, welfare states, or political multinational unions, are explicitly exclusionary. They are erected with the overt purpose of administering group privileges granted to members while at the same time keeping non-members at bay. While formal membership rules are widespread, group membership can also be regulated through direct forms of exclusionary action. Informal groups, such as cliques, gangs, and other diffusely bounded groups constituted around ethnicity, class, political views or any other salient and identity-defining

category, constantly renegotiate membership through ever changing patterns of interaction within and across boundaries (Lamont & Molnár, 2002).

(iii) Beyond markets and groups, intentional and direct forms of closure can also be observed in the intergenerational transmission of resources in the family. Parents transmit resources to their children not only passively through genes but also actively through parental investments in the form of time, money, and attention devoted to their offspring. The fact that parents normally take care of their own children and not the children of others is a pervasive, certainly not solely human, form of exclusionary action in the transmission of parental resources with deep consequences for the production and reproduction of social inequality. The family is, in fact, the single most important factor in explaining differences in skill formation even after taking into account the compensating effect of schools (Heckman, 2006). But exclusionary action takes place even within the family. Resource allocation among siblings is not uniform. As research on siblings has shown, children in the same family are not treated the same. The unequal allocation of resources within the family, favoring boys over girls or first-born over later-borns, explains at least to some extent diverging paths in educational and occupational attainment among siblings (Conley, 2004).

Gender stereotypes and norms about birth order, or even consciously followed parental preferences regarding these two dimensions, influence how parental time, money, and attention are distributed among children (Osmanowski & Cardona, 2012). Similarly, class-specific motives of avoiding downward mobility and the cumulative dynamics of skill growth may lead parents to treat children differently according to their skills, thus likely generating persistent inequalities in skills development over time (Cardona & Diewald, 2014). Finally, parents may treat children differently without knowing it, through efficiency gains and returns of scale to parental investments that favor first-borns over later-borns (Osmanowski & Cardona, 2014). The effect of different forms of egalitarian and nonegalitarian parental allocation of resources within the family, intentional or otherwise, on levels of skill inequality at the societal level both within and across generations will be further explored in **Chapter 5**.

Unintentional forms. (i) Assortative network formation is perhaps the clearest example of an unintentional, direct form of closure. Homophilous tie formation in personal networks produces networks with high assortativity or positive network autocorrelation. Assortativity in networks may result from socially homogeneous contexts, such as place of residence, job, or leisure activities (Feld, 1981), that present individuals with a constrained opportunity structure for tie formation. Network autocorrelation can be also the result of individual discriminatory preferences to form ties with others who share similar characteristics along the

lines of age, sex, religion, ethnicity, or socioeconomic status (McPherson, Smith-Lovin, & Cook, 2001). Whether opportunity or choice, the unintended consequences of assortativity in personal networks are segregation and the accumulation of both advantages and disadvantages in the form of access to information and resources, as well as positive or negative feedback through peer effects, depending on the characteristics of network members.⁷

In labor markets, network autocorrelation has proved to be decisive in finding a job. Both the information obtained through personal networks and referrals from network members are vital for successfully navigating labor markets (Elliott, 2001; Fernandez, Castilla, & Moore, 2000; Ioannides & Loury, 2004; Stainback, 2009). Aside from information on jobs, research on social capital has documented similar effects of network autocorrelation along socioeconomic dimensions on access to resources mobilized through personal networks, including both instrumental and emotional social support (Lin, 2000).

Personal networks may also affect ego's preferences, attitudes, and behavior directly. Peer effects have been identified as critical factors in explaining both positive and negative influence on individuals. Peer effects partially explain the incidence and prevalence of unhealthy behavior, including smoking, alcohol intake, and eating habits (Smith & Christakis, 2008), as well as deviant behavior such as delinquency (Baerveldt, Völker, & van Rossem, 2008), and suicide (Bearman & Moody, 2004). By the same token, positive emotions, such as happiness (Fowler & Christakis, 2008), and positive performance feedback at school and university (Sacerdote, 2011), or place of work (Moretti, 2004), are similarly channeled through personal networks. Peer effects are present in multiple domains and may be decisive even early in the life course, as suggested in **Chapter 6** in an empirical analysis of the effect of proficiency of the language used in the kindergarten on tie formation among preschool children and its possible impact on language development.

(ii) In addition to network formation, some instances of exclusion from the market may classify as unintentional forms of closure. Exclusionary action can have an impact on the distribution of resources among groups or individuals in a category by affecting their capacity to compete in a similar fashion as intentional forms of closure such as professional licensing but without the conscious exclusionary motives or the concerted action. In contexts where performance is evaluated by gatekeepers, such as schools and the work place, unconscious biases have been shown to affect systematically the perceived competence or perceived performance of individuals. For example, research on sex stereotypes in organizations suggest that women's performance tends to be judged more harshly than

⁷ For a general discussion of the effects of assortativity on inequality, see Bowles, Loury, and Sethi (2010) and DiMaggio and Garip (2011, 2012).

men's (Ridgeway, 1997). In this case, women lose against their peers when it comes to important transitions such as job promotions, for which performance evaluations are critical, even if their real performance is equal or superior to men. Again, to classify as closure, gatekeeper evaluation bias must be enacted by members of the excluding category, the category that benefits, such as men as occupants of privileged positions in organizations or teachers as members of the middle class in schools.

In general, the question of whether direct or mediated forms of closure are intentional or unintentional in their motives should remain empirical. This may be particularly challenging in the case of intentional forms of closure, where an explicit exclusionary motive is required. As has been argued by Reskin (2003), in the context of ascriptive inequality in organizations, agents' motives usually remain concealed to the researcher. In those cases where motives remain unclear, the temptation to assume intentional motives on the side of the group or category that benefits should be avoided. Failing to do so would lead to speculative storytelling about agency in which the privileged are regarded as an active agent consciously conspiring against the excluded. Thus, for example, asserting that the privileged position achieved by men relative to women in organizations is due to the focused agenda of 'men,' consciously designed to outcompete 'women' (intentional form), would be fundamentally different from suggesting that disparate discriminatory acts of individuals in gatekeeping positions systematically deprive individual women of privileges within an organization even if only as an unintended consequence of individual action. Similarly, arguing that immigrants end up in low-paying jobs because locals have organized and strategically acted to exclude them from better jobs collectively (intentional form) is not the same as showing that the functioning of job information networks driven by homophily in the creation of ties and ingroup bias in the transmission of information favors individuals with contacts among those already holding better jobs (unintentional form).

All in all, aside from differences in motives and forms of interaction, the distribution of resources and opportunities among groups or categories of individuals affected by exclusionary action, and hence the manifestations of intergroup inequality that closure produces, are multiple in nature. Based on the examples listed above, closure may affect intergroup inequality in terms of

- Access to markets: right to buy/sell goods and services in a market
- Resources conferred by membership to states, organizations, communities, or networks: civil rights and public goods, instrumental and expressive support, prestige, know-how, jobs, information, positive behavioral/attitudinal feedback.

- Favorable performance evaluation: advancement in educational and productive organizations.
- Parental resources: time, attention, financial resources.

3.3.4 The 'closure space'

Given that the two dimensions of closure, intentional/unintentional and direct/mediated, represent only ideal types of different motives and forms of interaction expressed in a myriad of concrete exclusionary acts, a 'closure space' can be conceived that accommodates all *possible* combinations of exclusionary action. The space is two-dimensional; it links a continuum of forms of interaction on the y-axis with a continuum of motives on the x-axis. Forms of interaction range from direct to mediated, while motives span two extremes, purely intentional exclusionary motives and entirely unintentional acts. **Figure 3.2** depicts the closure space thus defined, including the examples mentioned so far. Actors can range from individuals in a category (e. g., gender or ethnicity) to organized collective actors capable of concerted collective action (e. g., firms or professional organizations). How densely populated the closure space is, should be explored empirically.

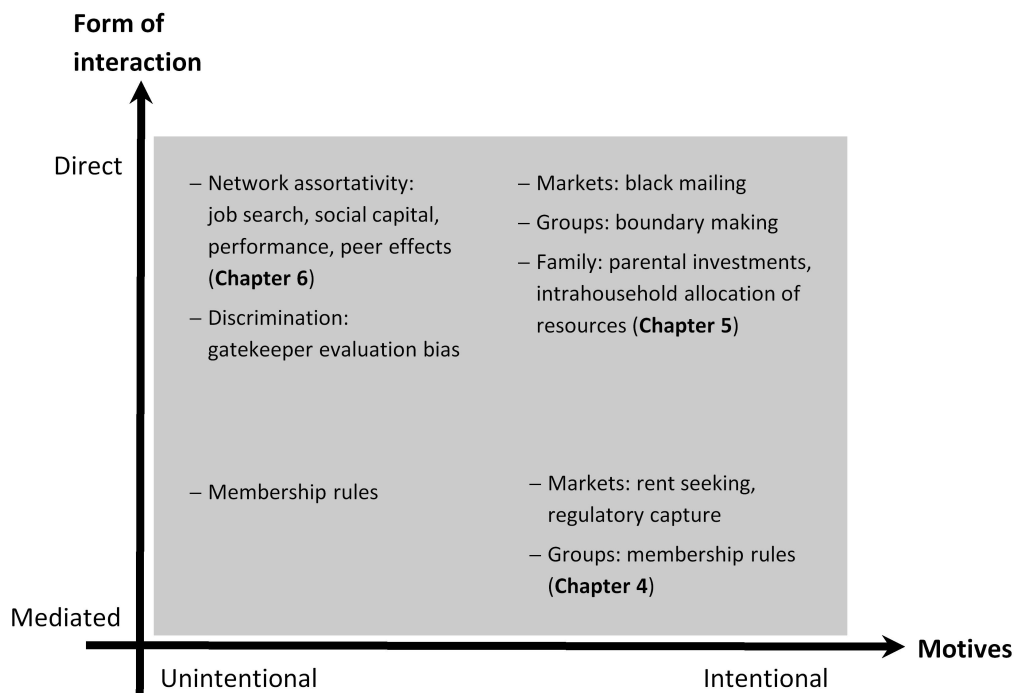


Figure 3.2: The closure space

Note that phenomena that on the surface appear to be the same form of closure, may conceal different types of exclusionary action. For example, a landlord

asking for higher rental prices from ethnic minorities might be either the prey of statistical discrimination (unintentional forms) or an outright racist (intentional forms). Similarly, laws to license professional practitioners, such as lawyers or doctors, may result both from lobby by professional associations acting in their own economic interest (intentional forms) or acting to protect the health of their patients from shady practitioners (unintentional forms). In the latter case, even if doctors are not involved in lobbying for the law with the sole purpose of increasing their economic benefits by excluding rivals from competition, the fact that the resulting regulation systematically grants them an economic advantage by securing preferential access to the market (e. g. through licensing), should suffice to consider those laws unintentional and mediated forms of exclusionary action comparable to unconscious instances of individual discrimination.

With this new definition of closure as exclusionary action at hand to guide empirical analysis and the 'closure space' to help classify different forms of closure, the next three chapters illustrate in depth how closure brings about inequality. **Chapter 4** explores mediated forms of closure in labor markets, mostly intentional, through membership rules and regulated labor markets. **Chapters 5 and 6** turn to direct forms of closure, both intentional and unintentional, analyzing the role of parental investment decisions on societal levels of skill inequality and the impact of language homophily on friendship ties among preschool children and their likely effect on inequalities in language development, respectively.

3.4 Summary

Interest in the concept of closure has come at a cost. The concept lost much of its precision and explanatory power through modifications by neo-Weberians and empirical inequality researchers. Extending the meaning of closure beyond collective actors and intentional action without sacrificing its action-based core has been the main goal of this chapter.

To avoid the risks of overstretching Weber's original definition of the concept, while acknowledging the complexity of the phenomenon it pretends to describe, closure was generalized as exclusionary action. According to this new definition, closure encompasses not only the concerted actions of groups to secure privileges but entails *all forms of preferential or discriminatory interactions and transactions among groups or categorically bounded individuals that accrue or secure benefits to one group or category by actively excluding others*. Forms of exclusionary action were spelled out along two dimensions: motives (intentional or unintentional) and forms of interaction (direct or mediated). Accordingly, while closure is always exclusionary in its consequences, it can be either intentional or unintentional in its advantage-seeking exclusionary motives and either face-to-face or channeled

through institutional or legal channels in its form of interaction.

Although this new definition of closure goes beyond Weber's initial formulation, it preserves its original action-based character while enlarging its scope in the form of a transformational, micro-to-macro mechanism evident in multiple domains. These multiple contexts where closure can be found include but are not restricted to exclusion of competitors from the market through rent-seeking and regulatory capture, exclusion from groups through membership rules, parental investments and intrahousehold allocation of resources in the family, assortativity in network formation, and gatekeeper evaluation bias. As exclusionary action, closure explains the emergence of intergroup inequality by connecting the action realm, consisting of group and individual interaction and transactions, with macro processes of collective accumulation of resources.

III. Closure and inequality in markets, families, and networks

Chapter 4

Closure in markets: closing the group or the market?

The rise of income inequality seems to have become the common denominator in industrialized countries since the 1980s and in particular since the 1990s (OECD, 2011). One of the most widely accepted explanations of the increased wage disparities in labor markets, especially among economists, is the so-called skill-biased technical change (SBTC). According to this thesis, the greater dispersion of income in industrialized economies is due to a shift in demand favoring qualified over non-qualified workers, precipitated by technological advances in agricultural, industrial, and services sectors alike (Berman, Bound, & Machin, 1997). Giving credence to this explanation are two additional phenomena also documented in those same countries where income inequality has grown: job polarization, or the increase in demand at the top and at the bottom but not in the middle of the skills distribution (Autor, Katz, & Kearney, 2008; Goos, Manning, & Salomons, 2009), and a much more pronounced growth in wage inequality between occupations than within them (Mouw & Kalleberg, 2010).

For sociologists, however, SBTC is not the whole story. As argued by Weeden and Grusky (2014), market failure in the form of rents, in particular those enjoyed by occupational groups, explains some of the growing inequality found in labor markets. According to this view, occupations are active collective actors who strategically attempt to increase demand for their services and constrain supply by controlling access to their ranks and regulating market entry, thus increasing their earnings above what could have been expected in a free market (Weeden, 2002). In other words, inequality rises through the combined effect of market and group closure as practiced by occupational groups.

In this chapter an agent-based simulation model (ABM) is designed and implemented to illustrate how the combined dynamics of market closure and group closure produce inequality.¹ Computer-based simulation models are a powerful and versatile method relatively underused in the social sciences as compared with

¹ This chapter can be found as part of a working paper in Cardona (2013a).

the physical and life sciences. Among the many uses of computer models to assist social scientists—including explanation, prediction, experimentation, and policy formulation (Grüne-Yanoff & Weirich, 2010)—theory development costs the least and is relatively less controversial in a discipline still distrustful of the advantages of computer simulation techniques. Instead of gaining theoretical insights through sheer introspection, computer-based simulations applied to theory development provide the option of running virtual thought experiments to extensively explore the internal consistency and hidden complex implications of interacting theoretical premises. Simulation is then, as some have argued, a third symbol system available to scientists for formulating theories in addition to mathematics and natural language and an ideal tool for theory development (Hanneman, Collins, & Mordt, 1995; Ostrom, 1988). Of the various existing simulation techniques such as microsimulation, system dynamics, or cellular automata, agent-based models (ABM) stand out as the preferred choice when simulated entities are thought to be heterogeneous, embedded in an environment, and expected to interact autonomously to reproduce nonlinear and out-of-equilibrium system dynamics (Gilbert, 2008). These properties, combined with increasing computing power, object-oriented programming, and advances in distributed artificial intelligence, have given ABM the edge in the vibrant and rapidly growing field of social computational modeling (Gilbert, 2008; Miller & Page, 2007; Squazzoni, 2012).

In the simulation developed in this chapter, a simplified labor market for professional services is assumed. The model represents an stylized labor market in which individuals compete for group membership and groups compete for market share by closing group boundaries and attempting to close the market in their favor. The purpose of the simulation is not to model realistically how individuals and groups compete in a particular market. Instead, the goal is to conduct a virtual experiment based on the theoretical premises implicit in the definition of closure and to explore how they interact to bring about inequality under simplified assumptions. Perhaps most importantly, the model reconstructs the causal paths through which the mechanism of closure operates in markets to produce inequality. Two main modeling decisions underlie the simulation:

- i) While allocation in markets for professional services can be affected both by self-employed practitioners who administer the conditions under which services are offered as well as by employers who hire those professionals as salaried labor, only the latter case was chosen for the simulation as it separates more clearly supply from demand on the one hand, and distinguishes between group and market closure on the other. In labor markets for professional services, professional groups (demand) can open and close their

- group boundaries independently from hiring decisions by employers (supply), who in turn can decide independently from group closure to close the market by favoring one group over the rest in the hiring process (Haupt, 2012).
- ii) Although inequality in labor markets is usually measured at the level of individuals—higher pay, shorter working hours, more stable jobs—the simulation focuses on differences between groups. In particular, it is assumed that groups compete for market share by attracting skilled workers in a market niche where the number of jobs is fixed and where worker skills are influenced by group average skills, a form of peer effects that is similar to the one discussed in **Chapter 6** for friendship networks among preschool children and for language development. Thus, high intergroup inequality is reached if a group dominates the market by hoarding workers with high skills while at the same time preventing workers with low skills from entering the group.

Additional model assumptions and their implementation in the model are explained below.

Building on the discussion about the two meanings of the Weberian definition of closure in **Chapter 2**, this chapter starts by spelling out four distinct causal paths that may lead to inequality among groups in a market for professional services (**Section 4.1**). Next, **Section 4.2** presents the design and implementation of the simulation, while **Section 4.3** presents the experimental design. Results are discussed in **Section 4.4**.

4.1 Individual and group competition: four causal paths

Implied in the Weberian notion of closure is the idea that competition for economic resources and opportunities can take the form of individuals going up against each other in a free-for-all market or of groups acting strategically by tightening their boundaries or attempting to exclude competitors with the purpose of raising the market success of its members. Abstracting from these dynamics of individual and group competition, four causal paths connecting individuals and groups to intergroup inequality can be spelled out.

- i) *Pure individual competition*. The definition of closure suggests that without group intervention in the free flow of the market, those best suited for competition end up better off than others not equally well equipped. Hence, the

- first causal path connects individual attributes to market outcomes directly, independently of group membership.
- ii) *Individual competition through group membership.* The definition of group closure implies the possibility that groups confer advantages to their members which enhance their capacity to compete for resources. If belonging to a group furthers individual market chances by improving their market-relevant attributes, for example, by having access to group-specific expertise, then group membership may be causally connected to market outcomes. Individuals still compete against each other in the market but they also compete for group membership. This competition for group access makes other attributes (not those necessary to be successful in the market) equally important. Thus, gender, age, ethnicity, or any other individual trait may indirectly affect market success insofar as these condition access to a group that increases individual market opportunities, even if taken alone those attributes do not affect market performance.
 - iii) *Group competition through group closure.* Intimately related to the latter, when groups have an impact on individual outcomes, they may act strategically by modifying their boundaries to enhance accumulated advantages by members. This is the case with rationally driven group closure. Membership rules are enacted and group advantages protected from outsiders. Groups that are more successful in protecting valued resources and opportunities will prevail in competition. Yet, even if groups compete to protect their assets, their advantage still depends on the attributes of their members. If group members fail in the market as individual competitors - for example, if the expertise hoarded by a professional group is no longer advantageous in the eyes of clients - group closure in itself cannot do much to curve market outcomes in favor of its members.
 - iv) *Pure group competition through market closure.* A fourth causal path draws a direct line between group membership and market outcomes, bypassing individual attributes. In a closed market, group affiliation exerts an independent effect on market access, hampering allocation rules based solely on individual attributes. If a group completely closes a market for itself, individual competition might still exist but only for members of the group that closed the market. All other potential contenders are not allowed to compete.

Needless to say, these four causal paths are mere analytical distinctions distilled from the very particular scenario depicted by the Weberian concept of closure where individuals and groups compete against each other with the sole pur-

pose of securing economic advantages. In the following, it will be shown using a simple ABM how these four mechanisms, individually or in combination, are sufficient to produce comparable levels of inequality among groups.

4.2 Model description

ODD stands for Overview, Design concepts and Details. It is a standard protocol developed by agent-based modelers in the field of ecology to overcome the difficulties of documenting, communicating, and replicating simulation models, which so far have mostly lacked standardized guidelines (Grimm et al., 2006, 2010). The purpose of the ODD protocol is to provide readers with the necessary general information to understand any simulation model as well as detailed technical information to replicate it in later independent simulation studies. Since its publication and subsequent update, the protocol has gradually won adepts not only among ABM modelers in ecology but also in other disciplines, including the social sciences (Janssen, Alessa, Barton, Bergin, & Lee, 2008).

Reading the “overview” section should be enough to get a general idea of the model. If readers are interested in understanding the inner workings of the model and how each process was designed and implemented, going through the “design concepts” and “details” sections is indispensable. Otherwise, these sections can be skipped.

4.2.1 Overview

Purpose. The purpose of the model is to illustrate how individual competition, group closure, and market closure separately or in combination are causally sufficient to produce inter-group inequality. The model does not attempt to realistically replicate any empirically observable system, but instead aims at revealing the distinct causal paths by which each of these processes affect the distribution of resources among groups. It simulates a simplified labor market with different degrees of market and group closure. Individual workers compete for a fixed number of jobs offered by a unique employer by choosing group membership, while groups compete for market share by closing or opening their boundaries and letting in more or fewer workers with different skill levels. The degree of market closure is given exogenously and benefits only one group.

Entities, State Variables, and Scales. The simulated market consists of three types of agents: workers, groups, and an employer. The only scale the model has is time, which is defined on a positive discrete scale starting at $t=0$. Since the time scale serves only to coordinate the decisions of the employer, workers, and

groups, its exact meaning is irrelevant. States variables and scales are summarized in **Table 4.1**

- Hiring decisions are made by a unique employer. There are three state variables: a fixed number of available jobs, group-specific hiring probabilities, and a hiring bias coefficient, which captures the degree to which a market is closed by modifying hiring probabilities of workers belonging to a particular group. The hiring bias coefficient is activated by default at $t=1$ and favors one group only.
- Workers belong to a particular group. They possess observable skills and a binary employment status (employed/unemployed). Workers' skills improve as a function of the average group skills of the group they belong to. There are no wages.
- Group size, potential size growth, market share, average skills, and employment rate are group-level auxiliary variables computed from worker variables. Market share differences are the main indicator of intergroup inequality. As agents, groups have only one state variable, a protection/expansion coefficient that indicates the group's preference for present and future market share. The coefficient is used to compute the degree of group closure in the form of an exclusivity factor or the probability that a group rejects a new member.

Table 4.1: State and auxiliary variables

Agents	State Variables	Auxiliary Variables
Employer	Number of jobs (demand) Hiring probability for each group Hiring bias coefficient	
Workers	Skills Group membership Employment status	Number of workers (supply)
Groups	Protection/expansion coefficient	Group size Potential size growth Market share Average skills Employment rate Exclusivity factor

Process Overview and Scheduling. Time t is discrete. Each t can be divided into three stages: before hiring, hiring, and after hiring. Before hiring, workers take

actions aimed at enhancing their market chances in t . During hiring, the employer hires workers. After hiring, groups adapt to the resulting market conditions by closing or opening their boundaries and prepare for $t+1$.

- *Before hiring:* At the beginning of each t , workers observe their own employment status and, if unemployed, they move to a group with a higher employment rate. A group's degree of closure determines whether these attempts are successful. If unemployed workers fail to enter the new group because of a high degree of group closure, they stay in their current group until $t+1$. Only after all workers have had the chance to move to a new group do groups compute their average skills, group size, and potential size growth. Workers then update their skills as a function of group average skills. Finally, groups update their average skills.
- *Hiring:* The employer observes the updated distribution of skills after some unemployed workers have moved to a new group and, given a certain degree of market closure, hires workers until the fixed number of jobs demanded is reached. All workers are hired again at each t .
- *After hiring:* Given the new distribution of employed and unemployed workers, groups update their market share and employment rate. They also decide whether to open or close their boundaries by modifying their exclusivity factor, which determines the probability of a worker being rejected when attempting to enter the group at $t+1$.

At the end of each t , time is increased by one unit and market share inequality is computed. The sequence of processes can be summarized as follows:

(Before hiring)

1. Workers [simultaneously]: Change group.
2. Groups [simultaneously]: Compute group size, average skills, and potential size growth.
3. Workers [simultaneously]: Update skills as a function of group average skills.
4. Groups [simultaneously]: Update group average skills.

(Hiring)

5. Employer: Hire workers.

(After Hiring)

6. Groups [simultaneously]: Compute group market share and employment rate.

7. Groups [simultaneously]: Close/open group.
8. Increase time by one unit. Compute market share inequality.

4.2.2 Design concepts

Basic principles. The basic processes modeled are pure individual competition, individual competition through group membership, and group competition through group closure under varying degrees of market closure. Implicit in these processes are four basic premises:

- i) Individual attributes are of importance for the allocation of resources (pure individual competition). Skills determine access to jobs.
- ii) When a group offer advantages to its members, individuals have an incentive to enter the group (individual competition through group membership). Workers skills grow as a function of group average skills.
- iii) Groups have an incentive to close their boundaries to protect the resources held by their members (group competition through group closure). Workers with low skills are left out of the group.
- iv) Groups benefit from closing the market and excluding rival groups from competition (pure group competition through market closure). All workers in one group benefit from higher hiring probabilities.

In the model, individuals compete for jobs either directly by offering their skills to the employer or indirectly by choosing group membership and benefiting from future skill upgrades. In the case of group closure, the model concentrates on strategic boundary making driven by shared economic interests, operationalized as behavioral rules which are sensitive to market share and potential size growth, depending on the preferences of the group for present or future market share. No other motives for group closure are modeled. Market closure is not explicitly modeled as a collective action. Instead, only the effect of closing the market, namely the degree of market closure (*Geschlossenheit*), and not the process itself (*Schließung*) was implemented as a simplification of pure group competition through market closure. As discussed in **Chapter 2**, strategically closing a market to favor one's group requires some form of concerted action aimed at modifying the allocation rules of the market (e. g., the employer), which in turn presupposes a direct intervention of the state or other entity capable of regulating market transactions. Developing an explicit model for market closure that takes into account these complexities exceeds the analytical simplicity sought with the present model and therefore this was not implemented.

Emergence. Intergroup inequality is the most interesting emergent property of the model and is a direct result of the combined effect of individual and group competition. Differences in market share are the clearest indicator of inequality. The higher the difference, the higher intergroup inequality will be (see *Index of market share inequality* in the **Submodels on page 113**).

Adaptation. Unemployed workers adapt to market conditions by moving to a group with a higher employment rate. At the same time, groups adapt to market conditions by opening or closing group boundaries in an attempt to protect or increase market share in the next period by keeping workers with lower skills at bay. To do so, they have to decide between tightening group boundaries, which protects group average skills and secures current market share, or making boundaries more permeable, which increases group size and may secure a larger portion of the market in the longer term at the cost of lowering average skill levels in the short run. Whether protection of accumulated resources or expansion is preferred depends on the group's protection/expansion coefficient as well as on their current market share and potential size growth. By contrast, since the degree of market closure is exogenous and fixed at $t=1$, it is insensitive to market conditions. All decisions in the model are rule based and involve no costs.

Objectives. Neither workers nor groups have an explicit objective function to maximize. However, both groups' and workers' rule-based adaptive behavior assumes an implicit objective. Groups strive to increase their market share, while workers aim at increasing the probability of getting a job. Adaptive behavior is heuristic and does not guarantee obtaining the expected results.

Prediction. A form of prediction is implied by the behavioral rules that groups and workers follow to adapt to market conditions. When a group closes its boundaries, it behaves as if it knew that by doing so the level of skills, and with it its market share, will be safeguarded against new members with low skills in the future. Similarly, when a group opens its boundaries, it acts as if it could foresee the higher market share that could be achieved later if the group grew in size by admitting new members. By the same token, unemployed workers move to groups with a higher employment rate as if they could estimate the probability of getting a job in $t+1$. This predictive behavior is, again, ruled based and does not follow from the maximization of any explicit objective function.

Sensing. The model assumes a market with perfect information. Sensing is global and information is observed without error. The employer observes the skills of all workers. Workers observe their own skills and employment rates of

all groups. Groups observe their average skills, group size, market share, and total number of workers in the market.

Interaction. Individual and group competition for jobs is the main form of interaction in the model. Competition is not direct but mediated. In the case of workers, they compete against each other for jobs and for group membership. Job competition is mediated by the employer, who has the power to change the employment status of workers. Group membership competition is in turn mediated by groups and their decision to accept or reject new group members based on their exclusivity factor. Similarly, group competition does not involve a direct interaction among groups. Rather, it is mediated by the degree of group and market closure. When closing boundaries, groups compete for workers and their skills by modifying their exclusivity factor, depending on market conditions, particularly market share and potential size growth. Group competition is further mediated by the size of the employer's hiring bias coefficient. If the coefficient is high, a group may secure an advantage in hiring for all their members on top of skill level, and thus gain a decisive edge over rival groups.

Stochasticity. Random numbers are used to generate agents' heterogeneity. Workers' skills are random in order to avoid creating intergroup inequality from the outset and to allow for differences in market share among groups to emerge from the adaptive strategies of agents. The protection/expansion coefficient of each group is also randomized. This makes the model less predictable and makes it possible to explore the dynamics of individual competition under different protection/expansion tendencies of groups.

Collectives. Groups are both a collection of workers and a type of agent in the model.

Observation. A dataset with average values of key variables for each model variation, design point, experimental run, and time period is produced (see *Experimental Design on page 114* below). In addition to the parameters of each design point, including number of groups, unemployment rate, and hiring bias coefficient, the dataset reports average protection/exclusion coefficients and exclusivity factors of the top percentile of groups ranked according to their employment rate. The maximum group size in each period and the main output variable, the index of inequality in market share, are also reported.

4.2.3 Details

Initialization. Time starts at 0. The model was initialized with 30 unemployed workers in each group. The exclusivity factor was initialized with the value of 1 to prevent workers from changing group in $t=1$ when all workers are still unemployed. The hiring probability for each group was set to 1 divided by the number of groups. The hiring bias coefficient at $t=0$ is 0. Hence, without market closure, members of all groups have the same probability of being hired. A log-normal distribution with identical parameters for each equally sized group is used to generate workers' initial skill level. There are two reasons why a log-normal distribution is suitable for representing workers' skills. First, all values of a log-normal distribution are positive, something that cannot be guaranteed with a normal distribution. And second, the skewness and right tail of the resulting skill distribution resembles observed income distributions in real labor markets.² Skills are redrawn every simulation run. The speed of skill growth, which is controlled by a constant C or skill growth modifier (see **Section 4.2.4** below), was set at a low arbitrary level of 1% to avoid explosive skill growth. Similarly, to prevent all unemployed workers rushing to the group with the highest employment rate, they choose randomly among the top 20% of the distribution of group employment rate. Initialization values are summarized in **Table 4.2**.

Table 4.2: Initialization of key parameters

Parameter	Value
Constants	
Workers per group (supply)	30
C (skill growth modifier)	0.01
Reference percentile for group change	80
Agents' state/auxiliary variables	
Employment status	0
Hiring probability	1/number of groups
Hiring bias coefficient	0
Exclusivity factor	1
Pseudo-random parameters	
Workers' skills (one distribution for each group)	Log-normal distribution (underlying normal distribution with $\mu =$; $\sigma = 0.2$).
Protection/expansion coefficients (one value for each group)	Uniform continuous distribution; range: see factorial design.

² See Limpert, Stahel, and Abbt (2001) for a discussion of these and more properties of log-normal distributions.

Input data. No external data was used to initialize the simulation.

4.2.4 Submodels

For each of the processes listed above in the model description, the exact agent behavior is explained below.

Change group (workers). After hiring takes place, some workers remain unemployed. Faced with unemployment, workers have to choose between remaining in their current group and profiting from the skills of their fellow workers, or changing to a new group and profiting from them instead. To avoid complicated calculations of the probability of getting a job as a member of any group at $t+1$ given observed group average skills and hiring probabilities at t , workers make their decision to change groups based on a simple heuristic followed simultaneously by all unemployed workers (synchronous updating). Unemployed workers move to one randomly chosen group from the top x percent of the group employment rate distribution. All things equal, the observed group employment rate at t is the best indicator of the probability of getting a job as a member of a given group at $t+1$. However, not all things are equal. Given that workers' own skill level affects group average skills, changing group in this way involves a sizable amount of uncertainty. Even if all workers observe the same group employment rate distribution before changing groups, the number of workers actually moving to a new group and the resulting modified group skills are unknown to each worker. Moreover, they are also unaware of how many workers are in fact accepted in the new group and hence cannot accurately predict their skills level *after* workers have been reshuffled. Whether workers changing groups are rejected by the new group depends on the group's exclusivity factor or probability of rejection. This is operationalized for every attempted change of group as a unique trial drawn from a binomial distribution with $p = \text{exclusivity factor}$.

Compute group variables (groups). At each t , group size (S), potential size growth (S_p), market share (M), average skills (K_{Avg}), and employment rate (E) of a group g comprising n workers i are described by **equations 4.1, 4.2, 4.3, 4.4 and 4.5**, respectively.

$$S_{p,t}^g = 1 - \frac{S_t^g}{\text{Total supply}} \quad (4.1)$$

$$S_t^g = \sum_{i=1}^{n_t^g} \text{Workers}_{i,t}^g \quad (4.2)$$

$$M_t^g = \frac{\sum_{i=1}^{n_t^g} \text{Employed Workers}_{i,t}^g}{\text{Total demand}} \quad (4.3)$$

$$K_{Avg,t}^g = \frac{\sum_{i=1}^{n_t^g} K_{i,t}^g}{n_t^g} \quad (4.4)$$

$$E_t^g = \frac{\sum_{i=1}^{n_t^g} \text{Employed Workers}_{i,t}^g}{S_t^g} \quad (4.5)$$

Update skills (workers). Workers i in each group g update their skills (K) as a function of groups' average skills according to **equation 4.6**.

$$K_{i,t}^g = K_{i,t-1}^g + C \cdot \ln\left(\frac{2 \cdot K_{Avg,t}^g}{K_{i,t-1}^g}\right) \quad (4.6)$$

Without the inclusion of a simple mechanism to update workers' skills, the results of the simulation would be trivial. Given that the employer hires workers with the highest skills and that skills are randomly distributed among individuals and groups, not allowing skills to be modified would mean workers on the upper area of the skill distribution would tend to remain employed until the end of the simulation. The same result would be achieved if skill growth is a linear function of actual skill growth: the higher the skill level, the faster the skill growth. The solution is to allow skills to grow as a function of group average skills but correct for actual skill level. As given by **equation 4.6**, the skills of workers below group average grow faster than those above group average. Multiplying group average skills by 2 prevents growth from becoming negative for workers with above-average skills. The constant C or skill growth modifier controls how fast or slowly skills grow within the group.

Hire workers (employer). Hiring is an iterative process. The employer observes the updated distribution of skills after unemployed workers have moved to a new group and puts them in descending order. He then hires workers one at a time by setting their employment status to *employed* starting from the worker with the highest skill level down the distribution of skills until the fixed number of jobs demanded is reached. It is assumed that at each t , all workers are actively looking for a job, regardless of market conditions and employment history. This implies that before hiring, the employment status of all workers is set to unemployed. Although in principle all members of a given group enjoy the same probability $P_H = 1/(\text{number of groups})$ of being hired, those at the end of the

queue are less likely to get the job since the probability that vacancies remain unfilled falls with each hiring iteration. The decision of hiring is operationalized as a unique trial drawn from a binomial distribution with $p =$ group's hiring probability (P_H). Hiring decisions are, without hiring bias, 'group blind.' However, if the degree of market closure is greater than 0, the hiring probability P_H of the one group favored by market closure is modified upwards by a hiring bias coefficient (B_H), while that of the excluded groups is modified downwards as described by **equation 4.7**.

$$\text{Modified } P_H^g = \begin{cases} P_H^g + B_H \cdot (1 - \frac{1}{N}) & \text{if group benefits from market closure,} \\ P_H^g - B_H \cdot \frac{1}{N} & \text{if not} \end{cases} \quad (4.7)$$

The hiring bias coefficient (B_H), takes values between 0 (open market with equal hiring probabilities for each group) and 1 (closed market with hiring probability of 1 for one group and 0 for all others). Note that since $1/N$ is the initial hiring probability, what **equation 4.7** does is to modify the hiring probability of each group, either bringing it closer to 1 (first if condition) or closer to 0 (second if condition). The magnitude of the modification in both cases is a percentage of the distance between actual hiring probability and 1 or 0, respectively. As shown in **Table 4.3**, with two groups (1 and 2), this means that the gain in absolute terms in the hiring probability of the group benefiting from market closure (P_H^1) is identical to the loss of group 2 (P_H^2). Hence $\Delta P_H^1 = \Delta P_H^2$. With $N > 2$, the equal losses of each group not benefiting from closure is added to the hiring probability of the privileged group.

Table 4.3: Modified P_H^g with $N = 2$ for different levels of B_H

B_H	P_H^1	P_H^2	$\Delta P_H^1 = \Delta P_H^2$
0.00	0.50	0.50	0.00
0.20	0.60	0.40	0.10
0.40	0.70	0.30	0.20
0.60	0.80	0.20	0.30
0.80	0.90	0.10	0.40
1.00	1.00	0.00	0.50

Close/open group (groups). Unlike market closure, group closure is endogenous. At each t , groups compute an exclusivity factor (EF) based on observed market share (M_t^g), potential size growth ($S_{P,t}^g$), and protection/expansion coefficient ($X_{P/E,t}^g$) as described by **equation 4.8**.

$$EF_t^g = 0.5 + \frac{X_{P/E}^g \cdot M_t^g - (1 - C_{P/E,t}^g) \cdot S_{P,t}^g}{2} \quad (4.8)$$

$X_{P/E}$ controls the relative importance of present market share and future market share in deciding how closed or open group boundaries should be. There is no utility function to maximize, nor a discount rate for values of future market share. A simple behavioral rule is assumed on the basis of observed state variables. The higher the value of $X_{P/E}$ and the higher the market share, the more likely it is that a group protects current employed workers by closing its boundaries to incoming unemployed workers. The more exclusive a group becomes, the higher the probability of rejecting new members up to a maximum value $EF = 1$ ($X_{P/E}^g = 0, M_t^g = 1$). By contrast, the lower the value of $X_{P/E}$ and the higher the potential size growth, the more a group values growing in size as a means to a higher market share in the future. This leads to more permeable boundaries or no boundaries at all if the minimum is reached, where 0% of all new members are accepted ($X_{P/E}^g = 0, S_{P,t}^g = 1$). $X_{P/E}$ varies among groups. It is defined at the beginning of every simulation and remains constant for a particular simulation run.

The simple mechanism to set the exclusivity factor described by **equation 4.8** captures the logic of rationally driven group closure, as discussed in **Section 2.4** above. Driven by shared economic interests, groups close their boundaries to protect accumulated resources and open their boundaries to expand group size in the hope of increasing market share. Moreover, given that the exclusivity factor takes the form of a probability, it is not necessary to be explicit about which attributes of workers are relevant for gaining access to the group. In the case of professional associations, it could, for example, be assumed that membership rules focus on those same skills that members need to be successful in the market. However, this need not always be the case. Group membership may be decided on the basis of ascriptive traits such as gender, ethnicity, or religion which bear little weight on the skills valued in the market. Explicitly modeling membership rules using different individual attributes correlated to different degrees to skills might be an interesting extension of this submodel.

Index of market share inequality (intergroup inequality). The index measures the ratio of the average distance of individual group market shares to mean market share and the maximum possible size of that distance. For a total of N groups, the numerator of the index is defined as the mean absolute deviation (MAD) of the distribution of group market shares M at t , as given by **equation 4.9**. With market share defined in the interval $[0,1]$, mean market share $M_t^{Avg} = 1/N$.

$$MAD_t = \frac{\sum_{g=1}^N |M_{g,t} - M_t^{Avg}|}{N} \quad (4.9)$$

Since market share is a number between 0 and 1, the maximum mean absolute

deviation of the distribution MAD^{max} for the market share (M) of any given number of groups N is reached when one group dominates the market with a market share of 1 while all other groups have a market share of zero. Thus, MAD^{max} can be simplified to **equation 4.10**.

$$MAD_t^{Max} = \frac{2 \cdot (N - 1)}{N^2} \quad (4.10)$$

Dividing (9) by (10), the index of intergroup market share inequality (I) is obtained in equation (11).

$$I_t = \frac{MAD_t}{MAD_t^{Max}} = \frac{N \cdot \sum_{g=1}^N |M_{g,t} - M_t^{Avg}|}{2 \cdot (N - 1)} \quad (4.11)$$

If the market share of all groups is equal, the index drops to the minimum value of 0. By contrast, if one group dominates the market, the index peaks at a maximum value of 1. As an example, **Table 4.4** shows the results of **equations 4.9**, **4.10**, and **4.11** with $N = 2$ groups in the market and using arbitrarily chosen market shares. A maximum level of intergroup inequality is reached at $t = 1$ and $t = 7$, while the minimum level is obtained at $t = 4$.

Table 4.4: Example of values of index of market share inequality (I)

t	$M_{1,t}$	$M_{2,t}$	MAD_t^{Avg}	MAD_t	MAD_t^{Max}	I_t
1	0.00	1.00	0.50	0.50	0.50	1.00
2	0.20	0.80	0.50	0.30	0.50	0.60
3	0.40	0.60	0.50	0.10	0.50	0.20
4	0.50	0.50	0.50	0.00	0.50	0.00
5	0.60	0.40	0.50	0.10	0.50	0.20
6	0.80	0.20	0.50	0.30	0.50	0.60
7	1.00	0.00	0.50	0.50	0.50	1.00

4.3 Experimental design

The model was implemented using Python.³ DOE was used to set up the experiment and initialize the remaining model parameters (Lorscheid, Heine, & Meyer, 2012), including number of time periods, number of groups, unemployment rate (intensity of individual competition), and hiring bias coefficient. As already explained above, the hiring bias coefficient implements the degree of market closure as an exogenous parameter. By contrast, the degree of group closure captured by the exclusivity factor is determined endogenously (see submodels). **Table 4.5** summarizes dependent, independent, and control variables.

³ <https://www.python.org/>

Table 4.5: Classification of variables

Dependent variable	Independent variable	Control variables
Average differences in market share over all t (index of market share inequality).	Hiring bias coefficient	Time periods Number of groups Unemployment rate

A factorial experimental design with three factor levels for control variables and eleven factor levels for the independent variable, a total of 108 design points, was implemented (**Table 4.6**). To establish the optimal number of runs (n) for each set of factors, the experimental error was computed for the dependent variable in a subsample of 48 design points for $n = 5, 10, 15, 20, 25, 50, 100, 250,$ and 500 . For each n and each design point, the coefficient of variation $C_v = \frac{\text{standard deviation}}{\text{mean}}$ was estimated (Lorscheid et al., 2012). Results indicate that C_v stabilizes around 30 iterations at most, although for over half of the subsample of 48 design points, results are stable even with as few as 5 runs. As a result, 30 iterations were run for each design point.

Table 4.6: Factorial design

Factors	Factor level range	Factor levels
Hiring bias coefficient	$[0, 1]$	$\{0, 0.2, 0.4, 0.6, 0.8, 1\}$
Time periods	$[0, \infty]$	$\{100, 300\}$
Number of groups	$[2, \infty]$	$\{5, 10, 25\}$
Unemployment rate	$[0, 1]$	$\{0.1, 0.2, 0.4\}$

Using this factorial design, three models were explored. First, a null model was run for the 18 combinations of control variables in which all workers' and groups' actions are turned off. Workers do not change groups, nor are their skills updated. Groups refrain from closing the group. Second, an open-groups model was run for all 108 design points with group closure turned off. Third, a full model including all processes described in **Section 4.2** was used. The diverse constellations produced by these three models allow us to explore intergroup inequality under varying degrees of market and group closure, time horizons, number of competing groups, and labor market conditions. Most importantly, it makes it possible to investigate the four causal paths connecting individual and group competition to intergroup inequality separately (see **Section 4.1**). **Table 4.7** summarizes the three model variations.

Table 4.7: Model variations

Model	Restrictions	Design points
Null model	Workers: no skill upgrade, no group change. Groups: no group closure. Hiring bias coefficient (degree of market closure) = 0.	18
Open-groups model	Groups: no group closure.	108
Full model	None	108

4.4 Results

To better understand the different processes modeled, each of the four causal paths identified in **Section 4.1** was isolated and analyzed separately. Since the simulations were run 30 times and over various time periods for each parameter setting, results are presented as box plots of the distribution of model outcomes over all time periods, except for the initial period $t = 0$, and all model runs.

4.4.1 Pure individual competition

[*Null model.*] Turning off group closure and workers' skill updates, and setting the degree of market closure to zero, the model becomes predictable. Without group hiring bias and skill growth, market inequality is fully explained by the differences in skill levels among groups. Although those with the highest skills are more likely to be employed, since skills are drawn randomly from a log-normal distribution with identical parameters for each group, differences in market share among groups remain low. Intergroup inequality could be arbitrarily raised by simply initializing the model with an unequal distribution of skills among groups.

As shown in **Figure 4.1**, the only factor that affects the overall level of intergroup inequality is the unemployment rate. Given that hiring starts with the workers with highest skills and goes on iteratively down the distribution of skills until all vacancies are filled, the higher the unemployment rate, or, put differently, the fewer the vacancies, the more crucial it is to be at the front of the skills queue. In other words, given the way the hiring process was implemented, a tight labor market elevates the premium of having higher skills. Higher rates of unemployment magnify any small differences in the skill distribution among groups and produce comparatively greater intergroup inequality.

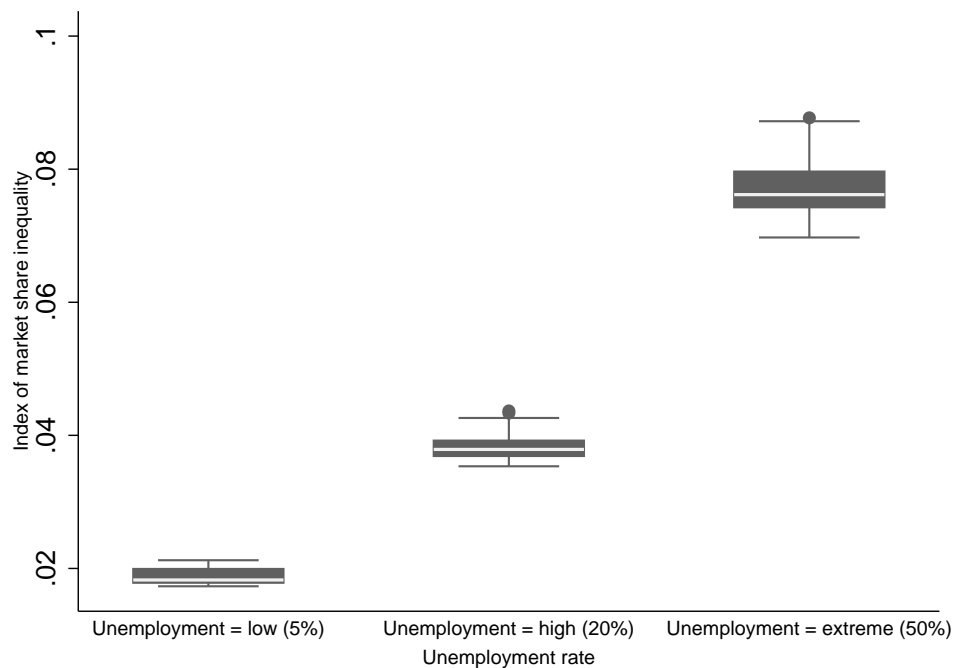


Figure 4.1: Pure individual competition, intergroup inequality and unemployment

4.4.2 Individual competition through group membership

[Open-groups model with degree of market closure = 0.] Allowing for skills to grow as a function of group average skills and for unemployed workers to move freely to groups with higher employment rates dramatically increases the levels of intergroup inequality. As shown in **Figure 4.2**, a smaller number of groups and larger unemployment rates are associated with higher intergroup inequality. As unemployment rates grow, the pressure on unemployed workers to leave the group increases. Groups with higher employment rates tend to attract more unemployed workers over time and quickly consolidate into a few big groups. Some groups even lose all their members during this process of polarization of market share. The fewer groups in the market, the more likely it is that a single dominant group emerges and hoards most of workers. Thus, in addition to inequality produced by pure individual competition, as individual competition through group membership increases, driven by high unemployment and small numbers of alternative groups to move to, intergroup inequality explodes.

4.4.3 Group competition through group closure

[Full model with degree of market closure = 0.] Adding group closure to the mix, groups have the choice of regulating how many unemployed workers they let

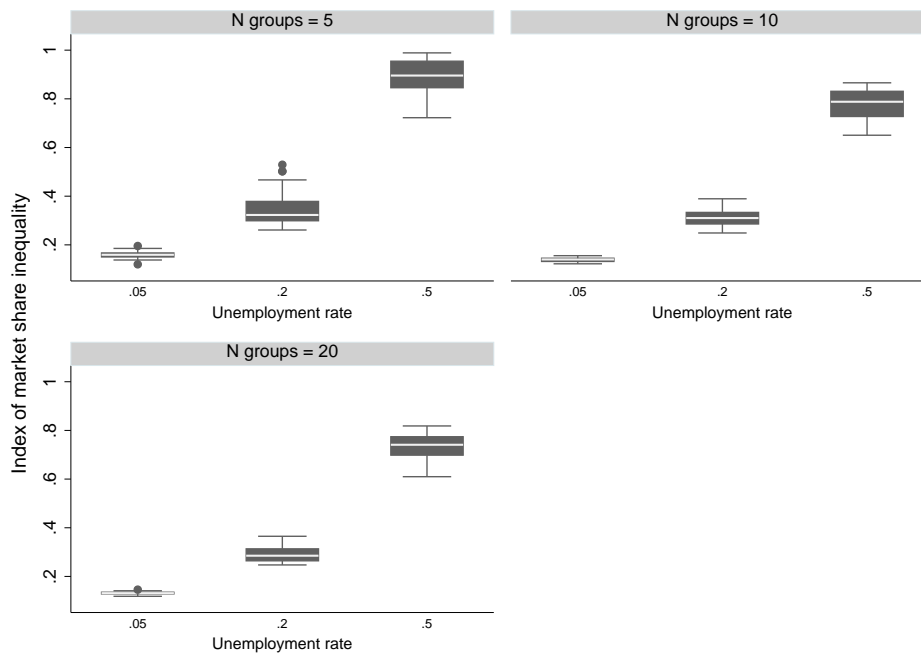


Figure 4.2: Individual competition through group membership, intergroup inequality, number of groups, and unemployment

in. The more they value present market share, the more likely they are to reject new workers. The opposite is true when groups place more emphasis on size growth and future market share than in protection of current market share. However, all else held constant, more groups necessarily implies smaller initial market shares for each group and hence bigger potential size growth. Therefore, even when protection/expansion coefficients indicate a high preference for present market share, and irrespective of level of unemployment, if the number of groups is large, groups are more readily inclined to open their boundaries and bet on expansion. This tendency is depicted on **Figure 4.3** using mean values of the exclusivity factor for the top quintile of groups with the highest employment rate over all experiments.

As it was shown with models (i) and (ii), with open groups, higher unemployment leads to a process of market share polarization and high intergroup inequality, particularly pronounced when the number of groups is small. However, allowing for group closure, the same process that drives group consolidation forward also pushes groups to tighten their boundaries. Instead of exacerbating intergroup inequality when unemployment is high, group closure in fact reduces inequality by putting a cap on the process of group consolidation and limiting the emergence of extreme differences in market share. Closed groups do not grow. As shown in **Table 4.8**, the relationship between group closure and intergroup

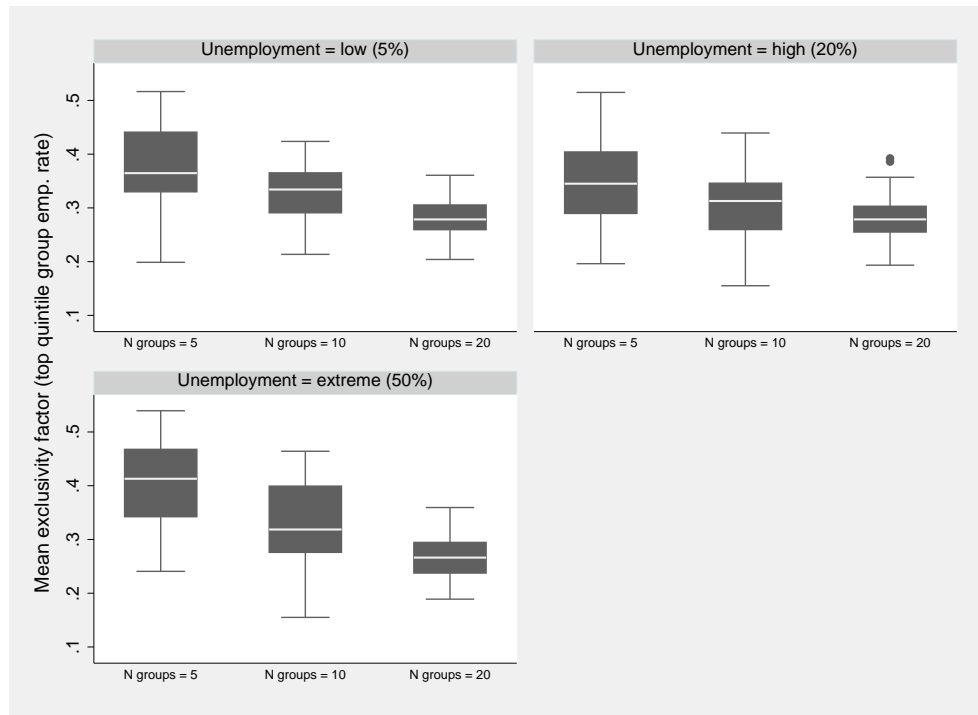


Figure 4.3: Mean exclusivity factor and group size

inequality tends to be more negative with fewer groups and higher unemployment rates. The higher the floating population of unemployed workers, the more effective is group closure in preventing one group from dominating the market, although inequality tends to be greater with higher unemployment. At extreme levels of unemployment and with many groups in the market, the negative relationship between group closure and inequality seems to flatten somewhat. Under such extreme conditions, the sheer number of workers rushing to the groups with the highest employment rate takes away some of the effectiveness of group closure to slow down market share polarization.

Table 4.8: Correlation between market share inequality and mean exclusivity factor

	Unemployment		
	low (5%)	high (20%)	extreme (50%)
N groups = 5	-0.03	-0.60	-0.57
N groups = 10	-0.24	-0.69	-0.56
N groups = 20	-0.33	-0.57	-0.36

4.4.4 Pure group competition through market closure

[Open-groups model with variable degree of market closure.] Contrary to the inhibitory effect of group closure on the process of consolidation of group size and polarization of market share observed in a model with unfettered individual competition in a market with open group boundaries (ii), market closure acts as a catalyst. By allowing workers to move freely into the group benefiting from market closure, the emergence of a dominant group that hoards all workers and jobs is unavoidable and swift. The higher the degree of market closure, the faster a dominant group appears. Increasing the number of groups slightly slows down the process (see **Figure 4.4**), while higher unemployment further accelerates it (see **Figure 4.5**).⁴ In the end, however, is only a matter of time until intergroup inequality inescapably reaches its maximum value of 1.

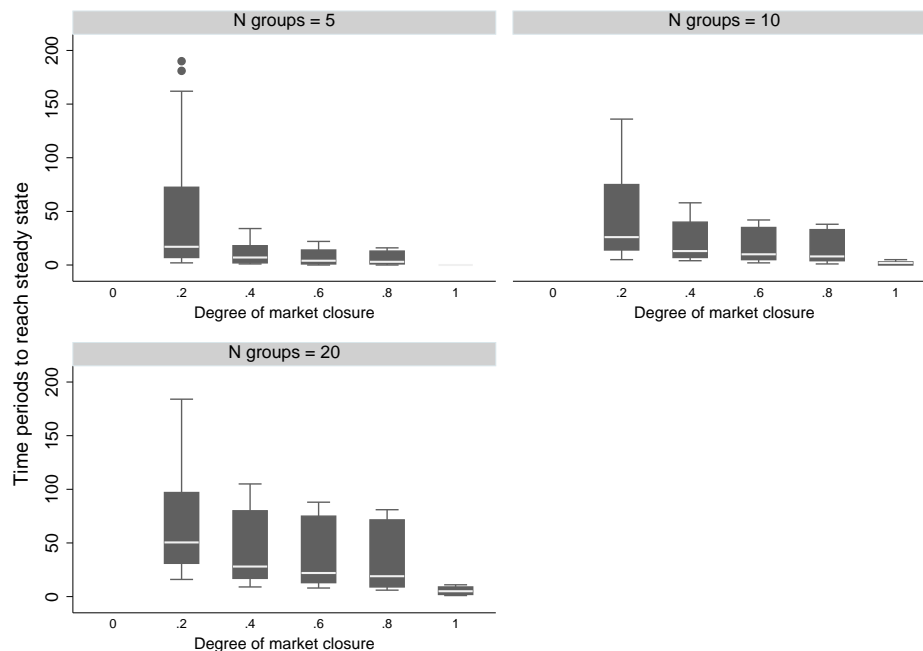


Figure 4.4: Number of groups and number of periods to reach maximum inequality

After this discussion of how each of the four processes of individual and group competition bring about intergroup inequality separately, **Table 4.9** summarizes the minimum, mean, and maximum levels of market share inequality produced by each process. As was argued above, results show that each process is independently sufficient to produce moderate and high levels of intergroup inequality. The fact that pure individual competition generates only relatively low levels of

⁴ Given that in some cases the steady state of the model is not reached after 100 periods of time, the graphs only show the design points where time was allowed to reach 300.

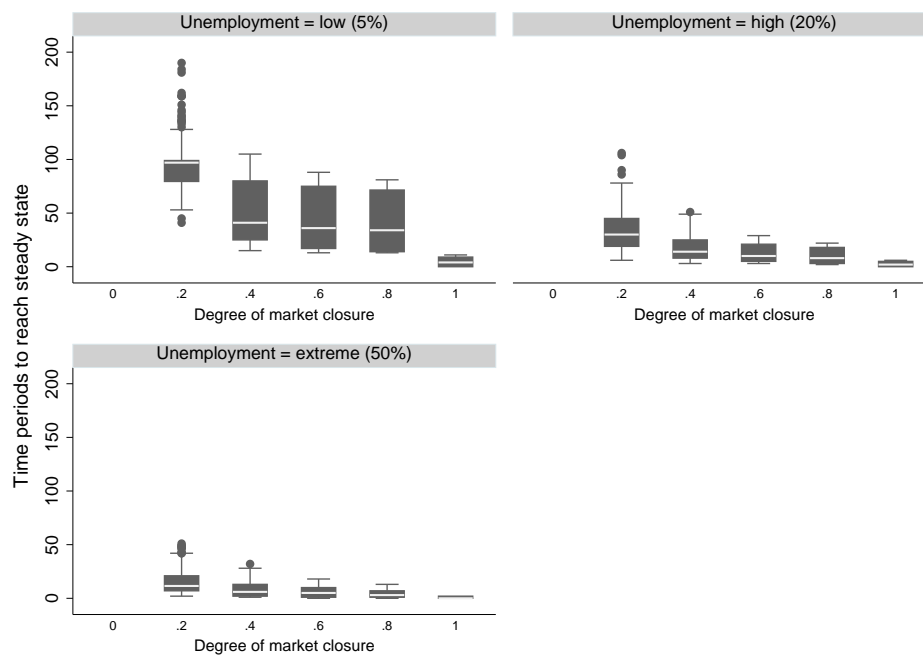


Figure 4.5: Unemployment and number of periods to reach maximum inequality

market share inequality should not affect the validity of this conclusion, since it follows from the conscious decision to initialize the model with worker skills equally distributed among groups. Initializing the model with an unequal distribution of skills would mean market share inequality reaching high values comparable to those in processes ii, iii, and iv.

Table 4.9: Different levels of inequality obtained from each model

Index of market share inequality	Min	Mean	Max
(i) Pure individual competition	0.02	0.04	0.09
(ii) Individual competition through group membership	0.12	0.42	0.99
(iii) Group competition through group closure	0.10	0.32	0.78
(iv) Pure group competition through market closure	0.61	0.95	1.00

4.4.5 All processes at the same time

While each process can produce high levels of inequality separately, what happens if they all interact simultaneously? Letting all independent and control variables vary in the full model makes it difficult to understand the output using simple two-dimensional graphs as has been done so far. Instead, regression analysis was used on the output dataset to produce a three-dimensional response surface that represents the relationship between degree of market closure, degree of

group closure, and intergroup inequality under different combinations of number of groups and unemployment rate for each experiment across all design points. Since the dependent variable, the index of market share inequality, is defined in the range [0,1], a Tobit regression was used with right-censored values set at 1. Independent and control variables were included linearly in the model, as well as interaction terms among them and quadratic terms for degree of market and group closure.

Results are shown in **Figure 4.6**. Darker regions of the surface (red) correspond to higher inequality, lighter regions (blue) to lower inequality. Three results are worth mentioning. First, as already shown in the previous model variations, it is still true that higher unemployment and fewer groups exert pressure on workers to amalgamate into a few dominant groups and produce high levels of intergroup inequality. Thus, on average, market share inequality is highest in the top right-hand graph (5 groups and extreme unemployment) and lowest in the bottom left-hand graph (20 groups and low unemployment).

Second, the interaction between group and market closure is not linear and depends on both number of groups and unemployment rate. Although low degrees of group closure combine with high levels of market closure to increase intergroup inequality, as group closure increases, it waters down the impact of market closure on inequality. Therefore, from the perspective of group closure, market closure enhances its power to slow down market share polarization; from the perspective of market closure, group closure reduces its effectiveness to accelerate that same process. The negative interaction between the two forms of closure becomes stronger the more intensive individual competition for group membership is, as captured by number of groups and unemployment rates. Why the interaction is negative is easy to reconstruct. If employers are only allowed to hire workers from one group (high degree of market closure) but only a small portion of unemployed workers are permitted into the group (high degree of group closure), a labor shortage is created that reduces the overall number of employed workers and limits market share differences among groups. The interesting question raised by this combination of high levels of market and group closure is what happens when demand remains unsatisfied, something that was not modeled in the simulations. Will groups change their preference for future market share and open the group despite market dominance to meet excess demand? Or will the employer simply decide to ignore market closure and hire workers from other groups to fill all vacancies? If labor shortage leads to opening the group, intergroup inequality would rise further, whereas if it leads to opening the market, inequality would fall.

Third, and in line with the results summarized in **Table 4.9**, different combinations of individual and group competition produce varying levels of intergroup

inequality, from low through intermediate to high. A high degree of market closure leads to high levels of inequality if combined with a low degree of group closure, but it produces intermediate market share inequality if group closure is high. By contrast, while a low degree of group closure produces low intergroup inequality if combined with no market closure, as the degree of market closure grows, so does inequality. In addition, and irrespective of levels of group or market closure, a reduced number of groups and a higher unemployment rate push market share inequality upwards.

In conclusion, not only are pure individual competition, individual competition through group membership, group competition through group closure, and pure group competition through market closure independently sufficient to produce comparable levels of inequality, but also their interaction is equally capable of bringing about a comparably broad spectrum of possible levels of intergroup inequality. This is the reason why, in the face of a given unequal distribution of resources, for instance, a market for accountancy services where 80% of all transactions are in the hands of one particular professional association, these four different causal paths have to be analyzed and their distinct effects disentangled both analytically and empirically. Are practitioners accounting for 80% of the market better competitors if taken individually? Is their individual advantage the result of group membership? What attributes are decisive for becoming part of a group that grants advantages to its members? Or is their advantageous position the inevitable consequence of a market in which allocation rules are biased towards one group? Failure to answer these questions will render any explanation of intergroup inequality incomplete.

4.5 Summary

The aim of this chapter was to demonstrate how market and group closure operate to causally produce inequality in markets. A computer-simulated agent-based model (ABM) of a simplified market for professional services was implemented and used to conduct virtual experiments of the effect of closure on market share inequality of competing professional groups under varying market conditions. In the model, individual workers compete for a fixed number of jobs offered by a unique employer by choosing membership in a professional group, while groups compete for market share by closing or opening their boundaries and letting in more or fewer workers with different skill levels. The degree of market closure is given exogenously and benefits only one group. Results show that individual competition, market closure, and group closure, both individually and in combination under different levels of unemployment and varying numbers of groups, are causally sufficient to produce high levels of intergroup inequality.

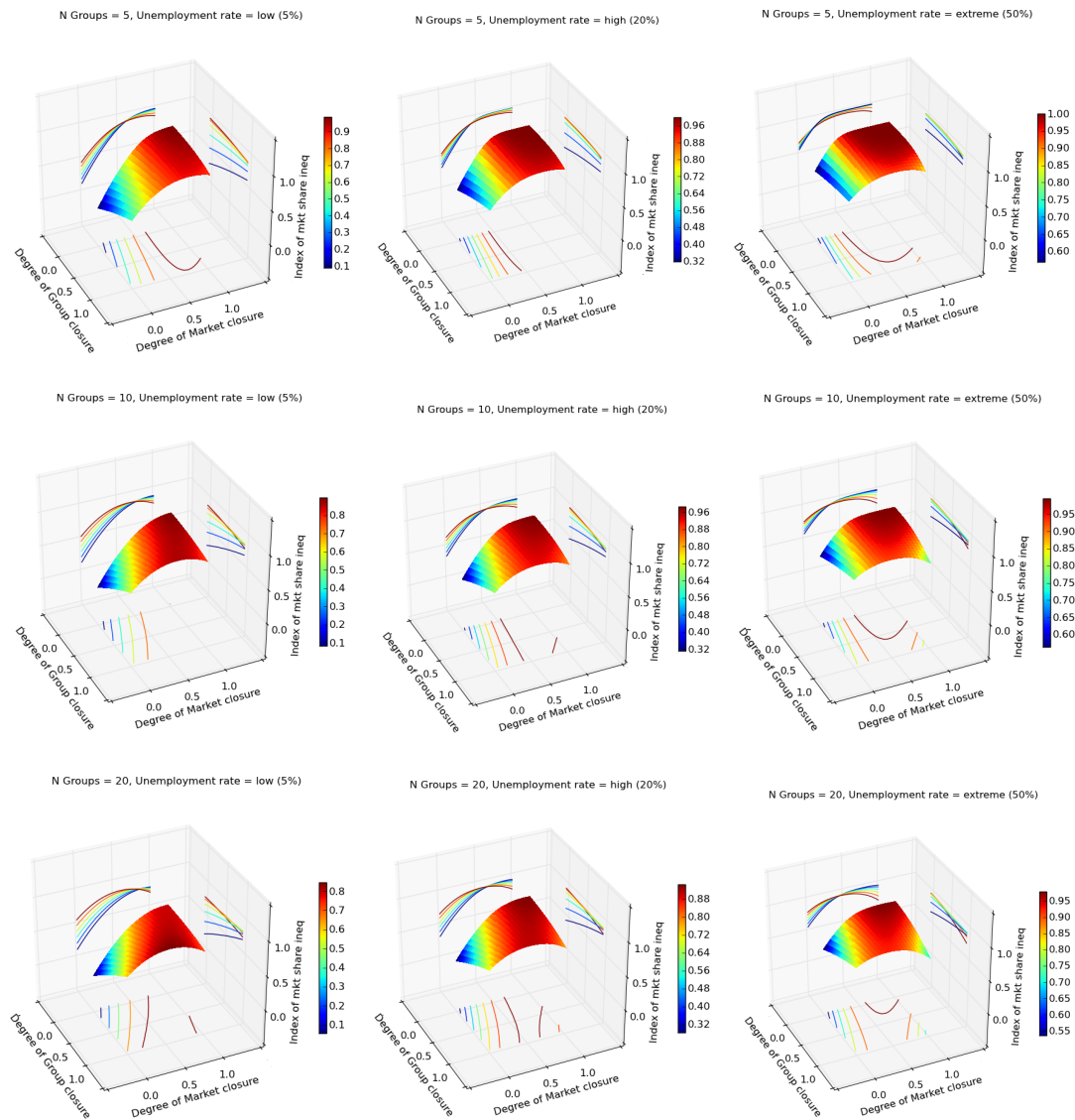


Figure 4.6: Response surface for market share inequality and degree of market and group closure

Chapter 5

Closure in families: parental choices and children's skills

Two central questions in the study of social inequality and the life span have caught the attention of scholars for decades: Why do some individuals become more successful than others as they grow up? And why does economic and social success tend to persist across generations? Social scientists now recognize that the intricacies of skill formation constitute an important piece of the puzzle. Cognitive abilities, including but not limited to those measured by IQ tests, as well as socio-emotional capacities such as achievement-striving, perseverance, assertiveness, curiosity, ambition, delay of gratification, and sociability, have been shown both to predict individual disparities in education, earnings, health, well-being, and deviant behavior (Heckman & Kautz, 2012; Roberts, Kuncel, Shiner, Caspi, & Goldberg, 2007) and to be crucial in the transmission of advantage from one generation to the next (Ermisch, Jäntti, & Smeeding, 2012).

Multidisciplinary research on skill formation has revealed the cumulative character of skill growth during a person's life span, pointing to the pivotal character and indelibility of parental investments in shaping children's skills starting early in life (Knudsen, Heckman, Cameron, & Shonkoff, 2006, and the references cited therein). The extent of parental material and time resources a child enjoys depends both on the amount of resources commanded by their parents and on parental discretion in allocating them within the family (Behrman, 1997; Conley, 2005). As a result, in order to explain differences in individual skills, parental allocation choices may be as important as the amount of parental resources available to allocate.

This chapter shows how direct forms of closure inside the family, in the form of parental investment behavior, serves as a transformational mechanism linking parental allocation decisions at the microlevel of the household to the emergence of skill inequality at the societal level.¹ To do so, it uses agent-based modeling

¹ This chapter, including this introductory words, has been published in the *Journal of Artificial Societies and Social Simulation* (Cardona, 2014a), <http://jasss.soc.surrey.ac.uk/17/4/8.html>

(ABM) to explore what happens to inequality in cognitive and socio-emotional skills within and across generations if parents differ in their investment behavior. The model also explores how variations in resources available to households, as well as number and spacing of children, affect the unequal distribution of skills in families and in society over time. In contrast to the model on market closure and group closure presented in the previous chapter, the present model is oriented more toward empirical reality. In particular, skills growth is modeled according to the technology of skill formation developed in the field of economics, calibrated with empirically estimated parameters from existing research. In addition to a more evidence-oriented simulation design, one prediction of the model is validated using empirical data.

The chapter is structured as follows: **Section 5.1** makes the case for parental investment behavior beyond optimizing agents. **Section 5.2** describes the model using the Overview, Design Concepts, and Details (ODD) protocol (Grimm et al., 2006, 2010). **Section 5.3** explains the experimental design based on the Design of Experiments (DOE) (Lorscheid et al., 2012). The results of the experiments and an empirical validation of one prediction of the model are presented in **Section 5.4** and **Section 5.5** respectively. In documenting the simulation, an effort was made to comply with best practices. Therefore, in addition to the ODD and the DOE, the full code of the simulation in Python is provided; and is available at: <http://www.openabm.org/model/4084/version/1/view>.

5.1 Beyond optimizing parents: heuristics and norms

Traditionally, models of parental investments have been dominated by depictions from biology and economics of individuals as optimizers. In evolutionary biology, parents invest in their offspring to maximize reproductive success (Hamilton, 1964a, 1964b; Trivers, 1972), while in economics, parents maximize household utility, which is a function of children's achieved levels of wealth, income, or human capital (Becker & Tomes, 1986; Behrman, Pollak, & Taubman, 1982; for a review, see Björklund & Jäntti, 2009, 493–95). Despite the dominance of these assumptions about parental behavior, or perhaps precisely as a consequence of it, models that compare alternative parental investment strategies among humans and their impact on children's outcomes, such as the simulation study by Davis, Todd, and Bullock (1999) on alternative feeding strategies among birds, have not yet been devised. ABM offers a natural modeling strategy to represent heterogeneous agents and to inquire into the macro-consequences of agent behavior under changing environmental conditions. With the use of ABM, it is thus possible to go beyond optimizing parents and compare optimizing with non-optimizing behavior.

There are at least two good reasons not to limit the modeling of parental investments to optimizing agents. First, the assumption that parents are perfect optimizers ignores the extensively documented computational and informational limitations faced by individuals in solving real-world tasks (Kahneman, 2011). There is no reason to believe that the same internal and environmental constraints that make *Homo economicus* an unlikely model of decision making in general are not equally limiting in the demanding task of optimizing parental investments. Finding the optimal investment profile that maximizes children's skills would require that parents have perfect information about the child's endowments; know the exact functional form of skill formation; and are capable of allocating, in real time, just the right amount of nourishment, toys, emotional support, cognitive stimulation, and other parental inputs that will produce the best possible outcome in all their offspring many years into the future. Since this kind of optimization is most likely intractable for individuals, and perhaps even burdensome for less powerful computers, parents may instead default to simple heuristics or rules of thumb in the allocation of resources (Gigerenzer, 2004), which, although not necessarily less effective in bringing them closer to their goal of promoting children's skills, are computationally less costly. Second, declaring that all parents behave as output maximizers ignores agent heterogeneity in motives and goals. Culturally dictated norms regarding the relative importance of children within the family, in particular those related to gender and birth order, constitute an alternative framework that regulates parental resource allocation among siblings.

In the following, heuristics and norms that shape parental investments are briefly discussed. The exact operationalization of these alternative forms of parental behavior are explained in the model description below (see *Parental investment behavior on page 142*).

5.1.1 Heuristics

According to (Gigerenzer, 2004), a complete model of a heuristic consists of three elements: first, the exact rules that guide decision making; second, the individual capacities they exploit; and third, the type of problem they are supposed to solve (p. 67). For parental investments two candidate heuristics can be found in the literature on the intrahousehold allocation of resources: a) equality and b) reinforcing or compensation.

Allocation rules. For an egalitarian distribution, the allocation rule is very simple: divide total resources equally among children (Hertwig, Davis, & Sulloway, 2002). Research on the so-called dilution hypothesis, which poses a negative relationship between sibship size and amount of resources available to siblings,

provides indirect empirical support for the equality heuristic (Baydar, Hyle, & Brooks-Gunn, 1997; Blake, 1989; Stewart, 2005). As an alternative rule to equality, a growing body of empirical research supports both the existence of compensatory (Del Bono, Ermisch, & Francesconi, 2012) and reinforcing investment strategies (Datar, Kilburn, & Loughran, 2010) triggered by children's initial endowments. When parents reinforce (compensate) they give more than the equal share of resources to children with high (low) endowments relative to their siblings.

Individual capacities. At a minimum, parents should be able to divide inputs. This is a plausible assumption for goods, services, and time devoted to children. Other inputs such as affection might prove to be more difficult to ration. In addition, allocating inputs requires that parents keep track of past resources given to children and adapt present distribution accordingly. Finally, to follow compensating or reinforcing strategies, parents must be in a position both to observe children's strengths and weaknesses and to draw comparisons between them in order to reallocate resources. Thus, divisibility of inputs, memory of past allocation, and perception of children's differences are required to put these two heuristics into practice.

Type of problem. The third element of the heuristic model is more difficult to pinpoint, since research on parental investment behavior in humans from a heuristic perspective is scant. The explanation advanced here is therefore sketchy and should be updated when more research on the subject becomes available. According to Gigerenzer and Gaissmaier (2011), an egalitarian distribution of resources is an instance of a "tradeoff" heuristic, where individuals weigh alternatives equally, a "1/N Rule" (Ibid.: pp. 470f. and the references cited there). In the context of parental investments, Hertwig et al. (2002) argued that an egalitarian distribution should be observed among parents who command enough resources and can afford not having to decide which of their offspring to nourish preferentially. This, however, is a prediction about the environmental conditions under which such a heuristic is likely to be observed in parental investment behavior and not an explanation of the problem the heuristic is supposed to solve. In general terms, the problem faced by parents can be formulated as allocation of resources under uncertainty regarding both observed child endowments and expected returns on investment. Davis and Peter (2001) suggest that for equal expected returns an egalitarian distribution should yield the highest outcomes from parental inputs. However, it is also plausible that equality is less a response to equal expected returns and more an adaptation to unknown returns. In the domain of financial decisions, equal allocation of assets among alternative investments, or

“naïve diversification,” has been demonstrated to yield surprisingly positive results compared with more complicated allocation strategies (DeMiguel, Garlappi, & Uppal, 2007). Thus, with noisy expected returns on investments, parents may default to an egalitarian distribution as a way to reduce the volatility of child outcomes.

A similar argument can be advanced to explain the heuristic of reinforcement or compensation. According to the taxonomy found in Gigerenzer and Gaissmaier (2011), this heuristic can be classified as a “one-clever-cue” heuristic, a form of “one-reason”-type heuristic. Instead of weighing cues equally, as with the egalitarian heuristics (i.e., number of children), individuals look for a “good” cue among known alternatives and choose one based on that standard. If parents face uncertainty about returns but somehow observe child endowments at birth, this additional information might be interpreted as a cue for expected returns on investments that can be used to adjust allocation decisions. Highly endowed children promise high returns, hence reinforcement as a way to secure higher payoffs; low-endowed children, by contrast, threaten to produce low returns, hence compensation as a way to reduce losses. In both cases the cue that activates the heuristic is the child’s endowments and the problem the heuristic solves is return volatility.

Which of these two strategies is followed by parents—equality or compensation-reinforcement—may depend on the environment they face (Todd & Wolpin, 2007). As argued by Conley (2005), families with fewer resources may tend to prioritize parental investments toward better-endowed children. The rationale behind reinforcement is summarized by Conley as the desire of low-class parents to maximize upward mobility. By the same token, if middle-class and high-class parents aim to avoid downward mobility, as Goldthorpe (2000) argues, then compensation for less-endowed children or equality could be the ecologically rational strategy. To some extent these arguments are compatible with the hypothesis of Trivers and Willard (1973) that parents always follow a gender-specific reinforcing strategy, changing parental investment behavior depending on available resources, but always in such a way that the most promising gender in terms of expected reproductive success is favored.² Such a relationship between resource scarcity/reinforcing strategies and resource abundance/compensation has been observed in birds and shown through simulation to produce high payoffs in terms of offspring fitness (Davis & Peter, 2001).

2 According to this hypothesis, if sexual competition is more decisive for the reproductive success of males than females and if the rank or status of parents correlates with that of their offspring, then low-rank parents would tend to invest preferentially in females, while high-rank parents who can afford giving males enough resources to successfully face reproductive competition would favor them instead (Trivers & Willard, 1973). In humans, this hypothesis predicts that high-status parents invest more in boys and low-status parents more in girls, a correlation that has been supported by only weak and mixed evidence when tested empirically (Cronk, 2007).

In the case of equality, an additional environmental triggering factor could be the difficulty in observing differences in endowments among children. If parents are unable to extract meaningful cues about the potential of their offspring, the less risky guess in the allocation of resources is to distribute them equally among siblings. Furthermore, even if parents choose a compensating or reinforcing strategy, an equality heuristic can still be used as an anchor (Messick, 1993), a benchmark to help them decide how much of their resources should be devoted to one particular child.

5.1.2 Norms

Norms about gender and birth order, such as those manifested in the millennia-old traditions of primogeniture and son privilege, are the two most prominent allocation rules likely to affect parental investment behavior across societies. In the case of gender, parental bias can be as moderate as spending more time with same-sex children (Lundberg, 2005) or as extreme as selective abortion and even infanticide (Sen, 1992, 2003). Thus, even if only for outliers, the bias in the allocation of resources can in practice approach a maximum of zero investments in particular children. In contrast to gender, research on birth order norms suggests that investment bias along this dimension tends to be much more moderate, taking the form of favoritism rather than outright neglect. Empirical studies on parental favoritism offer mixed results as to which child receives more parental attention. Although there is evidence of both last-born and first-born bias, what seems to be a consistent result is that middle children are seldom favored (Suitor, Sechrist, Plikuhn, Pardo, & Pillemer, 2008).

It is important to note the apparent overlap of norm-oriented behavior with heuristic-based and optimizing behavior. Norm-oriented agents follow rules of thumb to guide their investment decisions in a way that, on the surface, appears to be similar to heuristic-following agents. Yet, in contrast to heuristics, norms are not means to an end but ends in themselves. The goal of norm-oriented behavior is to comply with the norm rather than to achieve an ulterior goal by using the norm as an instrument, as in the case of heuristics. In practice, it is true, by merely observing parental behavior it is not always possible to decide whether norms or heuristics are guiding decision making. For example, parents who abide by an equality norm may appear to an observer as behaving exactly the same way as parents who follow an equality heuristic, although the underlying decision mode is different.³ Furthermore, favoritism based on gender or birth order may result when parents adapt to environmentally dictated expected payoffs of parental in-

³ See Messick (1993) for an experimental design that tries to distinguish between the two types of decision modes.

vestments, and hence may to some extent be compatible with optimizing behavior (see Lundberg, 2005 and Ejrnaes & Pörtner, 2004, for an economic perspective; Trivers & Willard, 1973 and Sulloway, 1996, for a biological perspective). However, norms change only gradually and persist even after environmental conditions have shifted (see, e. g., Almond, Edlund, & Milligan, 2013), so normative pressure may still influence action even if the payoffs seen from the perspective of a rational agent are no longer present. Finally, both gender and birth order bias can be explained without resorting to norms; for example, first-born and gender favoritism may result from a reinforcing heuristic strategy, where parents use age (Davis & Peter, 2001, 311) and gender (Trivers & Willard, 1973) as cues for expected payoffs and invest accordingly.

In short, heuristics and norms are alternative and separate forms of action that parents may follow when allocating resources among children, even if empirically they are not always clearly distinguishable from each other and may to some extent be compatible with optimizing behavior. As summarized in **Table 5.1**, parental investment strategies vary according to agents' goals, available information, and computational capabilities.

Table 5.1: A comparison of parental investment behavior

	Optimizing	Heuristics	Norms
Investment strategy	Optimize children's skill levels.	Rules of thumb based on observed initial skill endowments: - Equality - Reinforcement, compensation	Rules of thumb based on social norms: - Son preference - First-born favoritism - Last-born favoritism
Goal	Maximize expected sum of children's skills.	Achieve the highest possible sum of children's skills (reduce return volatility).	Conform to norms.
Information	Complete: - Children's skill endowments - Technology of skill formation	Incomplete: - Children's skill endowments	Minimal: - Children's gender and birth order
Computational capabilities	High	Limited	Minimal

5.2 Model description

5.2.1 Overview

Purpose. The model explores the emergence of inequality in cognitive and socio-emotional skills at the societal level within and across generations that results from differences in parental investment behavior at the household level during childhood and adolescence. Parents behave alternatively as optimizers, heuristic-based, or norm-oriented. The simulation is a middle-range model informed by stylized facts from research on skill formation and the intrahousehold allocation of resources. It is intended to produce testable hypotheses about parental decisions and overall skill inequality in society. Since the main focus is on parental investment decisions, other processes, including skill homophily in partner search, fertility decisions (number and spacing of children), and the amount of resources available to parents, are treated as exogenous factors that are varied experimentally.

Entities, State Variables, and Scales. The only scale in the model is time (t). One time unit equals 2 years, derived from the biennial empirical estimates used to calibrate the technology of skill formation (see **Section 5.2.4** on *Submodels* below). Two entities are modeled: persons (or individuals) and parents (or households). Individual state variables can be classified into four groups: demographics, partner matching, life-course events, and skill formation. Households combine mothers and fathers into one agent with state variables related to fertility and parental investments. Endogenous variables are identified with an “[e]” and exogenous variables with an “[x]” (see **Table 5.2** and **Table 5.3**) The most central endogenous variables in the model are the current skill stocks of each individual and the amount of parental resources invested by households in each child.

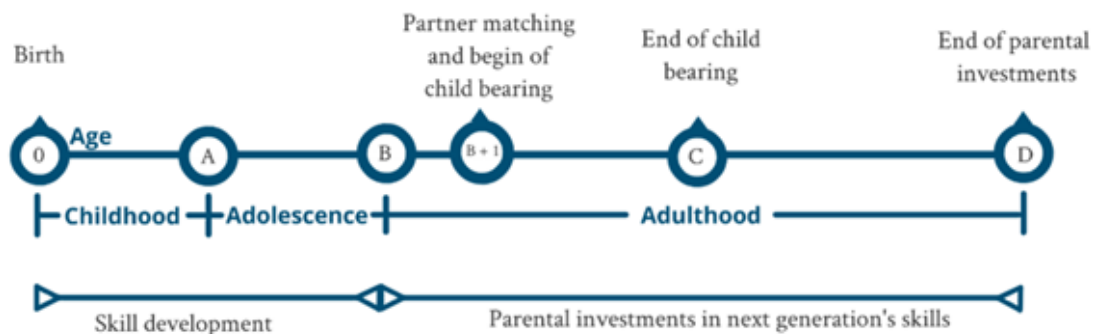
Process Overview and Scheduling. Each generation of individuals follows a standard life course, with identical life stages and age intervals for particular events. The life course consists of three stages—childhood, adolescence, and adulthood—as depicted in **Figure 5.1**. During the first two stages (ages 0 to B), cognitive and socio-emotional skills are produced through parental investments starting from an initial inherited amount of skill endowments. In the first period of adulthood (age $B + 1$), agents update their skill from investments in the last period of adolescence. During the third stage (ages $B + 1$ to D), individuals find a partner, form a household, give birth to the next generation, and invest in the skills of their offspring.

Table 5.2: Individual state variables

State Variable	Description
ind_id, hh_id, hh_id_parents, gen_id [x]	Numerical identifications (Ids) were assigned to each individual to facilitate keeping track of skill dependencies within families and across generations. ind_id is unique; hh_id identifies current household; hh_id_parents is shared by siblings and refers back one generation; and gen_id is equal for all agents belonging to the same generation.
<i>Demographics</i>	
age_ind [e]	Age of individual in number of years
sex [x]	Female (1), male (2)
birth_order [e]	First-born, second-born, etc. [1, 2, ...] Partner matching
homophily_skills_partner [x]	Preference for a partner with similar skill level [0, 1]
<i>Life-course events</i> (see Figure 5.1 below)	
age_end_childhood [x]	Age of last year of childhood; A in Figure 5.1
age_end_adolescence [x]	Age of last year of adolescence; B in Figure 5.1
<i>Skill formation</i> (see <i>Submodels</i> , equation 5.3)	
initial_cog_skills [e]	Initial skill endowments of cognitive and socio-emotional skills (0,1)
initial_soc_emo_skills [e]	
initial_avg_skills [e]	
current_cog_skills [e]	Stocks of cognitive and socio-emotional skills (0,1)
current_soc_emo_skills [e]	
productivity_cog_child_cog [x]	Effect of past cognitive skill stocks on present child and adolescent skill growth (0,1)
productivity_cog_child_soc_emo [x]	
productivity_cog_adolesc_cog [x]	
productivity_cog_adolesc_soc_emo [x]	
productivity_soc_emo_child_cog [x]	Effect of past socio-emotional skill stocks on present child and adolescent skill growth (0,1)
productivity_soc_emo_child_soc_emo [x]	
productivity_soc_emo_adolesc_cog [x]	
productivity_soc_emo_adolesc_soc_emo [x]	
parental_inv_productivity_child_cog [x]	Effect of parental investments on child and adolescent skills (0,1)
parental_inv_productivity_child_soc_emo [x]	
parental_inv_productivity_adolesc_cog [x]	
parental_inv_productivity_adolesc_soc_emo [x]	
parental_cog_child_cog [x]	Effect of parental skills on child and adolescent skills (0,1)
parental_cog_child_soc_emo [x]	
parental_soc_emo_child_cog [x]	
parental_soc_emo_child_soc_emo [x]	
parental_cog_adolesc_cog [x]	
parental_cog_adolesc_soc_emo [x]	
parental_soc_emo_adolesc_cog [x]	
parental_soc_emo_adolesc_soc_emo [x]	
input_substitutability_child_cog [x]	Captures how difficult it is to compensate early investments with late investments in t . Higher values are associated with higher elasticities of input substitution. $(-\infty, 1]$.
input_substitutability_child_soc_emo [x]	
input_substitutability_adolesc_cog [x]	
input_substitutability_adolesc_soc_emo [x]	

Table 5.3: Household state variables

State Variable	Description
hh_id [x]	Numerical Ids assigned to each household to facilitate keeping track of family members.
members_parents [e] members_children [e] Fertility	List of parents' and children's Ids belonging to the household
age_parents [e]	Age of parents (age of mothers = age of fathers)
intended_fertility [x]	Intended total number of children
actual_fertility [e]	Actual total number of children
child_spacing [x]	Distance in years between each birth
number_children_0_16 [e]	Number of children between 0 and 16 years of age. These are the children that receive parental investments.
skill_heritability_cognitive [x], skill_heritability_socio_emotional [x]	Heritability of cognitive and non-cognitive skills [0, 1]
Parental investments (see <i>Submodels</i> , equations 5.4 - 5.9)	
parental_cognitive_skills [e] parental_soc_emo_skills [e] available_res_total [x]	Average maternal and paternal cognitive and socio-emotional skills [0,1] Total annual resources available to invest in offspring (0, 1]
investment_behavior [x]	One of the different investment strategies followed by parents optimal, equality, reinforcement/compensation, son privilege, first-born privilege, last-born privilege
investment_bias [x]	Deviation from perfectly egalitarian distribution of resources among siblings [0, 1]. Used for heuristic-based and norm-oriented investment behavior.
parental_inv_child_n [e]	Vector with resources allocated by parents to each of their children (0, 1]

**Figure 5.1:** Life course for individuals in each generation

At each t , processes are executed, starting with adults (age $\geq B$ and $< D$), then households, and finally children and adolescents (age $< B$). Among adults, only partner matching is executed in random order, since potential partners are limited and it matters who chooses first. For the remaining processes, the order of execution is not relevant, so it is scheduled according to the individual's or household's Id. Partner matching in the next generation starts only after parental investments have ended, which is the time when all individuals within a given generation have reached adulthood. Processes update state variables as soon as they are executed. The simulation is run for the number of generations defined in the experimental design (see *Experimental Design on page 145*). Output variables are produced at the end of all runs.

```

While t < time needed for all generations to reach adulthood
  For each generation
    While t < (D + (intended_fertility x child_spacing)) x (Id of current generation)
      For all Persons
        Person finds a partner and forms a Household
      For all Households within one generation
        Household updates number of children and adolescents
        If parents are in their fertile years, if they have not reached their
          intended fertility and are considering birth spacing, then
          Household gives birth to a new child, draws child's sex from a
            random distribution, and computes child's initial skill endowments
        End If
        If Household has only one child or adolescent, then
          Household invests all resources in that child
        Else
          Household decides the amount of parental resources to invest in each
            child according to its investment behavior
        End If
      For all Persons
        If Person is a child or an adolescent or is in the first period of adulthood
          If Person is not new born (age > 0), then
            Given parental inputs in t-1 and all parameters of the technology of
              skill production, Person updates its current skill stocks
          End If
        Save all state variables
        Increase t in one unit (2 years)
      For all Persons
        Increase age of each individual in 1 t unit
      End While
    End While
  Create data set with Person and Household state variables for all generations
  Compute output variables and save them to a generation data set

```

5.2.2 Design concepts

Basic principles. At the core of the simulation is skill formation through parental investments. Skill growth is modeled according to the technology of skill formation developed by Cunha and Heckman (2007), where initial endowments at birth are augmented by subsequent parental investments in a dynamic, self-reinforcing process of skill accumulation during multiple stages of the life course. Although skills are multiple in nature (Cunha & Heckman, 2007), they can be reduced to low-dimensional constructs (Heckman, Pinto, & Savelyev, 2012). Here, two dimensions of skills are assumed: cognitive skills and socio-emotional skills.

Stages of development are also simplified to include only childhood and adolescence as two central phases of skill growth. Parental investment decisions are informed by research on the intrahousehold allocation of resources (Behrman, 1997) and on heuristics in decision making (Gigerenzer & Gaissmaier, 2011). Three further processes of intergenerational dynamics-partner matching, fertility, and skill inheritance-are included but modeled in a simplified manner.

Emergence. Skill inequality is the main emergent phenomenon in the model. Inequality is measured both within a generation and across generations (see *Measures of inequality on page 144*).

Adaptation. Depending on which behavioral model they follow, parents adapt resource allocation decisions to family size, available resources, and children's attributes, including age, sex, and skill endowments (see *Parental Behavior on page 142*).

Objectives. For optimizing parents, the goal is to maximize the expected sum of their children's skills when they reach adulthood. Heuristic-based agents also strive to increase the sum of their children's skills as adults. By contrast, the implicit goal of norm-oriented parents is to comply with allocation rules as dictated by norms about gender and birth order.

Prediction. To allocate resources among siblings optimally, optimizing parents maximize future skill stocks and thus predict how present inputs will affect children's skill formation in the future.

Sensing. Parents observe children's skills without error.

Interaction. Parents interact directly with their children inside the household through parental investments. Adults interact with each other when searching for a partner. There is no direct interaction among households.

Stochasticity. Stochasticity is used to simplify the much more complex processes of partner matching, fertility, skill inheritance, and the determination of the amount of parental resources available to invest in children. Instead of providing an explicit model of genetic transmission and gene-environment interaction, skill inheritance is implemented by producing a correlated random distribution of children's skills based on empirically plausible fixed parent-child skill correlations. Stochasticity is also included in the models of partner matching and child bearing to produce variability in parental skill similarities and siblings' gender

composition respectively. The amount of resources available to adults to invest in children is treated as a random variable, too, with a distribution that reflects the amount of parental resource inequality as *experienced* by children. Parental resources are distributed unequally among parents, but so is the willingness of parents to invest those resources in their children. When posing the existence of an exogenous distribution of resources *effectively* invested in children as a single dimension, it is not necessary to model the source of parental resources (e. g., labor markets) nor how parents decide between their own consumption and child investments.

Collectives. Households combine mothers and fathers into one agent.

Observation. All endogenous state variables are collected at each time period in a main dataset. A second dataset is also generated that summarizes for each simulation run and for each generation key exogenous parameters, including number of children per parent, child spacing, and number of agents in each generation, as well as key outcome variables (see *Measures of inequality on page 144*).

5.2.3 Details

Initialization. Without a previous generation of parents to invest in children's skills, agents in the first generation start their lives as adults. To avoid creating skill inequality from the outset, both initial endowments and current levels of cognitive and socio-emotional skills are drawn from a random beta distribution with parameters $\alpha = \beta = 7$. With these parameters, the beta distribution is similar in shape to a normal distribution but with values defined in the range $[0, 1]$. The intragenerational inequality (Gini) of this initial distribution is approximately 0.145. The remaining values of exogenous parameters of life-course events and technology of skill formation are listed in **Section 5.2.4** on *Submodels* below, while number of agents as well as parameters for partner matching, fertility, and parental investments vary depending on the experimental setting and are explained in **Section 5.3** on *Experimental Design*.

Input data. No external input data are used.

5.2.4 Submodels

Life-course events. Life-course events are fixed for all agents with the values $A = 6$ and $B = 16$, which are approximations for sensitive developmental stages of cognitive and socio-emotional skills (Borghans, Duckworth, Heckman, & ter

Weel, 2008) and were chosen to match empirical estimations of the technology of skill formation by Cunha, Heckman, and Schennach (2010). B and C correspond to starting and final periods of child bearing; C and D are described by **equation 5.1** and **5.2**, as follows:

$$C = B + \text{child spacing} \cdot (\text{intended fertility} - 1) \quad (5.1)$$

$$D = B + C \quad (5.2)$$

Equation 5.1 means that parents invest in their children until each of them has reached adulthood. Although B, C, and D can be calibrated to match country-specific demographic characteristics, here they take on some plausible values intended to give the model a simple yet realistic life-course dynamic (see **Table 5.4**).

Table 5.4: Parameterization of life-course events

Parameter	Value
age_end_childhood (A)	6
age_end_adolescence (B)	16

Partner matching. Individuals are divided into two groups according to gender. Matching proceeds by taking the first agent in one list (e. g., men) and matching him with a probability p to an agent in the list of the opposite sex (e. g., women), starting from the first in the list, and moving down until a match occurs. After a successful match, the second agent of the first list is picked and the process is repeated with the remaining agents in the second list. Matching is continued until all individuals have found a partner or until no unmatched members of the opposite sex are left. Individuals without a partner remain single for the rest of the simulation.⁴ The probability of success is modeled as a unique trial drawn from a binomial distribution, with p as a function of the Euclidean distance d of cognitive and socio-emotional skills (**equation 5.3**) normalized in the interval $[0, 1]$ and modified by the homophily coefficient h (`homophily_skills_partner`), as expressed in **equation 5.4**.

$$d = \frac{\sqrt{(\theta_{i,t}^c - \theta_{j,t}^c)^2 + (\theta_{i,t}^e - \theta_{j,t}^e)^2}}{\sqrt{2}} \quad (5.3)$$

$$p = 0.5 \frac{h(1-d)}{2} \quad (5.4)$$

⁴ For a brief review of recent simulation-based models of marriage and mate selection, see Walker and Davis (2013).

If $h = 0$, partner matching takes place with a probability of 0.5 of matching success for every matched pair of individuals. If $h = 1$, the normalized Euclidean distance alone determines the deviation of p from 0.5.

Parental available resources. At age B , households draw their available resources randomly from a distribution modified experimentally to reflect different levels of inequality between parents (see *Experimental Design on page 145*). The amount of resources remains constant over the life course.

Child rearing. Number of children and child spacing are fixed parameters defined at the start of each simulation. Only sex composition is probabilistic. Each child has the same probability of 0.50 of being a boy or a girl. This aims at a 50:50 ratio and allows for multiple combinations of sibship sex composition. Given a number of children and child spacing, households give birth to the first child at age B and then again after the number of years determined by child spacing has elapsed. This continues until households have reached the number of children predefined for a given simulation run.

Initial skill endowments. For each child i , initial cognitive ($\theta_{i,0}^c$) and socio-emotional skill endowments ($\theta_{i,0}^e$) are drawn from a beta-distributed random distribution, with parameters $\alpha = \beta = 7$. The same applies to the initial distribution of adult skills in the first generation of agents, which correlates on average by a magnitude given by the heritability coefficient b with the distributions of one of the parents (e. g., maternal skills). During the generation of the random correlation distribution, a negligible amount of outliers slightly exceed 1. In these cases the value is corrected and assigned the value 1. Parameter b captures both genetic and environmental factors that influence children's skills at birth. According to research on behavioral genetics, the heritability of IQ and of personality traits has been estimated at around 0.50 to 0.80 and 0.20 to 0.50 respectively (Johnson, Turkheimer, Gottesman, & Bouchard Jr., 2009). To simplify, b is assumed to be 0.50 for both cognitive and socio-emotional skills (**Table 5.5**). This is not only an empirically plausible value, but given that the parameter is used to generate a correlated random distribution that on average produces a correlation of 0.50, it prevents direct parent-child inheritance at a fixed rate from dominating skill transmission across generations.

Update skills. Skill growth is modeled according to the technology of skill formation developed by Cunha and Heckman (2007) and extended in Cunha et al.

Table 5.5: Parameterization of skill heritability

Parameter	Value
skill_heritability_cog	0.50
skill_heritability_soc_emo	0.50

(2010), as shown in **equation 5.5**.⁵

$$\theta_{i,t+1}^x = f_{x,s,t}(\theta_{i,t}^x, I_{p,t}, \theta_p^x), \forall x \in \{c, e\}, \forall t \in \{0, \dots, B\}, \forall s \in \{1, 2\} \quad (5.5)$$

For agent i , next-period cognitive ($\theta_{i,t+1}^c$) and socio-emotional skills ($\theta_{i,t+1}^e$) are a function of skill stocks ($\theta_{i,t}^c, \theta_{i,t}^e$), parental skills (θ_p^c, θ_p^e), and present parental investments ($I_{i,p,t}$).⁶ Given that skills remain constant after individuals have reached adulthood, parental skills have no time subscript. The function is defined for each age t starting at birth ($t = 0$) and up to adulthood ($t = B$). Parameters are different depending on the life-cycle stage s (childhood: $s = 1$; adolescence: $s = 2$; see **Figure 5.1** above). **Equation 5.6** expresses **equation 5.5** as a constant elasticity of substitution (CES) production function. (See **Table 5.6** below for a list of the corresponding variables in the simulation for each of the γ coefficients.)

$$\theta_{i,t+1}^x = \left[\gamma_{s,1}^x \theta_{i,t}^{c\phi_s^x} + \gamma_{s,2}^x \theta_{i,t}^{e\phi_s^x} + \gamma_{s,3}^x I_{p,t}^{\phi_s^x} + \gamma_{s,4}^x \theta_p^{c\phi_s^x} + \gamma_{s,5}^x \theta_p^{e\phi_s^x} \right]^{\frac{1}{\phi_s^x}}, \quad (5.6)$$

$$\forall x \in \{c, e\}, \forall s \in \{1, 2\}, \sum_{j=1}^5 \gamma_j^x = 1$$

The functional form of the technology of skill formation defined by **equation 5.6** captures two important stylized facts about skill growth (Cunha & Heckman, 2007):

- i) *Dynamic complementarity (self-productivity and cross-productivity)*. Skills in $t+1$ depend on past stocks of both cognitive and socio-emotional skills.
- ii) *Sensitive periods*. Depending on the age of the child, investments in skills may have more or less indelible consequences for children's skill development. The substitutability parameter ϕ_s and the associated elasticity of

⁵ Similar models of cognitive skill formation have been developed by Todd and Wolpin (2003, 2007). See early efforts to formulate the technology of skill production in Ben-Porath (1967).

⁶ The statistical model used by Cunha et al. (2010) includes an error term n_t^x that captures shocks and unobserved inputs. These are not modeled in the present version of the simulation to avoid additional sources of randomness in skill growth and hence the term was left out of **equation 5.5**.

substitution $1/(1 - \phi_s^x)$ capture how difficult it is to compensate early investments with late investments. The higher ϕ_s^x is, the higher the elasticity of substitution and the easier it is to substitute early investments with late ones. Low values of s imply that early and late investments are complements. Elasticities are specific to each type of skill ($x = c, e$) and each stage of the life course ($s = 1, 2$).

The exact content of parental investments ($I_{p,t}$) and the reason to include parental skills (θ_p^c, θ_p^e) in **equations 5.5** and **5.6** require further clarification. As research on brain development suggests, the two most relevant factors affecting children's emotional and cognitive development at the neurophysiological level, aside from prenatal factors, are parental care and a cognitively stimulating environment (Hackman, Farah, & Meaney, 2010). Parents invest in their children not only by spending material resources in goods and services, but also by deciding on the quantity and quality of time and attention to be devoted to their offspring (Berger, Paxson, & Waldfogel, 2009; Heckman, 2006). Both the quantity and quality dimensions of parental inputs are reflected in **equations 5.5** and **5.6**. While ($I_{p,t}$) measures the amount of parental inputs, a combination of material resources and parenting time, parental skills (θ_p^c, θ_p^e) can be understood as a proxy for quality of parenting.⁷ This separation of quantity from quality of inputs makes it possible to accommodate in the model the finding that household material resources do not necessarily correspond to good parenting (Heckman, 2008). Accordingly, even parents with fewer resources but high parenting skills may contribute to children's skill formation effectively.

To parameterize **equation 5.6**, empirical estimates based on the Children of the National Longitudinal Survey of Youth (NLSY79), a representative U.S. longitudinal study, were used (Cunha et al., 2010). High-quality parameter estimates for other countries are not available. These estimates control for measurement error, unobserved heterogeneity, and endogeneity of parental inputs (Ibid: Table V, p. 919). The original estimates conflate multiple measures of parental resources from the HOME scale into a single dimension of parental investments. Parental skills refer to those of the mother. Investments in different types of skills were not distinguished. Cognitive and non-cognitive (in this case socio-emotional skills) were summarized into two independent dimensions based on various age-specific scales of child development (Ibid.: Appendix, Section 9, for a list of measures). Estimates were obtained from biennial measures of children during two stages of development: ages 0 to 6 years and ages 6 to 14 years. To accomo-

⁷ The interpretation of parental skills as quality of parenting is not explicitly made in Cunha et al. (2010); however, there is evidence that parenting styles vary according to parental socioeconomic status (Bornstein & Bradley, 2003), which in turn correlates with cognitive and non-cognitive skills.

date the estimates to the present simulation, parameter estimates for the second stage of development (ages 6 to 14 years) were assumed to remain constant up to age 16. Furthermore, arbitrary scales were assumed for parental investments and skills, all ranging from 0 to 1. As shown in their web appendix (Ibid.: A11, Table 11-1), rescaling the variables for parental inputs and skills makes no qualitative difference in terms of parameter estimates (Ibid.: p. 921). Finally, parental skills (θ_p^c, θ_p^e) were taken to be the average of both maternal and paternal skills and not only the skills of the mother.

Table 5.6: Parameterization of the technology of skill formation

Parameter		Value
<i>Cognitive skills</i> ($\theta_{i,t+1}^c$) children (s = 1)		
productivity_cog_child_cog	$\gamma_{1,1}^c$	0.485
productivity_soc_emo_child_cog	$\gamma_{1,2}^c$	0.062
parental_inv_productivity_child_cog	$\gamma_{1,3}^c$	0.261
parental_cog_child_cog	$\gamma_{1,4}^c$	0.035
parental_soc_emo_child_cog	$\gamma_{1,5}^c$	0.157
input_substitutability_child_cog	ϕ_1^c	0.585
<i>Cognitive skills</i> ($\theta_{i,t+1}^c$) adolescents (s = 2)		
productivity_cog_adolesc_cog	$\gamma_{2,1}^c$	0.884
productivity_soc_emo_adolesc_cog	$\gamma_{2,2}^c$	0.011
parental_inv_productivity_adolesc_cog	$\gamma_{2,3}^c$	0.044
parental_cog_adolesc_cog	$\gamma_{2,4}^c$	0.051
parental_soc_emo_adolesc_cog	$\gamma_{2,5}^c$	0.011
input_substitutability_adolesc_cog	ϕ_2^c	-1.220
<i>Socio-emotional skills</i> ($\theta_{i,t+1}^e$) children (s = 1)		
productivity_cog_child_soc_emo	$\gamma_{1,1}^e$	0.000
productivity_soc_emo_child_soc_emo	$\gamma_{1,2}^e$	0.602
parental_inv_productivity_child_soc_emo	$\gamma_{1,3}^e$	0.209
parental_cog_child_soc_emo	$\gamma_{1,4}^e$	0.014
parental_soc_emo_child_soc_emo	$\gamma_{1,5}^e$	0.175
input_substitutability_child_soc_emo	ϕ_1^e	-0.464
<i>Socio-emotional skills</i> ($\theta_{i,t+1}^e$) adolescents (s = 2)		
productivity_cog_adolesc_soc_emo	$\gamma_{2,1}^e$	0.002
productivity_soc_emo_adolesc_soc_emo	$\gamma_{2,2}^e$	0.857
parental_inv_productivity_adolesc_soc_emo	$\gamma_{2,3}^e$	0.104
parental_cog_adolesc_soc_emo	$\gamma_{2,4}^e$	0.000
parental_soc_emo_adolesc_soc_emo	$\gamma_{2,5}^e$	0.037
input_substitutability_adolesc_socio_emo	ϕ_2^e	-0.522

Parental investment behavior. Three alternative models of parental behavior are considered: optimizing, heuristic-based, and norm-oriented. All types of parents allocate their available resources ($I_{p,t}$) among their children $i = 1, \dots, N$, as specified by the following budgetary restriction (**equation 5.7**).

$$I_{p,t} = \sum_{i=1}^N I_{i,t} \quad (5.7)$$

Until the birth of the second child, the first-born receives all parental resources ($I_{1,p,t} = I_{p,t}$). The same is true for the youngest child after all older siblings have reached adulthood.

(i) Optimizing behavior. Parents choose how much to invest in each sibling $i = 1, \dots, N$ in order to maximize the total expected sum of cognitive and socio-emotional skills over all children when they reach adulthood ($t = B$), subject to the technology of skill formation and the budgetary restriction. Optimization takes place once each time a new child is born or an adolescent reaches adulthood (**equation 5.8**).

$$\underset{I_{i,t} \in [0, I_{p,t}]}{\text{maximize}} \quad \exp\left(\sum_{i=1}^N \sum_{j=t}^B \theta_{i,j}^c + \theta_{i,j}^e\right), \forall i \in \{1, \dots, N\}, \forall t \in \{0, \dots, B\} \quad (5.8)$$

subject to **equations 5.6** and **5.7**.

The result of the optimization is a vector I with the amount of resources to invest in each child i and each period t until $t = B$ for every child. Maximization does not weigh a particular type of skill higher than the other, nor the skills of a particular sibling. To optimize **equation 5.8** in Python, the module for constrained optimization found in SciPy was used with the option for sequential least-squares programming.⁸ Before applying the optimization algorithm, the equation had to be solved analytically by means of backward induction (i.e., by reformulating the optimization problem for all periods t in terms of first-period investments). In Python, this was achieved using the library for symbolic mathematics SymPy.⁹

(ii) Heuristic-based behavior. Two alternative heuristics are considered: equality (**equation 5.9**) and reinforcement (**equation 5.10**) or compensation (**equation 5.11**).

$$I_{i,t} = \frac{I_{p,t}}{N} \quad (5.9)$$

⁸ <http://docs.scipy.org/doc/scipy/reference/generated/scipy.optimize.minimize.html>

⁹ <http://sympy.org/de/index.html>

$$I_{i,t} = \begin{cases} \frac{I_{p,t}}{N}(1 + \delta) & , i^{\max(\theta_{i,0}^c, \theta_{i,0}^e)} \\ \frac{I_{p,t}}{N}(1 - \frac{\delta}{N-1}) & , i \neq i^{\max(\theta_{i,0}^c, \theta_{i,0}^e)} \end{cases}, \forall i \in \{1, \dots, N\} \quad (5.10)$$

$$I_{i,t} = \begin{cases} \frac{I_{p,t}}{N}(1 + \delta) & , i^{\min(\theta_{i,0}^c, \theta_{i,0}^e)} \\ \frac{I_{p,t}}{N}(1 - \frac{\delta}{N-1}) & , i \neq i^{\min(\theta_{i,0}^c, \theta_{i,0}^e)} \end{cases}, \forall i \in \{1, \dots, N\} \quad (5.11)$$

An egalitarian distribution divides resources equally by the number of children (**equation 5.9**). By adhering to the other heuristic (**equations 5.10** and **5.11**), parents may instead choose an unequal distribution of resources either through reinforcement, by giving more to the child with the highest average endowments at birth ($\theta_{i,0}^c, \theta_{i,0}^e$), or through compensation, preferentially allocating resources to the less-endowed child. The exact size of preferential investment cannot be easily inferred from the empirical literature on parental investments (see **Section 5.1** above), and hence the size of compensation or reinforcement is modified experimentally by the investment bias parameter $\delta \in \{0, 1\}$. Choosing to reinforce or to compensate children's endowments is a function of the amount of resources available to parents. Reinforcement is followed by parents with relatively low resources, compensation by those with relatively high resources. The mean of the parental resource distribution is used to distinguish between low resources (below the mean) and high resources (equal to or greater than the mean).

(iii) Norm-oriented behavior. The two norms considered are son preference (**equation 5.12**) and favoritism based on birth order, either for the first-born or the last-born (**equation 5.13**).¹⁰

$$I_{i,t} = \begin{cases} \frac{I_{p,t}}{N}(1 + \frac{\delta}{N^{\text{boys}}}) & , i^{\text{boys}} \\ \frac{I_{p,t}}{N}(1 - \frac{\delta}{N^{\text{girls}}}) & , i^{\text{girls}} \end{cases}, \forall i \in \{1, \dots, N\} \quad (5.12)$$

$$I_{i,t} = \begin{cases} \frac{I_{p,t}}{N}(1 + \delta) & , i^b \\ \frac{I_{p,t}}{N}(1 - \frac{\delta}{N-1}) & , i \neq i^b \end{cases}, \forall b \in \{\text{f.born}, \text{l.born}\}, \forall i \in \{1, \dots, N\} \quad (5.13)$$

As with reinforcing and compensating strategies, the size of the deviation from an egalitarian distribution is measured by the investment_bias parameter $\delta \in \{0, 1\}$. The value of δ varies depending on the strength of parental bias, which can be as high as 1 in the case of infanticide.

¹⁰ Daughter preference is not modeled as a separate parental investment behavior, since results would be analytically identical to those obtained from son preference.

Measures of inequality. One measure of intragenerational inequality and two of intergenerational inequality are provided.

(i) **Gini.** This measures inequality in the distribution of cognitive (θ_i^c) and socio-emotional skills (θ_i^e) among individuals n belonging to a given generation g (**equation 5.14**). Values are defined in the range $[0, 1]$, with 1 being maximum inequality.

$$Gini_g^x = \frac{2 \sum_{i=1}^n i \theta_i^x}{n \sum_{i=1}^n \theta_i^x} - \frac{n+1}{n}, \forall x \in \{c, e\}, \forall g \in \{1, \dots, G\} \quad (5.14)$$

(ii) **Intraclass correlation.** This measures the portion of total variance in cognitive skills (θ_i^c) and socio-emotional skills (θ_i^e) due to variations between households h (**equation 5.15**). ICC can be interpreted as a measure of shared environment and used to quantify inequality among siblings. Values are defined in the range $[0, 1]$. The higher the ICC, the more important is family background for skill formation or the more similar siblings are to each other.¹¹

$$ICC_g^x = \frac{\sum_{j=1}^h (\hat{\theta}_{j,g}^x - \bar{\theta}_g^x)^2}{\sum_{i=1}^n (\theta_{i,g}^x - \bar{\theta}_g^x)^2}, \forall x \in \{c, e\}, \forall g \in \{1, \dots, G\} \quad (5.15)$$

where $\hat{\theta}_{j,g}^x$ is household's h mean and $\bar{\theta}_g^x$ the overall generation mean.

(iii) **Intergenerational correlation.** The Pearson correlation coefficient between children's cognitive and socio-emotional skills and parental average skills (household skills) is used as a measure of intergenerational persistence of inequality. Values are defined in the range $[0, 1]$. A correlation close to 1 means high persistence.

5.3 Experimental design

The DOE was used to set up the experiments (see Lorscheid et al., 2012). **Table 5.7** summarizes the dependent, independent, and control variables. Although the analysis is exploratory and is intended to produce and not to test hypotheses about which forms of parental behavior lead to which levels of inequality in society, it seems reasonable to expect higher levels of inequality both within and across generations from non-egalitarian and optimal allocation strategies compared to egalitarian strategies. The reason is simple: given variability in individ-

¹¹ If the size of households vary, **equation 5.15** should correct for household size in the denominator. This correction is not necessary in the present study because household size remains constant within each simulation run (see *Experimental Design* below).

ual gender, birth order, and skills, parents that are blind to these differences will tend, over time, to level them up unintentionally through egalitarian resource allocation. By contrast, resource allocation that not only deviates from equality but is dictated by precisely those differences in gender, birth order, or skills should tend to create divergent paths of individual skill growth along those same dimensions and ultimately increase overall inequality. In other words, it is reasonable to expect that equality (inequality) at the micro-level should translate into equality (inequality) at the macro-level. This, however, is a simple and “naïve” intuition about the macro-consequences of alternative parental behavior that needs to be explored systematically using the experimental setup. In particular, the experiments allow for the exploration of parental allocation decisions under changing environmental conditions within the household (number of children and child spacing) and in society as a whole (differences in resources among households).

Table 5.7: Classification of variables

Dependent variable	Independent variable	Control variables
Gini ICC intergenerational correlation	Investment behav- ior Number of children Child spacing Inequality of paren- tal resources	Skill homophily Investment bias (δ)

Factor levels for the independent and control variables are shown in **Table 5.8**. In the case of inequality of parental resources, zero inequality means equal resources for all parents. Low inequality and high inequality are implemented by a beta distribution with parameters that approximate a normal and a log-normal distribution respectively.

Table 5.8: Factorial design

Factors	Factor level range	Factor levels
Investment behav- ior	–	{Optimal, equality, reinforcement - compensation, son privilege, first-born privilege, last-born privilege}
Number of children	$[0, x]^*$	{2, 3, 4}
Child spacing	$[1, x]^*$	{2, 4, 6}
Inequality of paren- tal resources	–	{0, low, high}
Skill homophily	$[0, 1]$	{0.2, 0.8}
Investment bias (δ)	$[0, 1]$	{0.2, 0.8}

* In the factor level range, the x equals the upper boundary defined by the biological limits of childbirth.

A full factorial design was implemented. Since investment bias is not defined for optimizing and egalitarian parents, the number of design points varies depending on parental behavior, as summarized in **Table 5.9**. A total of 540 design points was thus obtained.

Table 5.9: Factorial design

Parental investment behavior	Design points
<i>Optimizing</i>	
1. Optimal allocation	54
<i>Heuristic</i>	
2. Equality	54
3. Reinforcement or compensation	108
<i>Norms</i>	
4. Son privilege	108
5. First-born favoritism	108
6. Late-born favoritism	108

For each design point, the optimal number of runs (n) was established by computing the experimental error for the dependent variables for $n = 5, 10, 15, 20, 25, 50, 100, 250,$ and 500 using egalitarian parents, which is the simplest allocation rule. For each n and each design point, the coefficient of variation $C_v = \frac{\text{standard deviation}}{\text{mean}}$ was estimated as suggested in Lorscheid et al. (2012). Results indicate that C_v stabilizes at around 50 iterations at most.

Owing to constraints in computer power, two separate experiments were run to make simulation experiments computationally feasible. Simulating optimizing parents is computationally expensive. Each household in the simulation, at each t , solves a dynamic problem of optimizing resource allocation among a changing number of children. Thus, the first experiment excluded optimizing parents and ran the remaining 486 design points, including egalitarian parents, alongside all other non-egalitarian strategies for 1,000 initial agents over five generations. The second experiment considered optimizing parents and again included all design points for egalitarian parents. The number of initial agents was 100, and the simulation was run for three generations. In this way, the computational burden was reduced and all parental behavior models could be compared with one another using egalitarian parents as a benchmark.

5.4 Results

To visualize and analyze output, a metamodel was used. Each of the three dependent variables for each type of skill was summarized based on a linear-regression

Tobit model, with the dependent variable defined in the range $[0, 1]$. The regressors included all independent and control variables (see **Table 5.7**), and an interaction term between parental investment behavior and number of children, child spacing, and parental resources. All variables were treated as categorical and were included in the model using dummies for each of its values, thus allowing for nonlinearities. A dummy for each generation was also included to control for time. For each of the two experiments, the data used to estimate the parameters of the regression encompassed all generations and experimental runs for each design point, as described above. The values of dependent variables corresponded to levels observed at the end of each generation when all agents had reached adulthood. Results are presented using predicted values.

5.4.1 Experiment 1: egalitarian vs. non-egalitarian parents

Non-egalitarian strategies include unequal distribution of resources based on child endowments (reinforcement/compensation), gender (son privilege), and birth order (first-born or last-born privilege). **Figure 5.2** summarizes the predicted margins for each dependent variable and type of skill as a function of parental investment strategies. Both overall predicted averages and averages for changes in covariates are displayed. Changes are presented using the overall predicted average as a benchmark. The graph lines do not represent any particular trend; they are shown to facilitate the visualization of predicted values across parental investment strategies. Based on these results, five conclusions can be drawn.

- i) Parental behavior matters. Parental investment strategies at the household level do affect aggregate levels of skill inequality within and across generations. This is particularly true for Gini and ICC. Intergenerational correlations are relatively insensitive to different parental investment strategies.
- ii) *Results are comparable for both types of skills.* Differences among parental cognitive and socio-emotional skills are not substantial. Only the ICC displays skill-specific differences. The ICC for cognitive skills is relatively more sensitive to child spacing, while the ICC for socio-emotional skills is relatively more elastic to fertility. Aggregate levels of inequality for parents that conferred last-born privilege also vary between types of skills; however, the differences are small.
- iii) *Being egalitarian or not is the most important distinction in parental investment behavior.* In terms of effect on aggregate levels of inequality, the largest differences can be seen between egalitarian and non-egalitarian parental investment strategies. Among non-egalitarian investment strategies, levels of inequality are comparable.

- iv) *There is a tradeoff between equality at home and inequality within and across generations.* Equality at home reduces skill inequality within one generation (Gini) but at the cost of increasing inequality across generations (ICC, intergenerational correlation). The opposite is true for a non-egalitarian allocation of resources at home. This contradicts the “naïve” expectation that equality (inequality) at the micro-level always leads to equality (inequality) at the macro-level.
- v) *Changes in the environment reduce or exacerbate inequality depending on parental investment behavior.* Although greater inequality in the distribution of parental resources produces greater inequality within (Gini) and across generations (ICC) for all types of parental investment strategies, changes in the composition of the household (fertility and child spacing) affect inequality differently depending on parental choices. All else being equal, higher fertility and wider child spacing have no influence on inequality within a generation but reduce inequality across generations if the parents are egalitarian. Yet, if they are non-egalitarian, larger families are associated with a lower Gini, a higher ICC (with the exception of son privilege), and a lower intergenerational correlation. Wider child spacing has no influence on Gini or intergenerational correlation but tends to reduce sibling similarity.

5.4.2 Experiment 2: egalitarian vs. optimizing parents

Do optimizing parents differ from egalitarian parents? **Figure 5.3** summarizes the predicted margins for each dependent variable and type of skill when parents act as optimizers relative to the predicted values for egalitarian parents using the latter as a reference (see **Figure 5.2**). The closer the difference in predicted values is to zero, the more optimizing parents produce the same results as egalitarian ones. On the graph, error bars around predicted values show whether differences above or below zero are statistically significant.

At the aggregate level, differences between egalitarian and optimizing parents are small. Only the difference in ICC for cognitive skills is sizable. Most of the differences between the two types of parental behavior are evident in their effects on inequality across generations as a response to changes in child spacing. When child spacing increases both the ICC and the intergenerational correlation for optimizing parents increases more than for egalitarian parents. The opposite is true for socio-emotional skills, for which wider child spacing reduces inequality across generations. In short, aside from their response to child spacing, societal levels of inequality generated by optimizing parents remain fairly close to those produced by egalitarian parents. This implies, by transitivity, that non-egalitarian parents differ from optimizing parents in the levels of societal inequality they produce.

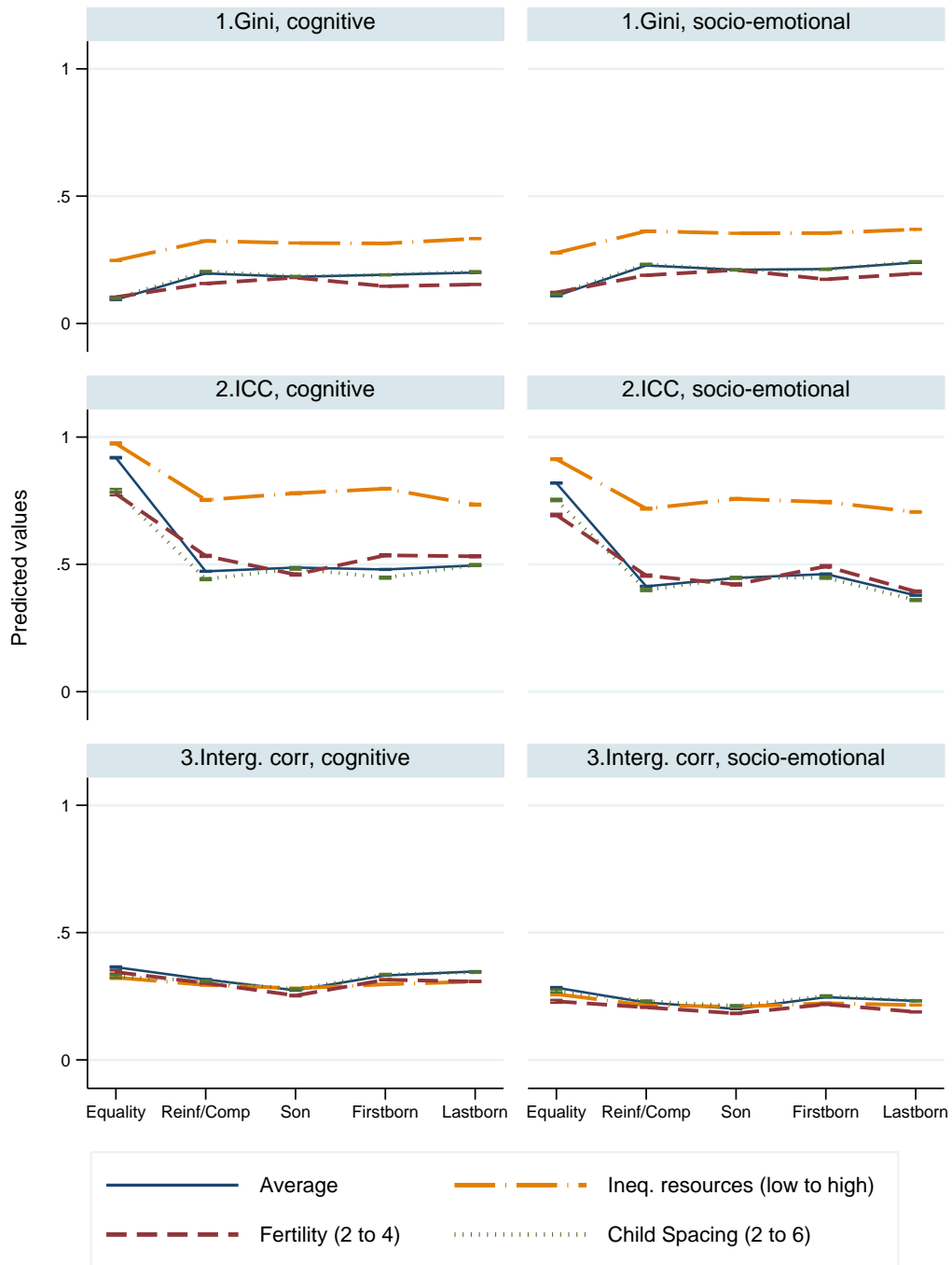


Figure 5.2: Differences in predicted values between egalitarian and non-egalitarian parents, showing 95% confidence intervals¹²

¹² Confidence intervals are so narrow that they appear as small rectangles on the graph. Lines connecting these rectangles have been included to facilitate comparisons among models.

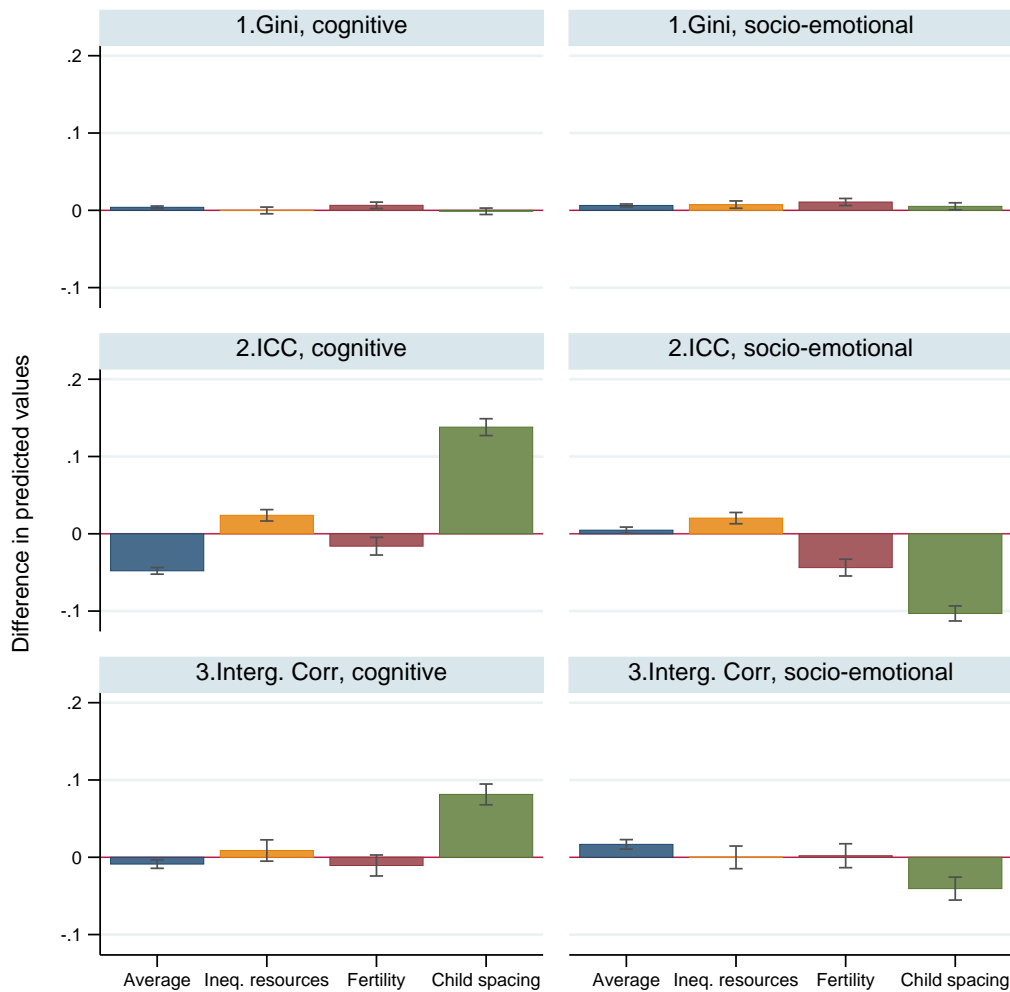


Figure 5.3: Differences in predicted values between egalitarian and optimizing parents, showing 95% confidence intervals

5.5 Validation

Although the simulation is a middle-range model, it is possible to assert the validity of at least one of its conclusions using empirical data. Ideally, cross-country representative data on cognitive and socio-emotional skills for all members of the household and for more than one generation, as well as data on parental allocation behavior, would be required to test the relationship between parental investments and societal levels of inequality. Unfortunately, such comprehensive data do not exist. Although there are scattered, country-specific longitudinal studies with some of the data needed, such as the Panel Study of Income Dynamics (United States) and Socio-Economic Panel (Germany), they are not sufficient to compare the Gini, ICC, and intergenerational correlation of different skills for

various countries with varying parental investment strategies. For this reason, only one model prediction can be validated, and only through indirect measures.

In terms of data needed, the less demanding prediction to validate is the one related to cognitive skills within one generation, since neither data on siblings or parents nor data on multiple generations are required. One common operationalization of cognitive skills is IQ. To obtain the distribution of cognitive skills for young people, data from the Programme for International Student Assessment (PISA) was used. The PISA test evaluates student competencies from randomly selected students in multiple countries at age 15 in mathematics, science, and language.¹³ As shown by Lynn and Vanhanen (2006, 69), the correlation between average mathematics scores in the PISA study and average country IQ is 0.876. Thus, as a proxy measure of inequality in cognitive abilities within one generation, the Gini of total individual raw math scores in 61 countries based on 2009 PISA data was computed.

Furthermore, as a measure of parental investment strategies in the countries for which PISA results are collected, the World Values Survey (WVS) was used. The WVS includes representative data on values and beliefs across countries that concentrate over 85% of the world's population.¹⁴ Based on this dataset, Inglehart and Welzel (2005) defined a two-dimensional space that classifies all countries in the survey according to their values: traditional vs. secular and survival vs. self-expression. The more countries tend toward secular and self-expression values, the more they adhere to values such as individual freedom, equality, and democracy. Although society-wide trends in values and beliefs are not a direct measure of parental intrahousehold resource allocation strategies, it is plausible to assume that parents in countries that score high in traditional and survival values are more likely to follow non-egalitarian allocation rules such as gender or birth-order privileges and reinforcing heuristics, while parents in countries with predominantly secular and self-expression values are more likely to be inclined to follow egalitarian strategies that provide each individual child with equal chances. In addition, and more specific to gender inequality, the WVS asks respondents whether they agree, disagree, or neither agree nor disagree that men should have a greater right to a job than women if jobs are scarce. If one codes "agree" as -1, "neither agree nor disagree" as 0, and "disagree" as 1, a gender-equality scale can be constructed, with average scores at the country level defined between -1 (low gender equality) and 1 (high gender equality).

According to the predictions of the model, the inequality in mathematics scores should be greater in countries with traditional and survival values and higher gender inequality and less in countries with secular and self-expression values

13 <http://www.oecd.org/pisa>

14 <http://www.worldvaluessurvey.org>

and a lower tolerance for differences between men and women. As depicted in **Figures 5.4, 5.5 and 5.6**, this is in fact the case. The correlation between the Gini of mathematics scores and the traditional/secular index is -0.54 ; if the survival/self-expression index is used instead, the correlation is cut down by one third but remains negative. Using the gender-equality scale, the correlation is -0.37 . Similar results are obtained if science and language individual raw scores are used: correlations are -0.45 and -0.32 for the traditional/secular index, -0.33 and -0.33 for the survival/self-expression index, and -0.36 and -0.29 for the gender-equality score.

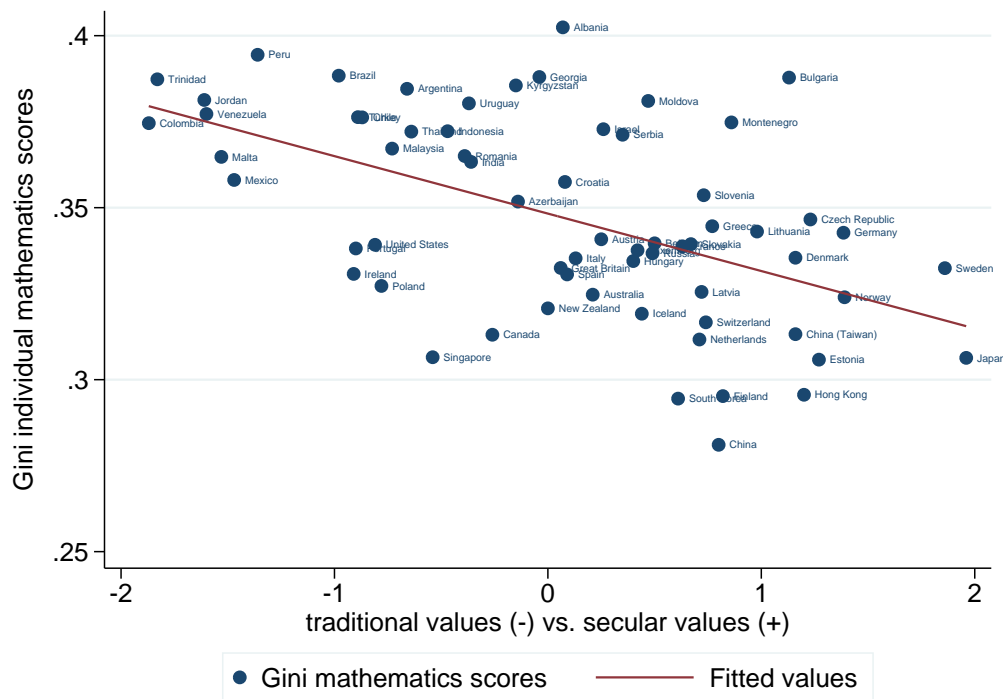


Figure 5.4: Gini of PISA mathematics scores and country according to traditional versus secular values

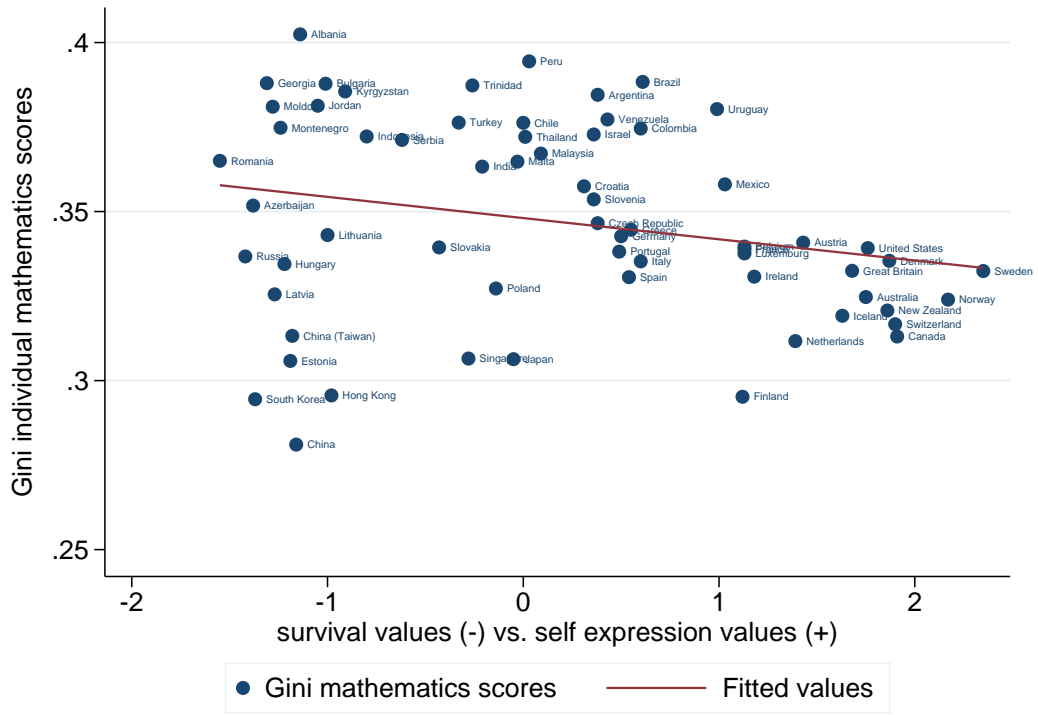


Figure 5.5: Gini of PISA mathematics scores and country according to survival versus self-expression values



Figure 5.6: Gini of PISA mathematics scores and country according to gender equality score

5.6 Summary

In this chapter, an agent-based simulation model (ABM) was developed and implemented using Python to explore the emergence of intragenerational and intergenerational skill inequality at the societal level that results from differences in parental investment behavior at the household level during early stages of the life course. The simulation can best be described as a middle-range model, informed by research on skill formation and the intrahousehold allocation of resources. Parental behavior was modeled as optimal, heuristic-based, or norm-oriented. Skills grow according to the technology of skill formation developed in the field of economics, calibrated with empirically estimated parameters from existing research. Agents go through a simplified life course. During childhood and adolescence, skills are produced through parental investments. In adulthood, individuals find a partner, give birth to the next generation, and invest in offspring. Number and spacing of children and available resources are treated as exogenous factors and are varied experimentally.

Simulation experiments suggested that parental decisions at the household level, a direct form of closure, play a role in the emergence of inequality at the societal level. Following egalitarian allocation rules as opposed to nonegalitarian heuristic or norm-based rules appears to be the most important distinction in parental investment behavior to explain aggregate differences in Gini, ICC, and intergenerational correlations of cognitive and socio-emotional skills. Results obtained from optimizing parental behavior were surprisingly close to those of egalitarian parents and thus distinct from those of heuristic-based and norm-oriented parental behavior. Furthermore, there is a tradeoff between equality at home and inequality at the macrolevel. Changes in the environment reduce or exacerbate inequality depending on parental investment behavior. Finally, the fact that one prediction of the model related to the distribution of cognitive skills within one generation and parental allocation strategies seems to be supported by empirical data, despite the proxy nature of the measures used, gives credence to the promise of using ABM productively in the study of social inequality from a life-course perspective.

Chapter 6

Closure in networks: language skills and friendship ties

The potential of applying the concept of closure to the study of social networks resides not only in understanding how social ties are formed and persist, or how individuals are affected by such ties, but in combining both processes systematically. By looking at social networks through the lens of network formation and peer effects *simultaneously* it becomes clear how exclusionary action brings about inequality.

There is abundant empirical evidence on the processes involved in tie creation, consolidation, and decay. Phenomena such as homophily and preferential attachment, dyadic transactions (in particular, reciprocity and repetition), triadic configurations (including balance and triadic closure), and contextual variables (such as physical space and shared activities) are all critical to understanding tie formation (Rivera, Soderstrom, & Uzzi, 2010). Parallel to the research on network formation, there is a growing literature on peer effects that is full of examples of how relationships exert a decisive influence on individuals, both positive, as with the spread of happiness (Fowler & Christakis, 2008), and negative, as with the apparent contagious character of suicide (Bearman & Moody, 2004).

The study of social inequality and social stratification has benefited from both research fields. Understanding network formation has been central in the study of inequalities resulting from differences in social capital, the resources embedded in social relationships (Burt, 2005; Lin, 2009). Similarly, peer effects in crime (Baerveldt et al., 2008), health (Smith & Christakis, 2008), and performance in school and tertiary education (Sacerdote, 2011) have become almost common-sense knowledge in discussions of social deviance and social problems. Given the relevance of each of these two research traditions taken separately for the study of social inequality and stratification, there is much to be gained by considering network formation and peer effects simultaneously from the perspective of closure as exclusionary action.

Efforts have already been devoted to achieve exactly this integration. For example, as reviewed by DiMaggio and Garip (2011, 2012), the spread of beneficial practices and behavior can be explained by the combined effect of tie formation and network dynamics. Given homophilous network formation, cumulative (dis)advantage results from network externalities, peer learning, and peer pressure, exacerbated by network segregation and repeated network interaction. In a similar vein but in much more general terms, Mulder et al. (2009) and Bowles et al. (2010) offer an explanation of the emergence and persistence of skill inequality within and across generations through the combined effect of network segregation and human capital spillovers through network ties.

Following this line of thought, this chapter investigates the role of language spoken at home, as a proxy measure for children's proficiency in the language spoken in kindergarten, on the creation of friendship ties at an early age. Insofar as friendship ties bring together individuals with shared attributes, they create, intentionally or otherwise, clusters of advantage and disadvantage, a form of closure that operates through direct interaction. If the language skills of those at the upper end of the skill distribution help them build networks that further accelerate their language development, while those less proficient in the language, such as children growing up in a bilingual environment, are not able to do so because of their lower language skills in the language spoken in kindergarten, then the effect of language on tie formation could set in motion both a virtuous and a vicious cycle in terms of language development, depending on the initial skills of a child in the early stages of the life course.

Networks have long been recognized as important contexts for child development (Cochran, 1993; Cochran & Brassard, 1979). Language, too, is developed to some extent through peer interaction, something that is particularly evident in the acquisition of a second language (e. g., Oller & Eilers, 2002; Swain, Brooks, & Tocalli-Beller, 2002). Peers provide children with the opportunity to use language and with a language model to learn from, both of which may potentially impact their language acquisition (Hoff, 2006), although interaction with competent adult speakers is still decisive and cannot be substituted for by peers (e. g., Huttenlocher, Waterfall, Vasilyeva, Vevea, & Hedges, 2010). While there are few studies measuring the exact impact of peers on language development (Hoff, 2006, 71), existing quantitative evidence seems to confirm a positive effect of peers' language skills on language development in preschool children. For example, Mashburn, Justice, Downer, and Pianta (2009) using data for 1,812 4-year-old children in 453 classrooms in the U.S. found a positive influence of classmates' language skills on language skill growth. Justice, Petscher, Schatschneider, and Mashburn (2011) arrive at similar conclusions with a smaller sample of 338 children in 49 classrooms. Thus, based on research about the importance of networks for de-

velopment in general and studies about peers and language development in particular, it seems safe to assume as a premise for the following analysis that the number of peers (network size) and their language skills in the language they use in kindergarten (network composition) may affect language development beginning early in life.

The analysis conducted in this chapter builds upon previous studies on friendship formation in preschool children. Friendship ties have been shown to be determined by age and gender homophily, popularity, reciprocity, and triadic closure (Daniel, Santos, Peceguina, & Vaughn, 2012; Schaefer, Light, Fabes, Hanish, & Martin, 2010). In this chapter, data on the friendship networks from 125 preschool children distributed in six different classrooms from two kindergartens in Germany are used to explore the so far neglected effect of proficiency in the language spoken in the kindergarten (in this case German) on tie formation.¹ Based on estimates from exponential random graph models (ERGM), two questions are answered:

- Do homophily, triadic closure, and reciprocity explain friendship network formation of preschool children?
- How are language skills in the language spoken at the kindergarten relevant for network formation?

The chapter is organized as follows. **Section 6.1** presents data and measures. The methods used, exponential random graph models (ERGM), are briefly explained in **Section 6.2**. **Section 6.3** presents bivariate results, summarizes estimates of the ERGMs, and discusses in detail the effect of language proficiency on tie formation from the perspective of inequality through peer effects.

1 The data on friendship networks used in this chapter were collected by the research project “Ethnic Heterogeneity and the Production of Inequality in Educational Organizations from Early Childhood Onward”, which is part the *Collaborative Research Unit (CRC) 882* at Bielefeld University (<http://www.sfb882.uni-bielefeld.de/en>). The project is lead by Prof. Isabell Diehm; the research team is composed by the research fellows Jennifer Carnin, Claudia Machold, and Lara Pöttschke, as well as by Melanie Kuhn and Miriam Mai, who are former research fellows and current associated members of the project (<http://www.sfb882.uni-bielefeld.de/en/projects/b1>).

I am very grateful to Melanie Kuhn, Miriam Mai, Lara Pöttschke, and Jennifer Carnin for their efforts to collect and prepare the data on friendship networks and for making it available for conducting the research reported in this chapter.

6.1 Data and measures

6.1.1 Site

Data were collected in two ethnically diverse kindergartens in Germany as part of a longitudinal ethnographic study of ethnicity and inequality in the educational system (see Diehm, Kuhn, & Mai, 2013, for more details about the study). Data gathering was conducted in six different classrooms in the two kindergartens over a period of approximately 6 weeks in early 2013.

6.1.2 Data

Data relevant to the present analysis comes from three different sources. For a total of 125 children, data on friendship ties were gathered by means of short individual interviews with each child. Language skills were measured individually for a subsample of 44 children using the standardized test *Delfin4*, which measures proficiency in the German language (Fried, Briedigkeit, Isele, & Schunder, 2009). Additional socio-demographic variables, such as gender and age, but also language spoken at home, were collected using a standardized questionnaire completed by the child's parents.

6.1.3 Measures

- Friendship ties: children were asked to name up to three other children in the same classroom as theirs with whom they enjoyed playing. Preference for play partners is an appropriate proxy for friendship given the high overlap between play and friendship among preschool children (Fehr, 1995).
- Language proficiency: as a direct measure of proficiency in German the scores from the *Delfin4* test were used. The test is routinely collected by kindergartens themselves in cooperation with elementary schools. Scores were therefore analyzed as secondary data.² Results of the test are defined in the interval [20, 75]. Values below 47.8 mean that children need additional German language training. However, since test scores were not collected for all children from which friendship ties were elicited, the first language spoken in the family was used as an indirect measure for proficiency in the German language (German as primary language at home = high German language skills; other primary language spoken at home = low German language skills). See **Figure 6.2** in the results section below (**Section 6.3**) for

² In North Rhine-Westphalia, where the data was collected, the test will be discontinued by the end of 2014. For more information on *Delfin4*, see Diehm et al. (2013).

the relationship between *Delphi4* scores and this proxy measure of German language skills.

- To investigate homophily in basic sociodemographic attributes, a dummy variable for sex (1=boys) and age measured in months were included. **Table 6.1** presents the descriptive statistics for the individuals and the networks of each classroom.

6.1.4 Missing data

Of the 125 children in the sample, data were not collected for 19 children whose parents declined to take part in the study. This amounts to 15% of the sample on friendship ties, which is not very high and does not affect the indegree distribution because the other children's answers about ties to the missing 19 cases are available. Regarding the covariates, there are almost complete cases. First language spoken at home was missing for two children only. For them a category of "missing" was created as a separate language and kept in the analysis. There were no missing data for these age and gender variables. Only the birth month of one child was missing, so for this child an age in months equal to the expected average age given the year of birth was imputed.

Table 6.1: Descriptive statistics

Variable	Mean	Std. Dev.	Min.	Max.
Individual level (N = 125)				
Age	56.416	11.073	31	82
Sex (Boy = 1)	0.568	0.497	0	1
Family language (German = 1)	0.744	0.438	0	1
Outdegree	1.648	1.138	0	3
Indegree	1.648	1.421	0	7
Network level (N = 6)				
Classroom size	20.833	1.602	19	23
Density	0.134	0.026	0.094	0.162

6.2 Methods: exponential random graph models (ERGM)

Exponential random graph models (ERGM) or p^* models are statistical models that investigate the mechanisms underlying tie formation (Robins, Pattison, Kalish, & Lusher, 2007). The main advantage of ERGMs is the possibility of making statistically informed conjectures about the likely local processes involved in network formation based on cross-sectional data. Even if the dynamics of network formation remain concealed, the microprocess underlying tie creation can be inferred from the resulting network configuration observed at a single point in time. An additional advantage of ERGMs is their versatility. They allow one to model *simultaneously* various local processes in networks, including the effect of different dyadic and triadic mechanisms, as well as various forms of interaction between node attributes and ties.

The logic behind ERGMs is simple. The frequency of configurations observed in the data, such as reciprocal or homophilous ties, is compared with a distribution from a sample obtained through simulation of all theoretically possible networks generated by chance that have the same number of nodes and ties as the network at hand. If the configurations found in the data are more frequent than expected by chance it can be inferred that the tie-formation processes associated with the observed configurations explain how the network came about.³ The general formulation of an ERGM is given by **equation 6.1** (Robins et al., 2007, 178–9).

$$Pr(Y = y) = \left(\frac{1}{k}\right) \left\{ \exp \sum_A \eta_A g_A(y) \right\} \quad (6.1)$$

$Pr(Y=y)$ is the probability distribution of networks of all possible networks with a given number of nodes, y is the observed network, k is a normalizing factor, A are the configurations, g_A tells whether A is observed in the graph, and η_A quantifies the importance of A in the model, that is, the higher or lower probability of tie creation given a configuration.

Based on past research using ERGMs (Daniel et al., 2012) and similar studies with longitudinal data (Schaefer et al., 2010), **equation 6.1** was fitted with the following network configurations:

- Network configurations based on ties.
 - *Density*: General tendency for tie formation.

³ For a comprehensive introduction to ERGMs see Lusher, Koskinen, and Robins (2012).

- *Reciprocity*: Children are mentioned as friends by those they regard as friends.
- *Isolates, sinks, and sources*: These effects represent children without any incoming ties (sources), without outgoing ties (sinks) or without both incoming and outgoing ties (isolates). As suggested by Robins, Pattison, and Wang (2009), it is important to include these configurations as control variables to better fit data.
- *Triadic closure*: For undirected graphs, triadic closure constitutes a triangle, whereas directed graphs allow for a total of seven possible triangle-like configurations. To simplify, and since the outdegree is limited to three friends by design, only two forms of triadic closure that involve one-directional ties are considered. These are the so-called transitive and cyclic triads (see **Figure 6.1**). While the former measures the tendency of friends to become friends, the latter captures generalized exchange (Robins et al., 2009).

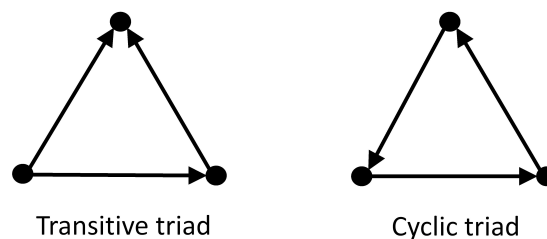


Figure 6.1: Two forms of triadic closure

- Node configurations based on node attributes (sex, age, and language spoken at home).
 - *Activity and popularity*: Children with a given attribute tend to nominate more friends (activity) or receive more nominations from others (popularity).
 - *Homophily in dyadic/categorical attributes (sex and family language)*: Children who share the same attribute tend to be connected. A positive parameter means homophily, a negative parameter heterophily.
 - *Homophily in continuous attributes (age)*: The logic is the same as with dyadic attributes. However, for continuous attributes, similarity is measured by the distance between the attributes of two nodes. If children with the same age tend to build ties, homophily is high. This corresponds to a negative parameter estimate (the smaller the distance, the higher the probability of a tie).

Two models are estimated. Model 1 treats language as a dichotomous variable, while Model 2 operationalizes language spoken at home categorically, coding the exact family language spoken by children at home, thus assuming that children who speak the same language at home have similar command of the German language. Aside from these differences in measuring language, Models 1 and 2 are identical.

It is assumed that parameter estimates of **equation 6.1** are the same for all classrooms, which is a reasonable assumption given that the two kindergartens in the sample are similar in their demographic composition. This same strategy was followed by Schaefer et al. (2010), whereas Daniel et al. (2012) used a meta-analysis approach that allowed for differences across classrooms. To estimate the parameters, a unique adjacency matrix with the ties of all children in the six classrooms was created. Since ties are not allowed between classrooms, a structural zero matrix that sets all between-classroom ties to zero was specified.

Because nonresponse missing data are present in the outdegree of 19 children, two alternative estimation strategies were followed. First, Models 1 and 2 were estimated using maximum likelihood estimates (MLE), ignoring missing data and assigning zeros in the adjacency matrix to the outgoing ties of children that did not report who their playmates were. Second, in order to get around the possible bias introduced by missing data in MLE, models were fitted a second time using Bayesian estimates and data augmentation methods (for a comparison of the two estimation methods, see Lusher et al., 2012, 147–9). The software PNet and its extension MPNet were used to obtain MLE and Bayesian estimates, respectively.⁴

6.3 Results

Results are presented in four steps. First, central descriptive and bivariate results are discussed. Second, MLE and Bayesian estimates of Models 1 and 2 are summarized. Third, a sensitivity analysis of the results was conducted by including high-order configurations in the models and fitting them once again using both MLE and Bayesian estimates. Closing the analysis, results were interpreted from the perspective of peer effects on the development of German language proficiency.

6.3.1 Descriptive and bivariate results

Distribution of language spoken at home. The distribution of languages spoken by children in the whole sample is summarized in **Table 6.2**. Children who speak German at home constitute the clear majority, reaching almost 75% of the total

⁴ Software and documentation can be downloaded from <http://sna.unimelb.edu.au/PNet>

number of participants in the study. In the remaining 25% of the sample, roughly three-fourths correspond to children who speak Turkish, Kurdish, and Russian at home. Only a small minority of children speak a language different from the four most prevalent languages in the sample. It is important to note that the second and third languages spoken in the family were also collected. Except for eight children, families that reported speaking a language other than German at home also declared that they spoke German as a second family language. Similarly, 35 out of 93 children that spoke German at home as the primary language also spoke a second language different from German. As explained next, in terms of language proficiency, the first and not the second language spoken at home seemed to be the most important indicator of proficiency in the German language.

Table 6.2: Language spoken at home

Language	N	%
German	93	74.4 %
Turkish	8	6.4 %
Kurdish	6	4.8 %
Russian	6	4.8 %
Arabic	2	1.6 %
Tamil	2	1.6 %
Albanian	1	0.8 %
Kosovar	1	0.8 %
Persian	1	0.8 %
Roma	1	0.8 %
Amaziht	1	0.8 %
Hungarian	1	0.8 %
Missing	2	1.6 %
Total	125	100 %

Language spoken at home and German language proficiency. The starting point of this analysis was that German language proficiency correlates with German language use at home. The results displayed in **Figure 6.2** give credence to this assertion. For a subsample of 44 children for whom command of the German language was assessed, average test scores were higher for children who spoke German at home as the primary language. A t-test suggests that this difference is statistically significant ($p < 0.05$).

One could argue that the relevant distinction is whether children speak only German at home or not, that is, whether there is a second family language. **Figure 6.3** shows average language skills for children classified according to their first and second language spoken at home. As can be seen, the best predictor of language proficiency is the first language.

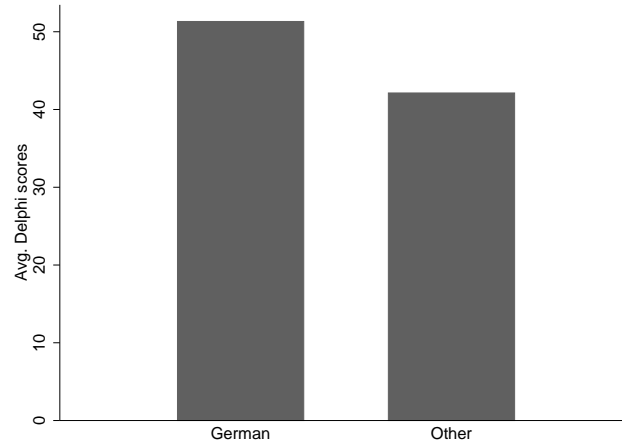


Figure 6.2: German language proficiency and first language spoken at home

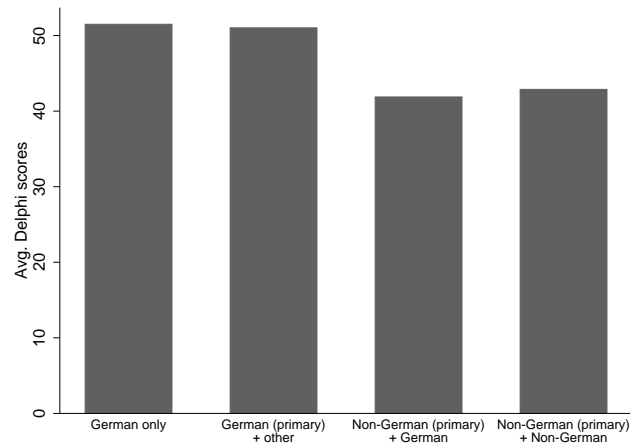


Figure 6.3: Language proficiency and first and second language spoken at home

Language proficiency, network size, and network composition. As argued in the introduction to this chapter, differences in language proficiency as a function of primary language spoken at home can impact children's language skill development through friendship networks (size and composition). For the subsample of children for whom German language proficiency was measured, the correlation between German language skills and both total degree (network size) and proportion of total incoming and outgoing ties constituted by children that spoke German as a primary language at home (network composition) was positive ($\rho = 0.13$ and $\rho = 0.08$, respectively).⁵ While this result proves nothing about the direction of causality in these two bivariate relations, results are at least consistent with the premise of the present analysis about the positive impact of network size and composition on language skills.

Language homophily in friendship ties. From the perspective of network formation and inequality in language development, the decisive question is whether language proficiency plays a role in the emergence of friendship networks. As shown in **Figure 6.4**, there appears to be no clear division of ties along the lines of language spoken at home and hence along differences in command of the German language.⁶

Beyond the mere visual inspection of **Figure 6.4**, language assortativity can be measured using a summary index. There are various strategies to quantify segregation in networks depending on which null model or definition of non-segregation is assumed (Bojanowski & Corten, 2014). Since the focus here is tie formation, it is critical to know whether the mixing pattern inside the classrooms can be explained by a child's preference for friends with similar language skills or whether it simply results from the constrained opportunities to form friendships given the distribution of children in terms of language spoken at home (**Table 6.2**). In other words, considering that one-fourth of the children spoke a language other than German at home, chances are higher that they will make friends with those in the German-speaking majority than vice versa.

With this distinction between choice and opportunity structure in mind, the Coleman's homophily index was chosen (Coleman, 1958). The index measures the tendency of nodes to connect across categorical boundaries over and above what can be expected assuming a uniform probability of tie formation, conditioned on the relative size of each category in the population. If the number of ties within categories correspond to what is expected by their size, the index takes the value of zero. Positive values of the index indicate homophily. The index

⁵ Given the high skewness of degree distribution in social networks, Spearman's ρ and not Pearson's r was used as a measure of correlation.

⁶ Each classroom is called by the name of a fruit, a strategy used during field work to ensure data anonymity.

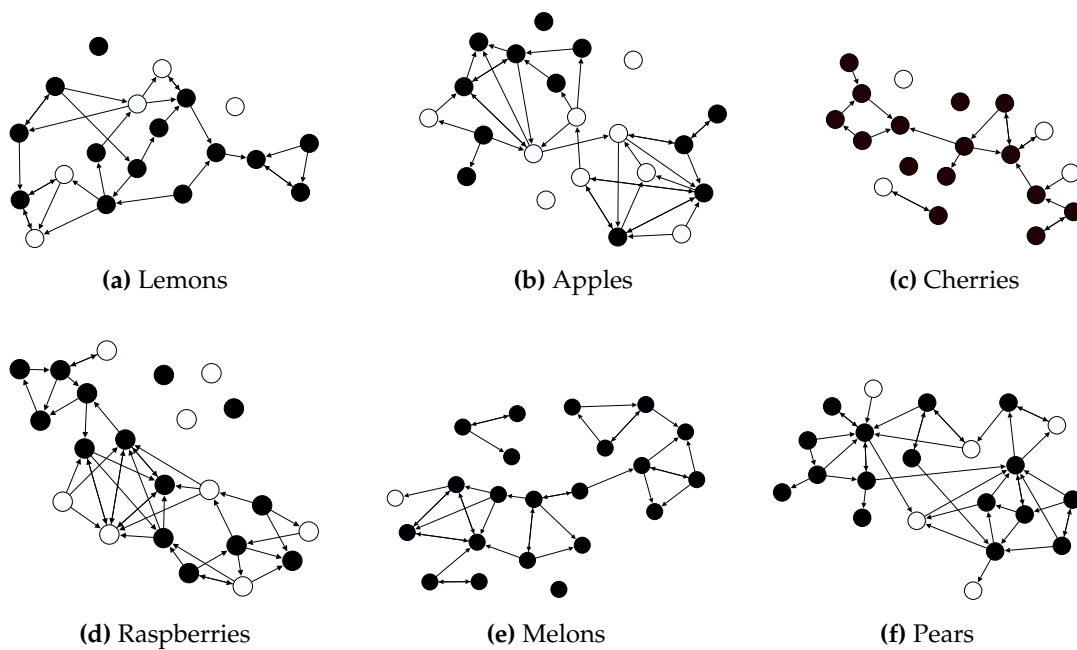


Figure 6.4: Friendship ties in 6 classrooms (black nodes: German spoken at home; white nodes: other language.)

is defined for each category separately and was computed classifying children according to a dichotomous distinction regarding the primary language spoken at home: those coming from German-speaking households and those from non-German-speaking households. Although using a categorical variable with each language separately would be more precise than a dichotomous distinction, children belonging to the non-German-speaking minority were scattered in the six classrooms so that at most only two children per classroom spoke the same non-German language at home as their primary language.

Results for the homophily index for each group in each classroom are summarized in **Figure 6.5**. The difference between groups is evident. While children in the German-speaking group showed positive or low homophily, children in the non-German-speaking group tended toward heterophily. Recall that Coleman's index controls for the relative size of the groups, so the heterophily among non-German-speaking groups is not due to their minority status. It is also interesting to note that, except for two classrooms, the homophilous tendency among German-speaking children was rather small. The two exceptions were the 'cherries' and the 'melons.'

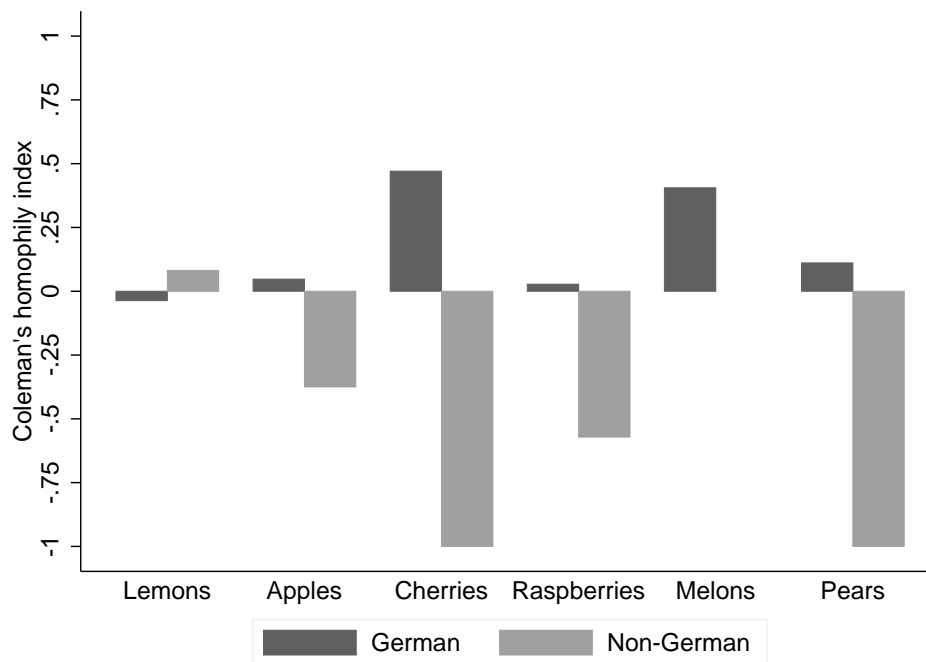


Figure 6.5: Homophily in friendship ties by language spoken at home

6.3.2 ERGM: maximum likelihood estimates (MLE)

To investigate the data further **equation 6.1** was fitted to include all network configurations listed in **Section 6.2**. First, maximum likelihood estimates (MLE) in PNet were used without imputing missing data on friendship ties and setting the maximum number of outgoing ties to three. In the next section, the results of using Bayesian methods and data augmentation for missing ties are reported. Language spoken at home is tested both as dichotomous (Model 1) and as a categorical variable (Model 2).

The MLE are summarized in **Table 6.3**. Estimates were run until all parameters converged (convergence < 0.1). The interpretation of the parameters is straightforward. Positive and statistically significant coefficients mean a greater-than-chance frequency of the particular configuration in the observed data (e. g., reciprocity), while negative and statistically significant coefficients mean a lower-than-chance frequency. These effects should be interpreted *ceteris paribus*, that is, keeping the other coefficients constant as in linear regression models. The size of the coefficient is not as relevant as whether the parameter deviates from what is expected by chance or not.

Model 1: Language dichotomous. The parameters for reciprocity and transitive closure were positive, while the parameter for cyclic closure was negative. This

suggests that children tend to make friends with friends of friends but are not engaged in generalized exchange constellations. Boys appear to be both less active and less popular than girls, as indicated by the negative parameter for the interaction of activity and popularity with sex of the child. This means that both indegree and outdegree is lower for boys. Irrespective of sex, older children tend to be more popular. The effects of similarity in sex and age suggest homophily in the two variables. However, once these effects are taken into account, proficiency in German language as measured through primary language spoken at home appears to have no impact on tie formation. The parameters for activity, popularity, and homophily of family language are estimated with large standard errors and thus are statistically not different from chance.

Goodness-of-fit analysis showed convergence and stability of parameter estimates. This can be inferred from the t-ratio obtained by comparing predicted counts of various graph statistics using model parameters with the observed graph. In all cases the t-ratio is below 0.1 for configurations explicitly defined in the model and below 2.0 for the remaining configurations, which are the recommended rules of thumb to assess goodness of fit in ERGMs (Lusher et al., 2012, pp. 165–77; 181–2).

Model 2: Language categorical. As a robustness test for the nonsignificant effect of language found in Model 1, a second model was fitted in which language was operationalized categorically. Results of this new model are also summarized in **Table 6.3**. Except for age homophily, estimates are very close to those of Model 1. The effect of language homophily is here also statistically nonsignificant, suggesting that German language proficiency appears to add little to the probability of tie formation over and above the network configurations included in the model.

6.3.3 ERGM: Bayesian estimates with imputed data

So far, missing data has not been addressed, which can have serious consequences for parameter estimates (Kossinets, 2006). Therefore, to evaluate the stability of results obtained from MLEs **equation 6.1** was fitted using Bayesian methods that include data augmentation for missing values. Parameter estimates were computed using MPNet, an extension of PNet for multilevel networks. A total of 20 estimation runs were performed to produce better estimates. Goodness-of-fit analysis showed that the model fit the data well. Owing to problems with the software, an interaction with a continuous node attribute made the program crash. For this reason, age was operationalized in years and treated as a categorical variable. Results are summarized in **Table 6.4**. The interpretation of the coefficients is the same as with MLE.

Table 6.3: MLE

Effects	Model 1			Model 2		
	Estimates	Std. Error	Converg.	Estimates	Std. Error	Converg.
Density	-4.639	0.761*	0.023	-3.907	0.637*	-0.033
Reciprocity	1.602	0.296*	0.025	1.603	0.310*	0.003
Sink	-0.064	0.435	-0.006	-0.069	0.424	0.005
Source	-1.189	0.410*	-0.019	-1.166	0.388*	-0.026
Isolates	-0.264	0.479	-0.019	-0.219	0.479	-0.049
Triadic closure						
<i>transitive triad</i>	0.952	0.109*	0.022	0.956	0.108*	-0.085
<i>cyclic triad</i>	-1.102	0.341*	0.026	-1.098	0.363*	-0.031
Sex (boys = 1)						
<i>activity</i>	-0.812	0.255*	0.002	-0.793	0.244*	-0.031
<i>popularity</i>	-1.588	0.282*	0.034	-1.590	0.280*	0.006
<i>homophily</i>	2.272	0.342*	0.028	2.261	0.341*	-0.037
Age (in months. continuous)						
<i>activity</i>	0.009	0.009	0.022	0.022	0.009*	-0.039
<i>popularity</i>	0.022	0.008*	0.032	-0.034	0.009*	0.047
<i>homophily (distance)</i>	-0.034	0.009*	-0.014	0.008	0.009	-0.032
Language at home (German=1)						
<i>activity</i>	0.726	0.436	0.031			
<i>popularity</i>	0.671	0.431	0.023			
<i>homophily</i>	-0.529	0.459	0.034			
(Categorical)						
<i>match</i>				0.276	0.147	-0.038

* Statistically significant estimates, Wald test at 95% confidence level.

Model 1: Language dichotomous. Results were very similar to those obtained through MLE. The sign of the parameters is consistent with the results already discussed. The main difference is that with Bayesian estimates the parameters associated with primary language at home were statistically significant. Children with a higher German language proficiency, those who spoke German as a primary language at home, tended to be more active (higher outdegree) and more popular (higher indegree) than those with lower German language skills. However, the homophily coefficient is negative, suggesting a tendency of the children to form friendship ties across boundaries of proficiency of German language, *ceteris paribus*.

Table 6.4: Bayesian estimates with missing data imputation

Effects	Model 1		Model 2	
	Estimates	Std. Error	Estimates	Std. Error
Density	-3.447	0.004	-2.916	0.010
Reciprocity	1.550	0.048	1.568	0.001
Sink	-0.392*	0.036	-0.550*	0.009
Source	-0.729*	0.023	-0.915*	0.016
Isolates	0.010	0.009	-0.518*	0.025
Triadic closure				
<i>transitive triad</i>	0.708*	0.012	0.679*	0.004
<i>cyclic triad</i>	-0.744*	0.016	-0.770*	0.004
Sex (boys = 1)				
<i>activity</i>	-0.909*	0.023	-0.699*	0.001
<i>popularity</i>	-1.725*	0.055	-1.878*	0.023
<i>homophily</i>	2.410*	0.023	2.488*	0.013
Age (in years. categorical)				
<i>match</i>	0.710*	0.017	0.387*	0.002
Language at home (German=1)				
<i>activity</i>	0.641*	0.013		
<i>popularity</i>	0.340*	0.002		
<i>homophily</i>	-0.331*	0.035		
(Categorical)				
<i>match</i>			0.096*	0.012

* Statistically significant estimates, Wald test at 95% confidence level.

Model 2: Language categorical. As with Model 1, results from Model 2 using Bayesian estimates were comparable to those obtained through MLE. Again, the only difference was the coefficient for language measured categorically, which in this case was statistically significant but very close to zero. This should come as no surprise, since as shown in Model 1, children who spoke German at home were indifferent to the language of their peers, whereas those who spoke a different primary language other than German at home seldom have the chance to find others who share their same language proficiency given the small numbers and high diversity of non-German speakers within classrooms (see **Section 6.3.1, Table 6.2**).

6.3.4 Sensitivity analysis: higher-order parameters

As evidenced by the similarity of results obtained with and without missing data imputation, parameter estimates seem to be robust to missing values. However,

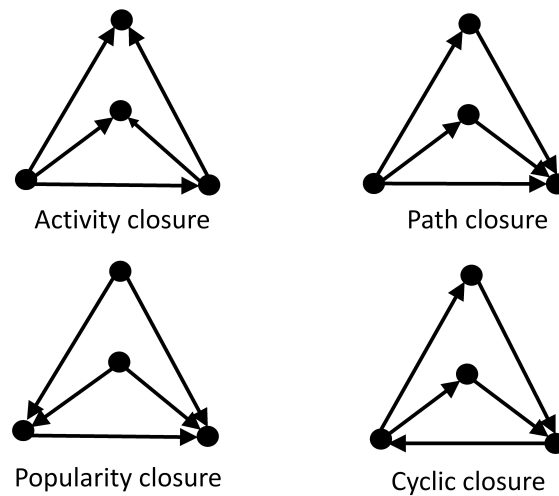


Figure 6.6: Higher order triads

to further test the sensitivity of results to model specification, higher-order parameters were specified and **equation 6.1** was again fitted with MLE and Bayesian methods.

Higher-order parameters refer to tie configurations that are more complex than dyads or triads. To measure the tendency of the network to be centralized in indegree or outdegree, two additional parameters were included: popularity spread (multiple ties pointing to one node) and activity spread (one node pointing to multiple ties). In addition, based on Robins et al. (2009), triadic closure was modeled in more detail, making use of higher-order triads. Four triadic configurations were tested separately (see **Figure 6.6**): (i) path closure, which corresponds to transitive closure and measures the tendency of open triads to closure; (ii) activity closure and (iii) popularity closure, or the tendency to connect among those who share outgoing or incoming ties, respectively; and (iv) cyclic closure, which as already mentioned, captures generalized exchange relationships.

Results are displayed in **Table 6.5** for MLE with missing data and in **Table 6.6** for Bayesian estimates with imputed data. Goodness-of-fit analysis suggested that all models fit the data well. Results were consistent with parameter estimates presented so far and suggest that the effect of reciprocity and triadic closure, as well as sex, age, and language, are robust to changes in model specification.

6.3.5 Discussion: the effect of language on tie formation

As explained by Lusher et al. (2012, ch. 8), the effects associated with node attributes should not be interpreted independent of each other. The probability of

Table 6.5: MLE: Higher order parameters

Effects	Model 1			Model 2		
	Estimates	Std. Error	Converg.	Estimates	Std. Error	Converg.
Density	-5.764	1.355*	0.010	-5.149	1.350*	-0.018
Reciprocity	1.535	0.293*	0.082	1.545	0.295*	-0.012
Sink	-1.860	1.246	-0.016	-1.863	1.290	0.077
Source	-0.659	0.783	-0.046	-0.709	0.781	0.029
Isolates	-1.479	1.414	-0.055	-1.501	1.394	-0.045
Centralization						
<i>popularity</i>	-0.422	0.436	-0.028	-0.387	0.445	-0.030
<i>activity</i>	1.311	0.896	-0.013	1.319	0.896	-0.013
Triadic closure						
<i>path closure</i>	1.799	0.706*	-0.007	1.798	0.698*	-0.009
<i>activity closure</i>	-0.336	0.140*	0.017	-0.328	0.141*	-0.031
<i>popularity closure</i>	-0.635	0.404	0.005	-0.645	0.393	-0.003
<i>cyclic closure</i>	-0.121	0.680	-0.010	-0.116	0.663	-0.011
Sex (boys = 1)						
<i>activity</i>	-0.815	0.263*	-0.052	-0.809	0.264*	0.038
<i>popularity</i>	-1.586	0.284*	-0.053	-1.593	0.286*	-0.005
<i>homophily</i>	2.254	0.361*	-0.059	2.252	0.336*	-0.010
Age (in months. continuous)						
<i>activity</i>	0.008	0.009	0.009	0.007	0.010	-0.028
<i>popularity</i>	0.024	0.009*	0.005	0.024	0.009*	-0.023
<i>homophily (distance)</i>	-0.034	0.008*	-0.055	-0.034	0.009*	-0.078
Language at home (German=1)						
<i>activity</i>	0.699	0.412	-0.015			
<i>popularity</i>	0.683	0.383	-0.012			
<i>homophily</i>	-0.519	0.425	-0.020			
(Categorical)						
<i>match</i>				0.279	0.143	-0.049

* Statistically significant estimates, Wald test at 95% confidence level.

a tie among, say two girls, is affected by their popularity, activity, and homophily parameters *simultaneously*. In order to make interpretation of the total effect of node attributes easier, they therefore advise the use of conditional odds ratios. This is analogous to the interpretation of the coefficients of a logistic regression: given a baseline probability between nodes with a certain attribute, the relative increase or decrease in the probability of a tie for all possible remaining combinations of attributes is computed. As an example, define the activity parameter θ^s , popularity parameter θ^r , and the homophily parameter θ^h . In the case of sex, with boys = 1 and girls = 0, the odd ratios can be formulated as follows (see Lusher et

Table 6.6: Bayesian estimates with missing data imputation: Higher-order parameters

Effects	Model 1		Model 2	
	Estimates	Std. Error	Estimates	Std. Error
Density	-2.337*	0.002	-2.498*	0.012
Reciprocity	1.833*	0.007	1.402*	0.021
Sink	0.757*	0.009	0.041	0.021
Source	-1.044*	0.014	-1.226*	0.042
Isolates	0.254*	0.011	-0.130*	0.045
Centralization				
<i>popularity</i>	0.047*	0.000	0.209*	0.017
<i>activity</i>	-1.164*	0.003	-0.777*	0.004
Triadic closure				
<i>path closure</i>	0.704*	0.011	1.523*	0.029
<i>activity closure</i>	0.817*	0.010	-0.084*	0.034
<i>popularity closure</i>	-0.436*	0.011	-0.363*	0.074
<i>cyclic closure</i>	-0.352*	0.008	-0.347*	0.013
Sex (boy=1)				
<i>activity</i>	-0.829*	0.020	-0.638*	0.035
<i>popularity</i>	-1.315*	0.009	-1.468*	0.048
<i>homophily</i>	2.017*	0.012	1.977*	0.095
Age (in years. categorical)				
<i>match</i>	0.441*	0.007	0.492*	0.003
Family language (German=1)				
<i>activity</i>	0.662*	0.015		
<i>popularity</i>	0.223*	0.007		
<i>homophily</i>	-0.172*	0.004		
Categorical				
<i>match</i>			0.231*	0.010

* Statistically significant estimates, Wald test at 95% confidence level.

al., 2012, 97–8):

- Tie between girls = 1 (baseline)
- Tie between boys = $e^{\theta^s + \theta^r + \theta^h}$
- Tie between a boy and a girl = e^{θ^s}
- Tie between a girl and a boy = e^{θ^r}

To illustrate, **Figure 6.7** displays the effects of sex on tie formation based on MLE parameter estimates of Model 1, **Table 6.3**. As can be seen, same sex ties have a higher probability to be observed in the data than ties across sexes.

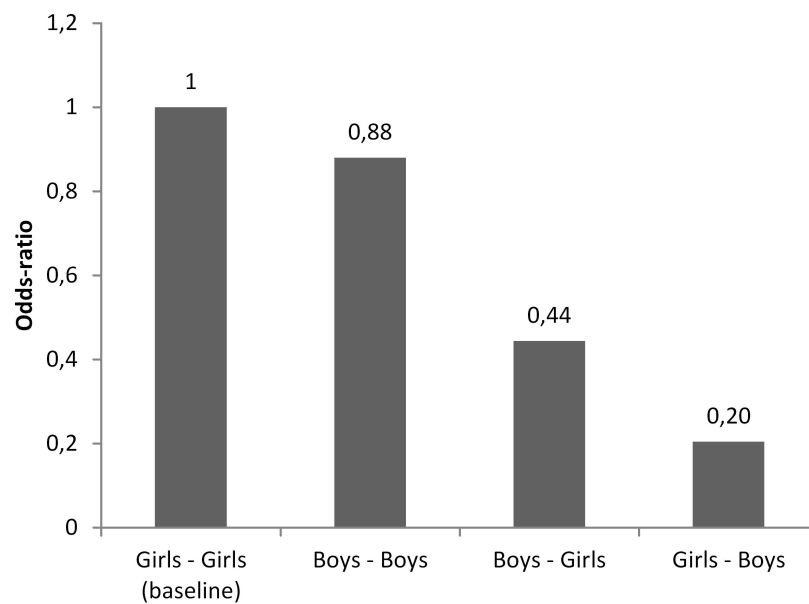


Figure 6.7: MLE total effect of sex on tie formation (odds ratios)

The same analysis can be conducted with German language skills. Since MLEs for language proficiency were statistically not significant, Bayesian estimates were used instead. As shown in **Figure 6.8**, the lowest probability for tie formation was predicted for ties among children who spoke primary language other than German at home (baseline). These children seemed to prefer peers who had German as their home language. By contrast, children from households in which German was the primary language seemed to make no distinction across language lines. In other words, language spoken at home does not seem to create a strong segregation across the boundary created by command of the German language such that proficient speakers are friends with proficient speakers and nonproficient speakers are friends with others like them. In fact, the combination that would definitely bring children together with lower German language skills appeared to be less prevalent in the data. So, if at all, segregation is likely among those who are better off being segregated in terms of being exposed to proficient peers in the German language.

Despite this lack of evidence for segregation, language seems to affect network size. Children who speak German at home tend to be both more active connectors and more popular friendship choices, which results in bigger networks for them. This is consistent with the heterophilous preference of children from non-German-speaking households for children whose primary language is German and the indifference of the latter for the language of their friends. In other words, the former are choosy and have smaller networks, the latter are less exclusive and have bigger networks.

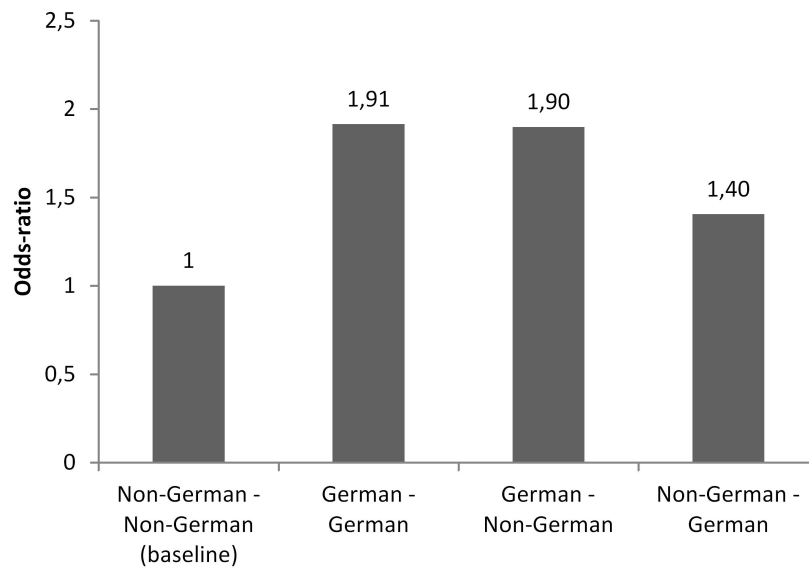


Figure 6.8: Bayesian estimates total effect of language spoken at home on tie formation (odds ratios)

In a nutshell, it can be concluded that German language skills, measured indirectly according to the primary language spoken at home, affects friendship networks through differences in activity and popularity that result in differences in network size and through the integration of children with different language skills. What the net effect of these differences in tie formation on German language development is remains an open question, and the answer depends on the relative importance of composition effects versus size effects. From the perspective of children in the minority group, those who speak a language other than German at home, composition effects might be positive while size effects might be negative. Estimates suggest that these children do exclude other children like themselves from their networks (others who speak a language other than German at home), which may turn out to be advantageous for them because it leads to a higher prevalence of friends in their networks who are proficient in the German language and from whom they can learn the language. On the other hand, their networks are smaller and hence they probably have a smaller chance of practicing the language. From the perspective of children in the majority group, those who speak German at home, results are exactly the opposite. They may benefit from bigger networks but probably lose from having friends in their networks who are less proficient in the German language. As a consequence of these opposing tendencies for children in different categories, the direction of the net effect on inequality in terms of advantages and disadvantages in language development cannot be predicted without ambiguity.

6.4 Summary

This chapter investigates the role of language skills in network formation, a direct form of closure, among 125 preschool children in two ethnically diverse kindergartens in Germany. The premise of the analysis is that peers can foster language development by providing a model to learn the language (composition effects) and interaction partners to practice (size effects). Using exponential random graph models (ERGM), the impact on tie formation of the language spoken by children at home, a proxy for proficiency in the German language, was quantified. The models were fitted both with MLE and Bayesian methods, controlling for dyadic and triadic processes shown in previous studies to affect friendship tie creation.

Results suggested that reciprocity, triadic closure, gender and age differences in activity and popularity, and age and gender homophily predict network ties. Language spoken at home impacts tie formation in two ways. First, it promotes integration: children who speak a primary language other than German at home (lower German language skills) prefer children as friends who live in a household that speaks German (higher German language skills), while the latter make no distinction across this language line when creating friendship ties. Second, children with higher German language proficiency are more active and popular connectors and hence enjoy bigger friendship networks.

How these effects of language on tie formation impact German language development is not clear since composition effects seem to favor children with low German language skills (more friends with high German language proficiency) while size effects seem to benefit children with high German language skills (more friends to talk with).

IV. Concluding remarks

Chapter 7

What have we learned? The path ahead

7.1 Main contributions

The main contributions of the present investigation can be summarized in three groups: a meta-level about how to do sociological research, a substantive applied level in the study of social inequality, and a methodological level regarding the use of agent-based simulation methods in a life-course perspective and of statistical models to quantify network formation in children.

- i) At a *meta-level*, this dissertation contributed to the discussion of fundamental epistemological and metaphysical issues surrounding the debate on social mechanisms and mechanistic explanations in sociology (Hedström & Ylikoski, 2010). It showed how to make the mechanistic agenda in sociology work by providing a definition of social mechanisms as an enriched heuristic and by making explicit both the core principles of a mechanistic approach and the risks of following the champions of social mechanisms in sociology without a healthy dose of skepticism. It also demonstrated how to apply a mechanistic agenda to guide research by emphasizing generative causality in theorizing and by choosing methods that explicitly model processes that actively bring about the explanandum, in particular agent-based simulation modeling and statistical network analysis methods of exponential random graph models (ERGM).
- ii) At the more *applied level*, it showed how to turn these principles of a mechanistic approach to social science into substantive research on social inequality by making a contribution to the theory and explanation of social inequality (Diewald & Faist, 2011; Therborn, 2006; Tilly, 1998). To achieve this, it redefined the Weberian concept of closure as an action-based transformational mechanism connecting various forms of exclusionary action at

- the microlevel, typified and classified in a closure space according to the forms of interaction and motives of action, to intergroup inequality at the macrolevel across contexts. Based on three separate studies it showed how exclusionary action brings about inequality in markets, families, and networks.
- iii) At a *methodological level*, the model presented in **Chapter 5** took a first step toward bringing together agent-based modeling (ABM) and social inequality research from a life-course perspective (Mayer, 2009), which has not been tried before (Meyer, Lorscheid, & Troitzsch, 2009; Squazzoni & Casnici, 2013).¹ Using simulation methods for the study of the life course is of particular relevance given the known restrictions affecting large longitudinal studies, such as missing data due to attrition, high administrative costs, and a rather slow pace of accumulating longitudinal data. Moreover, if agent-based simulation models are calibrated using empirical data, they can be used as virtual laboratories to generate hypotheses, guide data collection, and assist policy makers in designing and implementing social policy.² The fact that the code of the model was also made available to the research community for further exploration and development (Cardona, 2014b) makes the contribution of the present study more significant.
- iv) Also at a *methodological level*, the study also contributes to the quantitative study of social networks by applying exponential random graph models (ERGM) to investigate network formation in preschool children. So far, there are only a few studies that deal with the networks of young children using advanced statistical modeling tools (e. g., Daniel et al., 2012; Schaefer et al., 2010). In addition, the present study builds on previous studies by measuring the effect of language on tie formation and by analyzing the results from the perspective of peer effects and the production of social inequality.

Despite these contributions, there is still much ground to be covered, both on the meta-level of the metaphysics of mechanisms and the epistemology of mech-

1 It is true that ABM has already been used to understand the emergence of inequalities across contexts, as evidenced by existing studies on crime (Makowsky, 2006), health (Auchincloss, Riolo, Brown, Cook, & Diez Roux, 2011), labor markets (Dawid & Gemkow, 2013), gender (Robison-Cox, Martell, & Emrich, 2007), and place of residence (Schelling, 1971). However, there is still much to be done using ABM to investigate origins and persistence of inequalities in income, education, health, and deviant behavior paying attention to the role of categories such as class, gender and ethnicity among others and contexts like labor markets, social networks, neighborhoods, and households, within which individual lives evolve over time and decision-making takes place.

2 These arguments about ABM and life-course research have already been made in Cardona (2014a).

anistic explanations, as well as on the substantive level of empirical research and theorizing about closure as exclusionary action.

7.2 The future of a mechanistic agenda in sociology

The intricacies of the discussion on social mechanisms and mechanistic explanations in sociology presented in this work are a good indicator of the difficulties faced by anyone trying to make sense of this approach and evidence for the difficulties raised by the approach itself. The emphasis on individual predilections in theory and method when making use of the concept of social mechanisms explains why the discussion seems to have been more effective, at least up to now, in bringing forth particular agendas in the discipline (e. g., analytical sociology) than in fostering a more broadly based debate on causation and causal explanation in sociology. This programmatic bias of the discussion has a clear downside. It raises skepticism among sociologists about the pertinence of a mechanistic approach and its alleged novelty. Thus, while some appear to be more concerned with particular agendas, the skeptical are growing wary about the very notion of mechanisms and mechanistic explanations.

Where do we go from here? In the light of what was discussed in **Chapter 1**, two positions can be defended.³ First, an 'opportunistic' or 'cynical' position can be taken that reduces the notion of mechanisms to a transient metaphor to be used instrumentally for higher programmatic goals. This, of course, would disappoint the gullible among sociologists who had taken the social mechanism discussion at face value without being aware of its programmatic bias. The skeptical, however, will be satisfied, since an opportunistic or cynical position gives them a justification for their skepticism. The strategy of treating the mechanistic agenda as a 'style of theorizing,' a combination of deeper causal explanations, generative causality, and middle-range theorizing, can be accommodated under this 'opportunistic' position.

However, going down this path seems to go against the efforts of pushing a mechanistic agenda in sociology. Why insist on mechanisms if they are mere labels for a style of theorizing that simply bundles some other principles? Why not just embrace those principles and give up the "mechanistic talk" instead? If the mechanistic approach can be reduced to its constitutive elements—deeper and more transparent causal explanations, generative causality, and middle-range theorizing—then the idea of social mechanisms becomes *de facto* dispensable. Indeed, anyone committed to those same three principles practices 'mechanism-based' research *already*. In one word, if the mechanistic approach does not de-

3 Some of these ideas are found in Cardona (2013b).

pend upon the existence of mechanisms, there is no need for the concept; the same principles it allegedly represents can be safely endorsed and applied without mentioning mechanisms at all.

Second, and in contrast to this instrumental, programmatic view, a 'purist' position might be defended that judges the mechanistic approach in its own right, not as an accessory metaphor to any particular theoretical or methodological program in sociology but as an ongoing debate on the nature of causation and causal explanation despite methodological and theoretical tensions. Only if attention is directed away from programmatic struggles and focused on the core principles of generative causality and on a commitment to understanding through causal explanation can a broad-based discussion on social mechanisms and mechanistic explanations be fruitfully pursued. This, again, would disappoint the gullible who think they can do without the philosophy. It might, in fact, also disappoint the skeptical who had already given up the efforts to understand a mechanistic approach to sociology, rejecting it as vacuous 'mechanistic talk.'

This second alternative, *in addition* to endorsing the three principles of a mechanistic approach, would require a deeper commitment to investigating mechanisms as real social phenomena. This of course raises the same problem that philosophers are trying to solve and champions of mechanisms in sociology were so quick to give up: what are mechanisms? How do we define them by giving voice to the theoretical pluralism of sociology and the different competing social ontologies the discipline has to offer? The definition provided in this work of social mechanisms as a *robust and recurrent concatenation of outcomes that, given certain initial conditions, causally produces the explanandum* is by no means definite; it entails some core assumptions, widely attributed to social mechanisms—extension and recurrence in time, generative causality, as well as dependence on and robustness to initial conditions—while leaving most others unanswered such as their generality or stability. The definition is thus compatible with different social ontologies, such as processes or systems, as well as with other theoretical issues, including issues surrounding individualism and holism, theories of action, hierarchies and reducibility, and observability, among others. To be sure, anyone already committed to a specific social ontology (e. g., Bunge's systemism) need not endorse this core definition. However, it provides a minimal consensus of what a social mechanism is, or to be more precise, of what a social mechanism is supposed to be, for the decisive proof of the existence of mechanisms in the social world and the extent to which a research program built around it succeeds in fulfilling the promises it makes, remains an empirical question.

Admittedly, the first alternative, 'opportunism,' is the less costly. It protects the status quo for both the advocates and the skeptics of social mechanisms. By contrast, the second alternative might force sociologists at both ends of the spec-

trum to reconsider their positions. It implies diving squarely into philosophical questions and hence requires sociologists to invest time and effort in developing informed opinions on the philosophy of causation and explanation. If they fail to do so, they will very likely end up divesting the concept of its substance and the discussion on mechanisms and mechanistic explanations of its entire purpose. Among those 'purists' who decide to look into the philosophy of causation and causal explanation, some might decide not to support a mechanistic agenda while others who do support it will eventually have to choose a particular social ontology, theory, and method to put it into practice. However, and irrespective of these choices, probably only a purist position combined with a commitment to develop an ontology of social mechanisms will allow for understanding of and debate about the essence of a mechanistic approach, free from individual theoretical and methodological biases. And only then will gullibility or skepticism be warranted.

7.3 Closure as an explanation of intergroup inequality

The discussion on the meaning of closure and the application of the concept to inequality in markets, families, and networks can be seen as a plea for urgently needed conceptual and methodological rigor when raising causal claims about the origin of intergroup inequality.⁴ Gender, age, or occupation may certainly provide a basis for closure practices. It is, however, a mistake to *animate* these categories and regard them as actors acting effectively to exclude others simply because we observe an unequal distribution of resources among individuals grouped by them. In the case of collective actors, for example, even if it is shown that some categorically defined collectives do constitute a group with shared economic interests (e. g., lawyers), this need not imply that the group is capable of concerted collective action (Olson, 1971). Moreover, the fact that a well-constituted group decides to act upon its interests does not guarantee that its action will bring about the desired results, as was shown in the case of British accountants discussed by Walker and Shackleton (1998). In other words, the action character of the concept of closure as defined in the present investigation requires that any empirical study making a case for closure as an explanation of inequality should provide unambiguous evidence of actors bringing about inequality intentionally or not through direct or mediated forms of interaction. Without action there is no closure.

To be sure, the definition of closure as exclusionary action offered here is far from being a fully-fledged theory of inequality. Many questions remain unan-

4 Some of these arguments were already made by Cardona (2013a).

swered. In particular, the situational and action formation aspects of exclusionary action should be a priority in future research. A complete explanation of intergroup inequality based on exclusionary action as a transformational mechanism that closes the macro-micro-macro circuit needs to include situational and action formation mechanisms.

Take for example the emergence of skill inequality among groups defined by socio-economic status. As explained in **Chapter 5**, differences in status attainment within one generation can be traced back to differences in skill levels among classes or socioeconomic categories. Across generations, differences in resources in the previous generations reproduce skill inequalities in the next generation through parental investment behavior along those same socioeconomic boundaries. Dissecting analytically each part of the process, three causal paths can be identified to explain the production and reproduction of socioeconomic differences in skills. The complete macro-micro-macro chain is summarized in **Figure 7.1**.

1. *Resource differences among parents (situational)*. An unequal distribution of parental skills produces inequality in parental education, income, and occupation (Heckman & Kautz, 2012). Differences in resources set the stage for parental investments.
2. *Stratified parental investment behavior (action formation)*. Given the risk of downward mobility, it is rational for parents to invest differentially in children depending on children's skills and parental resources (Cardona & Diewald, 2014). This defines the rationale of action in terms of costs and benefits of alternative parental behavior.
3. *Intentional and direct closure through parental investments (transformational)*. Given parental resources, parents invest differently in children, intentionally or otherwise, depending on the child's gender, birth order and observed skills, thus producing differences in skill growth (**Chapter 5**). Differences in skill growth among children affect their life chances, in particular their education and occupational attainment, that is, their class position as adults (hence we come again to 1, resource differences among parents). This process repeats in each generation.

In short, formulating an explanation of inequality that bridges the micro to the macro and back again not only requires shedding light on the societal conditions under which exclusionary action is most likely to arise, but also makes it necessary place exclusionary acts and the actors enacting them under the microscope.

A theory articulating closure with broader stratification processes, as was the project of Parkin and Murphy, might be needed to understand the structural conditions needed for exclusionary action to emerge. In particular, it should be ex-

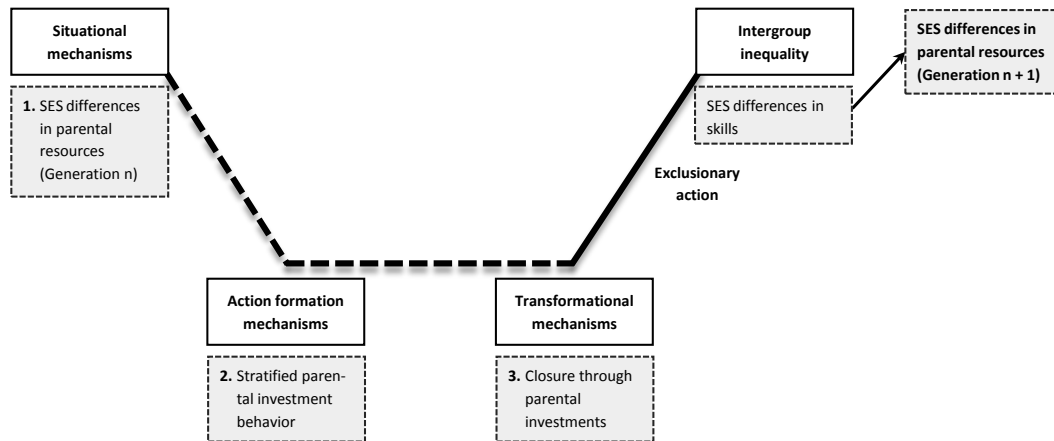


Figure 7.1: An explanation of socio-economic differences in skills

plained why certain groups or individuals belonging to a particular category are more able or more willing than others to practice closure. In the context of markets, the theory of rents by Sørensen (1996, 2000) offers a good example of how the emergence of exclusionary collective action can be theoretically based and traced back to deeper processes—in his theory, the struggles over enduring rents from rent-producing assets.

In addition to structural conditions, the inner logic of exclusionary acts needs to be understood. This is particularly relevant given the complexity of the proposed 'closure space,' which spans a diverse combination of actors, motives and modes of interaction. Opening the black box of agency is relevant not only for intentional and mediated forms of closure, for which political institutions and discourses may play a critical role in shaping the logic behind concerted efforts to introduce exclusionary devices such as laws (Chua & Poullaos, 1998), but also for unintentional and direct forms, for which society-wide stereotypes and legitimizing ideologies coupled with organizational practices enable and constrain individual exclusionary acts (Roscigno, 2007).

Bringing clarity to these additional issues surrounding different forms of exclusionary action should be an integral part of a thorough explanation of intergroup inequality from a mechanistic perspective using the concept of closure as its core

transformational mechanism. To advance such a systematic research program that bridges the macro-micro-macro circuit of exclusionary action, keeping the concept of closure explanatory by preserving its action-based character, as was the goal of this study, is a necessary first step.

List of references

- Abbott, A. (1998). The causal devolution. *Sociological Methods and Research*, 27, 148–181.
- Abbott, A. (2001). *Chaos of disciplines*. Chicago: University of Chicago Press.
- Abbott, A. (2007). Mechanisms and relations. *Sociologica*(2).
- Adams, T. L. (2008). Understanding professional regulation. *Conference Papers – American Sociological Association*, 1–22.
- Ahn, W.-k., & Kalish, C. W. (2000). The role of mechanism beliefs in causal reasoning. In F. C. Keil & R. A. Wilson (Eds.), *Explanation and cognition* (pp. 199–225). Cambridge and Mass: MIT Press.
- Almond, D., Edlund, L., & Milligan, K. (2013). Son preference and the persistence of culture: Evidence from South and East Asian immigrants to Canada. *Population and Development Review*, 39(1), 75–95.
- Amark, K. (1990). Open cartels and social closures: professional strategies in Sweden, 1860-1950. In M. C. Burrage & R. Torstendahl (Eds.), *Professions in theory and history* (pp. 94–114). London: Sage.
- Archer, M. S., Bhaskar, R., Collier, A., & Lawson, T. (Eds.). (1998). *Critical realism: Essential readings*. London: Routledge.
- Auchincloss, A. H., Riolo, R. L., Brown, D. G., Cook, J., & Diez Roux, A. V. (2011). An agent-based model of income inequalities in diet in the context of residential segregation. *American Journal of Preventive Medicine*, 40(3), 303–311.
- Autor, D. H., Katz, L. F., & Kearney, M. S. (2008). Trends in U.S. wage inequality: Revising the revisionists. *Review of Economics and Statistics*, 90(2), 300–323.
- Baerveldt, C., Völker, B., & van Rossem, R. (2008). Revisiting selection and influence: An inquiry into the friendship networks of high school students and their association with delinquency. *Canadian Journal of Criminology and Criminal Justice*, 50(5), 559–587.
- Baillargeon, R., Kotovsky, L., & Needham, A. (1995). The acquisition of physical knowledge in infancy. In D. Sperber, D. Premack, & A. J. Premack (Eds.), *Causal cognition: A multidisciplinary debate* (pp. 79–116). Oxford: Clarendon Press.
- Baker, W., & Faulkner, R. R. (2009). Social capital, double embeddedness, and mechanisms of stability and change. *American Behavioral Scientist*, 52(11), 1531.

- Barbalet, J. M. (1982). Social closure in class analysis: A critique of Parkin. *Sociology*, 16(4), 484–497.
- Barrera, D. (2008). The social mechanisms of trust. *Sociologica*, 2, 1–31.
- Baydar, N., Hyle, P., & Brooks-Gunn, J. (1997). A longitudinal study of the effects of the birth of a sibling during preschool and early grade school years. *Journal of Marriage and Family*, 59(4), 957–965.
- Bearman, P. S., & Moody, J. (2004). Suicide and friendships among American adolescents. *American Journal of Public Health*, 94(1), 89–95.
- Bechtel, W. (2006). *Discovering cell mechanisms: The creation of modern cell biology*. Cambridge: Cambridge University Press.
- Bechtel, W., & Abrahamsen, A. (2005). Explanation: A mechanist alternative. *Studies in History and Philosophy of Biological and Biomedical Sciences*, 36(2), 421–441.
- Becker, G. S., & Tomes, N. (1986). Human capital and the rise and fall of families. *Journal of Labor Economics*, 4(3), 1–39.
- Beebe, H., Hitchcock, K., & Menzies, P. (Eds.). (2009). *The Oxford handbook of causation*. Oxford: Oxford University Press.
- Behrman, J. R. (1997). Intrahousehold distribution and the family. In M. R. Rosenzweig & O. Stark (Eds.), *Handbook of population and family economics* (Vol. 1, pp. 125–187). Elsevier.
- Behrman, J. R., Pollak, R. A., & Taubman, P. (1982). Parental preferences and provision for progeny. *Journal of Political Economy*, 90(1), 52–73.
- Ben-Porath, Y. (1967). The production of human capital and the life cycle of earnings. *Journal of Political Economy*, 75(4), 352–365.
- Berger, L. M., Paxson, C., & Waldfogel, J. (2009). Income and child development. *Children and Youth Services Review*, 31(9), 978–989.
- Berman, E., Bound, J., & Machin, S. (1997). Implications of skill-biased technological change: International evidence. *NBER Working Paper Series*(6166).
- Björklund, A., & Jäntti, M. (2009). Intergenerational income mobility and the role of family background. In W. Salverda, B. Nolan, & T. M. Smeeding (Eds.), *The Oxford handbook of economic inequality* (pp. 491–521). Oxford and New York: Oxford University Press.
- Blake, J. (1989). *Family size and achievement*. Berkeley: University of California Press.
- Bojanowski, M., & Corten, R. (2014). Measuring segregation in social networks. *Social networks*, 39, 14–32.
- Borghans, L., Duckworth, A. L., Heckman, J. J., & ter Weel, B. (2008). The economics and psychology of personality traits. *IZA Discussion Papers*(3333).
- Bornstein, M. H., & Bradley, R. H. (2003). *Socioeconomic status, parenting, and child development*. Mahwah, NJ: Lawrence Erlbaum Associates.

- Boudon, R. (1998). Social mechanisms without black boxes. In P. Hedström & R. Swedberg (Eds.), *Social mechanisms* (pp. 172–203). Cambridge: Cambridge University Press.
- Bowles, S., Loury, G., & Sethi, R. (2010). The emergence and persistence of group inequality. *Unpublished manuscript*.
- Brante, T. (2008). Explanatory and non-explanatory goals in the social sciences: A reply to Reiss. *Philosophy of the Social Sciences*, 38(2), 271–278.
- Brubaker, R. (1992). *Citizenship and nationhood in France and Germany*. Cambridge and Mass: Harvard University Press.
- Brubaker, R. (2004). *Ethnicity without groups*. Cambridge and Mass: Harvard University Press.
- Buchanan, J. M. (1965). An economic theory of clubs. *Economica*, 32(125), 1–14.
- Buchanan, J. M. (Ed.). (1980). *Toward a theory of the rent-seeking society*. College Station and Texas: Texas A and M University Press.
- Bunge, M. (1997). Mechanism and explanation. *Philosophy of the Social Sciences*, 27(4), 410–465.
- Bunge, M. (2004). How does it work?: The search for explanatory mechanisms. *Philosophy of the Social Sciences*, 34(2), 182–210.
- Burt, R. S. (2005). *Brokerage and closure: An introduction to social capital*. Oxford: Oxford University Press.
- Cardona, A. (2013a). Closing the group or the market? the two sides of Weber's concept of closure and their relevance for the study of intergroup inequality. *SFB 882 Working Paper Series*, 15.
- Cardona, A. (2013b). The programmatic bias in the discussion on social mechanisms in sociology. *SFB 882 Working Paper Series*, 23.
- Cardona, A. (2014a). Parental choices and children's skills: An agent-based model of parental investment behavior and skill inequality within and across generations. *Journal of Artificial Societies and Social Simulation*, 17(4). Retrieved from <http://jasss.soc.surrey.ac.uk/17/4/8.html>
- Cardona, A. (2014b). Parental choices, children's skills, and skill inequality: An agent-based model implemented in Python (version 1). *CoMSES Computational Model Library*. Retrieved from <http://www.openabm.org/model/4084/version/1/view>
- Cardona, A., & Diewald, M. (2014). Opening the black box of primary effects: Relative risk aversion and maternal time investments in preschool children. *Currently under Review by Research in Social Stratification and Mobility*.
- Chua, W.-F., & Clegg, S. (1990). Professional closure: The case of British nursing. *Theory and Society*, 19(2), 135–172.
- Chua, W. F., & Poullaos, C. (1998). The dynamics of "closure" amidst the construction of market, profession, empire and nationhood: an historical anal-

- ysis of an Australian accounting association, 1886-1903. *Accounting, Organizations and Society*, 23(2), 155–187.
- Cochran, M. M. (1993). *Extending families: The social networks of parents and their children*. Cambridge: Cambridge University Press.
- Cochran, M. M., & Brassard, J. A. (1979). Child development and personal social networks. *Child Development*, 50(3), 601–616.
- Coleman, J. (1958). Relational analysis: The study of social organizations with survey methods. *Human Organization*, 17(4), 28–36.
- Coleman, J. S. (1986). Social theory, social research, and a theory of action. *American Journal of Sociology*, 91(6), 1309–1335.
- Coleman, J. S. (1988). Social capital in the creation of human capital. *American Journal of Sociology*, 94(1), 95–120.
- Collier, R. B., & Mazzuca, S. (2008). Does history repeat? In R. E. Goodin (Ed.), *The oxford handbook of contextual political analysis* (pp. 472–489). Oxford: Oxford University Press.
- Conley, D. (2004). *The pecking order. a bold new look at how family and society determine who we become*. New York: Vintage Books.
- Conley, D. (2005). *The pecking order: A bold new look at how family and society determine who we become*. New York: Vintage Books.
- Craig, E. (1998). *Routledge encyclopedia of philosophy*. London: Routledge.
- Craver, C. F. (2007). *Explaining the brain: Mechanisms and the mosaic unity of neuroscience*. Oxford: Clarendon Press.
- Craver, C. F., & Bechtel, W. (2007). Top-down causation without top-down causes. *Biology and Philosophy*, 22(4), 547–563.
- Cronk, L. (2007). Boy or girl: gender preferences from a Darwinian point of view. *Reproductive BioMedicine Online*, 15, 23–32.
- Cunha, F., & Heckman, J. J. (2007). The technology of skill formation. *American Economic Review*, 97(2), 31–47.
- Cunha, F., Heckman, J. J., & Schennach, S. M. (2010). Estimating the technology of cognitive and noncognitive skill formation. *Econometrica*, 78(3), 883–931.
- Dal Bo, E. (2006). Regulatory capture: A review. *Oxford Review of Economic Policy*, 22(2), 203–225.
- Daniel, J. R., Santos, A. J., Peceguina, I., & Vaughn, B. E. (2012). Exponential random graph models of preschool affiliative networks. *Social networks*.
- Datar, A., Kilburn, M., & Loughran, D. (2010). Endowments and parental investments in infancy and early childhood. *Demography*, 47(1), 145–162.
- Davis, J. N., & Peter, T. M. (2001). Parental investment by simple decision rules. In G. Gigerenzer & P. M. Todd (Eds.), *Simple heuristics that make us smart* (pp. 309–326). Oxford: Oxford University Press.
- Davis, J. N., Todd, P. M., & Bullock, S. (1999). Environment quality predicts

- parental provisioning decisions. *Proceedings: Biological Sciences*, 266(1430), 1791–1797.
- Dawid, H., & Gemkow, S. (2013). How do social networks contribute to wage inequality? insights from an agent-based analysis. *Bielefeld Working Papers in Economics and Management*(5).
- Del Bono, E., Ermisch, J., & Francesconi, M. (2012). Intrafamily resource allocations: A dynamic structural model of birth weight. *Journal of Labor Economics*, 30(3), 657–706.
- Demetriou, C. (2009). The realist approach to explanatory mechanisms in social science: More than a heuristic? *Philosophy of the Social Sciences*, 39(3), 440–462.
- DeMiguel, V., Garlappi, L., & Uppal, R. (2007). Optimal versus naive diversification: How inefficient is the 1/n portfolio strategy? *Review of Financial Studies*, 22(5), 1915–1953.
- Deutsch, K. A. (1951). Mechanism, organism, and society: Some models in natural and social science. *Philosophy of Science*, 18(3), 230–252.
- Diehm, I., Kuhn, M., & Mai, M. (2013). Ethnic heterogeneity and the production of inequality in educational organisations from early childhood onward. *Pedagogy. Theory and Praxis*, 6(1).
- Diewald, M., & Faist, T. (2011). From heterogeneities to inequalities: Looking at social mechanisms as an explanatory approach to the generation of social inequalities. *SFB 882 Working Paper Series*(1).
- DiMaggio, P., & Garip, F. (2011). How network externalities can exacerbate intergroup inequality. *American Journal of Sociology*, 116(6), 1887–1933.
- DiMaggio, P., & Garip, F. (2012). Network effects and social inequality. *Annual Review of Sociology*, 38(1), 93–118.
- DiPrete, T. A., & Eirich, G. M. (2006). Cumulative advantage as a mechanism for inequality: A review of theoretical and empirical developments. *Annual Review of Sociology*, 32(1), 271–297.
- Dowe, P. (2009). Causal process theories. In H. Beebe, K. Hitchcock, & P. Menzies (Eds.), *The oxford handbook of causation* (pp. 213–233). Oxford: Oxford University Press.
- Ejrnæs, M., & Pörtner, C. C. (2004). Birth order and the intrahousehold allocation of time and education. *Review of Economics and Statistics*, 86(4), 1008–1019.
- Elliott, J. R. (2001). Referral hiring and ethnically homogeneous jobs: How prevalent is the connection and for whom? *Social Science Research*, 30(3), 401–425.
- Elster, J. (1983). *Explaining technical change: A case study in the philosophy of science*. Cambridge: Cambridge University Press.
- Elster, J. (1990). *Nuts and bolts for the social sciences*. Cambridge: Cambridge University Press.

- Elster, J. (1998). A plea for mechanisms. In P. Hedström & R. Swedberg (Eds.), *Social mechanisms* (pp. 45–73). Cambridge: Cambridge University Press.
- Elster, J. (1999). *Alchemies of the mind: Rationality and the emotions*. Cambridge: Cambridge University Press.
- Elster, J. (2007). *Explaining social behavior: More nuts and bolts for the social sciences*. Cambridge: Cambridge University Press.
- Ermisch, J., Jäntti, M., & Smeeding, T. M. (Eds.). (2012). *From parents to children: The intergenerational transmission of advantage*. New York: Russell Sage Foundation.
- Fehr, B. A. (1995). *Friendship processes*. Thousand Oaks: Sage.
- Feld, S. L. (1981). The focused organization of social ties. *The American Journal of Sociology*, 86(5), 1015–1035.
- Fernandez, R. M., Castilla, E. J., & Moore, P. (2000). Social capital at work: Networks and employment at a phone center. *The American Journal of Sociology*, 105(5), 1288–1356.
- Fiske, S. T. (1998). Stereotyping, prejudice and discrimination. In D. T. Gilbert, S. T. Fiske, & G. Lindzey (Eds.), *The handbook of social psychology* (pp. 357–411). Boston: McGraw-Hill.
- Fowler, J. H., & Christakis, N. A. (2008). Dynamic spread of happiness in a large social network: longitudinal analysis over 20 years in the Framingham Heart Study. *BMJ*, 337, a2338.
- Fried, L., Briedigkeit, E., Isele, P., & Schunder, R. (2009). Delfin 4 - Sprachkompetenzmodell und Messgüte eines Instrumentariums zur Diagnose, Förderung und Elternarbeit in Bezug auf die Sprachkompetenz. *Zeitschrift für Grundschulforschung*, 2(2), 13–26.
- Gambetta, D. (1996). *The sicilian mafia: The business of private protection*. Cambridge and Mass: Harvard University Press.
- Gerring, J. (2007). The mechanistic worldview: Thinking inside the box. *British Journal of Political Science*, 38(1), 161–179.
- Giddens, A. (1973). *The class structure of the advanced societies*. New York: Barnes & Noble.
- Giddens, A. (1980). Classes, capitalism, and the state. a discussion of Frank Parkin, *Marxism and Class Theory: A Bourgeois Critique*. *Theory and Society*, 9(6), 877–890.
- Giesecke, J., & Verwiebe, R. (2009). Wachsende Lohnungleichheit in Deutschland. Qualifikations- und klassenspezifische Determinanten der Entlohnung zwischen 1998 und 2006. *Berliner Journal für Soziologie*, 19(4), 531–555.
- Gigerenzer, G. (2004). Fast and frugal heuristics: The tools of bounded rationality. In D. J. Koehler & N. Harvey (Eds.), *Blackwell handbook of judgment and decision making* (pp. 62–88). Malden, MA and USA: Blackwell Publishing

- Ltd.
- Gigerenzer, G., & Gaissmaier, W. (2011). Heuristic decision making. *Annual Review of Psychology*, 62(1), 451–482.
- Gilbert, N. (2008). *Agent-based models*. Thousand Oaks and California: SAGE Publications.
- Glennan, S. (1996). Mechanisms and the nature of causation. *Erkenntnis*, 44(1), 49–71.
- Glennan, S. (2002). Rethinking mechanistic explanation. *Philosophy of Science*, 69(3), 342–353.
- Glennan, S. (2009). Mechanisms. In H. Beebe, K. Hitchcock, & P. Menzies (Eds.), *The oxford handbook of causation* (pp. 315–325). Oxford: Oxford University Press.
- Glennan, S. (2010). Mechanisms, causes, and the layered model of the world. *Philosophy & Phenomenological Research*, 81(2), 362–381.
- Goldthorpe, J. H. (2000). Outline of a theory of social mobility. In J. H. Goldthorpe (Ed.), *On sociology* (pp. 230–258). Oxford: Oxford University Press.
- Goldthorpe, J. H. (2001). Causation, statistics, and sociology. *European Sociological Review*, 17(1), 1.
- Goos, M., Manning, A., & Salomons, A. (2009). Job polarization in Europe. *The American Economic Review*, 99(2), 58–63.
- Gorski, P. (2009). Social “mechanisms” and comparative-historical sociology: A critical realist proposal. In P. Hedström & B. Wittrock (Eds.), *Frontiers of sociology* (pp. 147–194). Leiden: Brill.
- Grimm, V., Berger, U., Bastiansen, F., Eliassen, S., Ginot, V., Giske, J., . . . DeAngelis, D. L. (2006). A standard protocol for describing individual-based and agent-based models. *Ecological Modelling*, 198(1-2), 115–126.
- Grimm, V., Berger, U., DeAngelis, D. L., Polhill, J. G., Giske, J., & Railsback, S. F. (2010). The ODD protocol: A review and first update. *Ecological Modelling*, 221(23), 2760–2768.
- Groß, M. (2009). Markt oder Schließung? Zu den Ursachen der Steigerung der Einkommensungleichheit. *Berliner Journal für Soziologie*, 19(4), 499–530.
- Gross, N. (2009). A pragmatist theory of social mechanisms. *American Sociological Review*, 74(3), 358.
- Grüne-Yanoff, T., & Weirich, P. (2010). The philosophy and epistemology of simulation: A review. *Simulation & Gaming*, 41(1), 20–50.
- Grusky, D. B., & Sørensen, J. B. (1998). Can class analysis be salvaged? *American Journal of Sociology*, 103(5), 1187–1234.
- Hackman, D. A., Farah, M. J., & Meaney, M. J. (2010). Socioeconomic status and the brain: mechanistic insights from human and animal research. *Nature Reviews Neuroscience*, 11(9), 651–659.

- Halpin, B. (1999). Simulation in sociology. *American Behavioral Scientist*, 42(10), 1488–1508.
- Hamilton, W. (1964a). The genetical evolution of social behaviour. i. *Journal of Theoretical Biology*, 7(1), 1–16.
- Hamilton, W. (1964b). The genetical evolution of social behaviour. ii. *Journal of Theoretical Biology*, 7(1), 17–52.
- Hanneman, R. A., Collins, R., & Mordt, G. (1995). Discovering theory dynamics by computer simulation: experiments on state legitimacy and imperialist capitalism. *Sociological Methodology*, 25, 1–46.
- Harré, R. (1972). *The philosophies of science: An introductory survey*. London: Oxford University Press.
- Haupt, A. (2012). (Un) Gleichheit durch soziale Schließung. *KZfSS Kölner Zeitschrift für Soziologie und Sozialpsychologie*, 64(4), 729–753.
- Heckman, J. J. (2006). Skill formation and the economics of investing in disadvantaged children. *Science*, 312(5782), 1900–1902.
- Heckman, J. J. (2008). Role of income and family influence on child outcomes. *Annals of the New York Academy of Sciences*, 1136(1), 307–323.
- Heckman, J. J., & Kautz, T. (2012). Hard evidence on soft skills. *Labour Economics*, 19(4), 451–464.
- Heckman, J. J., Pinto, R., & Savelyev, P. (2012). Understanding the mechanisms through which an influential early childhood program boosted adult outcomes. *IZA Discussion Paper Series*, 7040.
- Hedström, P. (2005). *Dissecting the social: On the principles of analytical sociology*. Cambridge: Cambridge University Press.
- Hedström, P. (2008). Studying mechanisms: strengthening casual inference in quantitative research. In J. M. Box-Steffensmeier & R. E. Goodin (Eds.), *The Oxford handbook of political methodology* (pp. 319–335). Oxford: Oxford University Press.
- Hedström, P., & Bearman, P. (Eds.). (2009). *The Oxford handbook of analytical sociology*. Oxford: Oxford University Press.
- Hedström, P., & Swedberg, R. (1996). Social mechanisms. *Acta Sociologica*, 39(3), 281–308.
- Hedström, P., & Swedberg, R. (Eds.). (1998a). *Social mechanisms: An analytical approach to social theory*. Cambridge: Cambridge University Press.
- Hedström, P., & Swedberg, R. (1998b). Social mechanisms: An introductory essay. In P. Hedström & R. Swedberg (Eds.), *Social mechanisms* (pp. 1–31). Cambridge: Cambridge University Press.
- Hedström, P., & Ylikoski, P. (2010). Causal mechanisms in the social sciences. *Annual Review of Sociology*, 36.
- Hempel, C. G. (1965). Aspects of scientific explanation. In C. G. Hempel (Ed.),

- Aspects of scientific explanation and other essays in the philosophy of science* (pp. 331–496). New York: Free Press.
- Hempel, C. G., & Oppenheim, P. (1948). Studies in the logic of explanation. *Philosophy of Science*, 15(2), 135–175.
- Hertwig, R., Davis, J. N., & Sulloway, F. J. (2002). Parental investment: How an equity motive can produce inequality. *Psychological Bulletin*, 128(5), 728–745.
- Hoekman, B. (2004). Agricultural tariffs or subsidies: Which are more important for developing economies? *The World Bank Economic Review*, 18(2), 175–204.
- Hoff, E. (2006). How social contexts support and shape language development? *Developmental Review*, 26(1), 55–88.
- Hollenberg, D. (2006). Uncharted ground: Patterns of professional interaction among complementary/alternative and biomedical practitioners in integrative health care settings. *Social Science & Medicine*, 62(3), 731–744.
- Huttenlocher, J., Waterfall, H., Vasilyeva, M., Vevea, J., & Hedges, L. V. (2010). Sources of variability in children's language growth. *Cognitive Psychology*, 61(4), 343–365.
- Inglehart, R., & Welzel, C. (2005). *Modernization, cultural change, and democracy: The human development sequence*. Cambridge: Cambridge University Press.
- International Monetary Fund. (2007). *Globalization and inequality: World economic outlook, october 2007*. Washington and DC: International Monetary Fund.
- Ioannides, Y. M., & Loury, L. D. (2004). Job information networks, neighborhood effects, and inequality. *Journal of Economic Literature*, 42(4), 1056–1093.
- Janssen, M. A., Alessa, L. N., Barton, M., Bergin, S., & Lee, A. (2008). Towards a community framework for agent-based modelling. *Journal of Artificial Societies and Social Simulation*, 11(26), 6.
- Johnson, J. (2006). Consequences of positivism: A pragmatist assessment. *Comparative Political Studies*, 39(2), 224.
- Johnson, W., Turkheimer, E., Gottesman, I. I., & Bouchard Jr., T. J. (2009). Beyond heritability twin studies in behavioral research: Twin studies in behavioral research. *Current Directions in Psychological Science*, 18(4), 217–220.
- Justice, L. M., Petscher, Y., Schatschneider, C., & Mashburn, A. (2011). Peer effects in preschool classrooms: Is children's language growth associated with their classmates' skills? *Child Development*, 82(6), 1768–1777.
- Kahneman, D. (2011). *Thinking, fast and slow*. London: Penguin Books.
- Karlsson, G. (1958). *Social mechanisms: studies in sociological theory*. Free Press.
- Kelner, M., Wellman, B., Welsh, S., & Boon, H. (2006). How far can complementary and alternative medicine go? the case of chiropractic and homeopathy. *Social Science & Medicine*, 63(10), 2617–2627.
- Kidder, W. C. (2004). The bar examination and the dream deferred: A critical

- analysis of the MBE, social closure, and racial and ethnic stratification. *Law & Social Inquiry*, 29(3), 547–589.
- Knudsen, E. I., Heckman, J. J., Cameron, J. L., & Shonkoff, J. P. (2006). Economic, neurobiological, and behavioral perspectives on building America's future workforce. *Proceedings of the National Academy of Sciences*, 103(27), 10155–10162.
- Koslowski, B. (1996). *Theory and evidence: The development of scientific reasoning*. Cambridge and Mass.: MIT Press.
- Kossinets, G. (2006). Effects of missing data in social networks. *Social networks*, 28(3), 247–268.
- Kuorikoski, J. (2009). Two concepts of mechanism: Componential causal system and abstract form of interaction. *International Studies in the Philosophy of Science*, 23(2), 143–160.
- Lamont, M., & Molnár, V. (2002). The study of boundaries in the social sciences. *Annual Review of Sociology*, 28(1), 167–195.
- Laslett, B. (2000). The poverty of (monocausal) theory: A comment on Charles Tilly's Durable Inequality. *Comparative Studies in Society and History*, 42, 475–481.
- Lawson, T. (1997). *Economics and reality*. London: Routledge.
- Lawson, T. (2003). *Reorienting economics*. London: Routledge.
- Lee, T. A. (2010). Social closure and the incorporation of the Society of Accountants in Edinburgh in 1854. *Accounting, Business & Financial History*, 20(1), 1–22.
- Limpert, E., Stahel, W. A., & Abbt, M. (2001). Log-normal distributions across the sciences: Keys and clues. *BioScience*, 51(5), 341–352.
- Lin, N. (2000). Inequality in social capital. *Contemporary Sociology*, 29(6), 785–795.
- Lin, N. (2009). *Social capital: A theory of social structure and action*. Cambridge: Cambridge University Press.
- Lorscheid, I., Heine, B.-O., & Meyer, M. (2012). Opening the 'black box' of simulations: increased transparency and effective communication through the systematic design of experiments. *Computational and Mathematical Organization Theory*, 18(1), 22–62.
- Lundberg, S. (2005). Sons, daughters, and parental behaviour. *Oxford Review of Economic Policy*, 21(3), 340–356.
- Lusher, D., Koskinen, J., & Robins, G. (2012). *Exponential random graph models for social networks: Theory, methods, and applications*. Cambridge: Cambridge University Press.
- Lynn, R., & Vanhanen, T. (2006). *IQ and global inequality*. Augusta: Washington Summit Publishers.
- Macdonald, K. M. (1985). Social closure and occupational registration. *Sociology*,

- 19(4), 541–556.
- Macdonald, K. M. (1995). *The sociology of the professions*. London: Sage.
- Machamer, P. (2004). Activities and causation: The metaphysics and epistemology of mechanisms. *International Studies in the Philosophy of Science*, 18(1), 27–39.
- Machamer, P., Darden, L., & Craver, C. F. (2000). Thinking about mechanisms. *Philosophy of Science*, 67(1), 1–25.
- Mackenzie, G. (1980). Review of 'Marxism and Class Theory: A Bourgeois Critique by Frank Parkin'. *British Journal of Sociology*, 31(4), 582–584.
- Mahoney, J. (2001). Review: Beyond correlational analysis: Recent innovations in theory and method. *Sociological Forum*, 16(3), 575–593.
- Mahoney, J. (2003). Tentative answers to questions about causal mechanisms. *Paper presented at the annual meeting of the American Political Science Association, Philadelphia, 28 August*.
- Makowsky, M. (2006). An agent-based model of mortality shocks, intergenerational effects, and urban crime. *Journal of Artificial Societies and Social Simulation*, 9(2), 7. Retrieved from <http://jasss.soc.surrey.ac.uk/9/2/7.html>
- Manza, J. (1992). Classes, status groups, and social closure: A critique of neo-weberian closure theory. *Current perspectives in social theory*, 12, 275–302.
- Mashburn, A. J., Justice, L. M., Downer, J. T., & Pianta, R. C. (2009). Peer effects on children's language achievement during pre-kindergarten. *Child Development*, 80(3), 686–702.
- Mayer, K. U. (2009). New directions in life course research. *Annual Review of Sociology*, 35, 413–433.
- Mayntz, R. (2004). Mechanisms in the analysis of social macro-phenomena. *Philosophy of the Social Sciences*, 34(2), 237.
- McAdam, D., Tarrow, S., & Tilly, C. (2008). Methods for measuring mechanisms of contention. *Qualitative Sociology*, 31(4), 307–331.
- McCauley, T. (1990). Nativism and social closure: A comparison of four social movements. *International Journal of Comparative Sociology*, 1(2), 86–93.
- McPherson, M., Smith-Lovin, L., & Cook, J. M. (2001). Birds of a feather: Homophily in social networks. *Annual Review of Sociology*, 27, 415–444.
- Merton, R. K. (1965). *Social theory and social structure* (3rd ed.). New York: Free Press.
- Merton, R. K. (1968). *On theoretical sociology. five essays, old and new*. New York: Free Press.
- Messick, D. M. (1993). Equality as a decision heuristic. In B. A. Mellers & J. Baron (Eds.), *Psychological perspectives on justice* (pp. 11–31). Cambridge: Cambridge University Press.
- Meyer, M., Lorscheid, I., & Troitzsch, K. G. (2009). The development of social sim-

- ulation as reflected in the first ten years of JASSS: a citation and co-citation analysis. *Journal of Artificial Societies and Social Simulation*, 12(4), 12.
- Miller, J. H., & Page, S. E. (2007). *Complex adaptive systems: An introduction to computational models of social life*. Princeton and NJ: Princeton University Press.
- Moretti, E. (2004). Workers' education, spillovers, and productivity: Evidence from plant-level production functions. *American Economic Review*, 94(3), 656–690.
- Morris, A. (2000). Building blocks of social inequality: A critique of Durable Inequality. *Comparative Studies in Society and History*, 42, 482–486.
- Mouw, T., & Kalleberg, A. L. (2010). Occupations and the structure of wage inequality in the United States, 1980s to 2000s. *American Sociological Review*, 75(3), 402–431.
- Mulder, M. B., Bowles, S., Hertz, T., Bell, A., Beise, J., Clark, G., ... Wiessner, P. (2009). Intergenerational wealth transmission and the dynamics of inequality in small-scale societies. *Science*, 326(5953), 682–688.
- Murphy, R. (1983). The struggle for scholarly recognition. *Theory and Society*, 12(5), 631–658.
- Murphy, R. (1984). The structure of closure: A critique and development of the theories of Weber, Collins, and Parkin. *The British Journal of Sociology*, 35(4), 547–567.
- Murphy, R. (1985). Exploitation or exclusion? *Sociology*, 19(2), 225–243.
- Murphy, R. (1986a). The concept of class in closure theory: learning from rather than falling into the problems encountered by Neo-Marxism. *Sociology*, 20(2), 247.
- Murphy, R. (1986b). Weberian closure theory: A contribution to the ongoing assessment. *The British Journal of Sociology*, 37(1), p 21-41.
- Murphy, R. (1988). *Social closure: The theory of monopolization and exclusion*. Oxford: Clarendon Press.
- Musch, J. (2001). Unequal competition as an impediment to personal development: A review of the relative age effect in sport. *Developmental Review*, 21(2), 147–167.
- Neuwirth, G. (1969). A weberian outline of a theory of community: Its application to the 'Dark Ghetto'. *British Journal of Sociology*, 20(2), 148–163.
- Norkus, Z. (2005). Mechanisms as miracle makers? the rise and inconsistencies of the "mechanismic approach" in social science and history. *History and Theory*, 44(3), 348–372.
- OECD. (2011). *Divided we stand: Why inequality keeps rising*. Paris and Bristol: Organisation for Economic Co-operation and Development and University Presses Marketing.

- Oller, D. K., & Eilers, R. E. (2002). *Language and literacy in bilingual children*. Clevedon and England and Buffalo: Multilingual Matters.
- Olson, M. (1971). *The logic of collective action: Public goods and the theory of groups* (Rev. ed. ed.). New York: Schocken Books.
- O'Regan, P. (2008). 'elevating the profession': the Institute of Chartered Accountants in Ireland and the implementation of social closure strategies, 1888-1909. *Accounting, Business and Financial History*, 18(1), 35–59.
- Osmanowski, M., & Cardona, A. (2012). Resource dilution or resource augmentation? number of siblings, birth order, sex of the child and frequency of mother's activities with preschool children. *SFB 882 Working Paper Series*, 5.
- Osmanowski, M., & Cardona, A. (2014). Is less more? number of siblings and frequency of maternal activities with preschool children. *Marriage and Family Review*.
- Ostrom, T. M. (1988). Computer simulation: The third symbol system. *Journal of experimental social psychology*, 24(5), 381–392.
- Parkin, F. (1979). *Marxism and class theory: A bourgeois critique*. New York: Columbia University Press.
- Parkin, F. (1980). Reply to Giddens. *Theory and Society*, 9(6), 891–894.
- Phillips, D. C. (1976). *Holistic thought in social science*. Stanford: Stanford University Press.
- Pickel, A. (2006). *The problem of order in the global age: Systems and mechanisms* (1st ed.). New York: Palgrave Macmillan.
- Psillos, S. (2004). A glimpse of the secret connexion: Harmonizing mechanisms with counterfactuals. *Perspectives on science*, 12(3), 288–319.
- Psillos, S. (2009). Regularity theory. In H. Beebe, K. Hitchcock, & P. Menzies (Eds.), *The Oxford handbook of causation* (pp. 131–157). Oxford: Oxford University Press.
- Railton, P. (1978). A deductive-nomological model of probabilistic explanation. *Philosophy of Science*, 45(2), 206–226.
- Ramirez, C. (2001). Understanding social closure in its cultural context: Accounting practitioners in France (1920-1939). *Accounting, Organizations and Society*, 26(4-5), 391–418.
- Raub, W., Buskens, V., & Van Assen, M. A. L. M. (2011). Micro-macro links and microfoundations in sociology. *The Journal of Mathematical Sociology*, 35(1-3), 1–25.
- Reiss, J. (2007). Do we need mechanisms in the social sciences? *Philosophy of the Social Sciences*, 37(2), 163–184.
- Rescher, N. (1996). *Process metaphysics: An introduction to process philosophy*. State University of New York Press.

- Reskin, B. F. (2003). Including mechanisms in our models of ascriptive inequality. *American Sociological Review*, 68, 1–21.
- Richardson, A. J. (1997). Social closure in dynamic markets: The incomplete professional project in accountancy. *Critical Perspectives on Accounting*, 8(6), 635–653.
- Ridgeway, C. L. (1997). Interaction and the conservation of gender inequality: Considering employment. *American Sociological Review*, 62(2), 218–235.
- Rivera, M. T., Soderstrom, S. B., & Uzzi, B. (2010). Dynamics of dyads in social networks: Assortative, relational, and proximity mechanisms. *Annual Review of Sociology*, 36, 91–115.
- Roberts, B. W., Kuncel, N. R., Shiner, R., Caspi, A., & Goldberg, L. R. (2007). The power of personality: The comparative validity of personality traits, socioeconomic status, and cognitive ability for predicting important life outcomes. *Perspectives on Psychological Science*, 2(4), 313–345.
- Robins, G., Pattison, P., Kalish, Y., & Lusher, D. (2007). An introduction to exponential random graph (p^*) models for social networks. *Social networks*, 29(2), 173–191.
- Robins, G., Pattison, P., & Wang, P. (2009). Closure, connectivity and degree distributions: Exponential random graph (p^*) models for directed social networks. *Social networks*, 31(2), 105–117.
- Robison-Cox, J. F., Martell, R. F., & Emrich, C. G. (2007). Simulating gender stratification. *Journal of Artificial Societies and Social Simulation*, 10(3), 8. Retrieved from <http://jasss.soc.surrey.ac.uk/10/3/8.html>
- Rodger, J. (1992). The welfare state and social closure: Social division and the 'underclass'. *Critical Social Policy*, 12(35), 45–63.
- Roscigno, V. J. (2007). *The face of discrimination: how race and gender impact work and home lives*. Rowman & Littlefield.
- Roscigno, V. J., Garcia, L. M., & Bobbitt-Zeher, D. (2007). Social closure and processes of race/sex employment discrimination. *The ANNALS of the American Academy of Political and Social Science*, 609(1), 16–48.
- Roscigno, V. J., Hodson, R., & Lopez, S. H. (2009). Workplace incivilities: the role of interest conflicts, social closure and organizational chaos. *Work, Employment & Society*, 23(4), 747–771.
- Roscigno, V. J., Karafin, D. L., & Tester, G. (2009). The complexities and processes of racial housing discrimination. *Social Problems*, 56(1), 49–69.
- Roscigno, V. J., Mong, S., Byron, R., & Tester, G. (2007). Age discrimination, social closure and employment. *Social Forces*, 86, 335–355.
- Roth, G. (1980). Review of 'Marxism and Class Theory: A Bourgeois Critique by Frank Parkin'. *Contemporary Sociology*, 9(2), 306–7.
- Rowley, C. K. (Ed.). (1991). *The political economy of rent-seeking*. Boston: Kluwer.

- Sacerdote, B. (2011). Peer effects in education: How might they work, how big are they and how much do we know thus far? In E. A. Hanushek, S. Machin, & L. Woessmann (Eds.), *Handbook of the economics of education* (pp. 249–277). Amsterdam: Elsevier.
- Salmon, W. C. (1984). *Scientific explanation and the causal structure of the world*. Princeton: Princeton University Press.
- Sawyer, R. K. (2004). The mechanisms of emergence. *Philosophy of the Social Sciences*, 34(2), 260–282.
- Schaefer, D. R., Light, J. M., Fabes, R. A., Hanish, L. D., & Martin, C. L. (2010). Fundamental principles of network formation among preschool children. *Social networks*, 32(1), 61–71.
- Schaffner, K. F. (1993). *Discovery and explanation in biology and medicine*. Chicago: University of Chicago Press.
- Schelling, T. C. (1971). Dynamic models of segregation. *The Journal of Mathematical Sociology*, 1(2), 143–186.
- Schmid, M. (2006). *Die Logik mechanismischer Erklärungen*. Wiesbaden: VS.
- Sen, A. (1992). Missing women. *British Medical Journal*, 304(6827), 587–588.
- Sen, A. (2003). Missing women—revisited. *British Medical Journal*, 327(7427), 1297–1298.
- Smith, K. P., & Christakis, N. A. (2008). Social networks and health. *Annual Review of Sociology*, 34, 405–429.
- Smits, J. (2003). Social closure among the higher educated: Trends in educational homogamy in 55 countries. *Social Science Research*, 32(2), 251–277.
- Smits, J., & Park, H. (2009). Five decades of educational assortative mating in 10 East Asian societies. *Social Forces*, 88(1), 227–255.
- Sørensen, A. B. (1983). Processes of allocation to open and closed positions in social structure. *Zeitschrift für Soziologie*, 12, 203–224.
- Sørensen, A. B. (1996). The structural basis of social inequality. *The American Journal of Sociology*, 101(5), 1333–1365.
- Sørensen, A. B. (2000). Toward a sounder basis for class analysis. *The American Journal of Sociology*, 105(6), 1523–1558.
- Sprietsma, M. (2010). Effect of relative age in the first grade of primary school on long-term scholastic results: international comparative evidence using PISA 2003. *Education Economics*, 18(1), 1–32.
- Squazzoni, F. (2012). *Agent-based computational sociology*. Chichester and West Sussex: Wiley.
- Squazzoni, F., & Casnici, N. (2013). Is social simulation a social science outstation? a bibliometric analysis of the impact of JASSS. *Journal of Artificial Societies and Social Simulation*, 16(1), 10. Retrieved from <http://jasss.soc.surrey.ac.uk/16/1/10.html>

- Stainback, K. (2009). Social contacts and race/ethnic job matching. *Social Forces*, 87(2), 857–886.
- Steel, D. (2004). Social mechanisms and causal inference. *Philosophy of the Social Sciences*, 34(1), 55.
- Steel, D. (2007). With or without mechanisms: A reply to Weber. *Philosophy of the Social Sciences*, 37(3), 360–365.
- Stewart, S. D. (2005). How the birth of a child affects involvement with stepchildren. *Journal of Marriage and Family*, 67(2), 461–473.
- Suitor, J. J., Sechrist, J., Plikuhn, M., Pardo, S. T., & Pillemer, K. (2008). Within-family differences in parent-child relations across the life course. *Current Directions in Psychological Science*, 17(5), 334–338.
- Sulloway, F. J. (1996). *Born to rebel: Birth order, family dynamics, and creative lives*. New York: Pantheon Books.
- Swain, M., Brooks, L., & Tocalli-Beller, A. (2002). Peer-peer dialogue as a means of second language learning. *Annual Review of Applied Linguistics*, 22.
- Tabery, J. G. (2004). Synthesizing activities and interactions in the concept of a mechanism. *Philosophy of Science*, 71, 1–15.
- Thagard, P. (1999). *How scientists explain disease*. Princeton: Princeton University Press.
- The World Bank. (2005). *Equity and development: World development report 2006*. Washington and DC: The World Bank.
- Therborn, G. (2006). Meaning, mechanisms, patterns, and forces: An introduction. In G. Therborn (Ed.), *Inequalities of the world* (pp. 1–58). London: Verso.
- Tilly, C. (1998). *Durable inequality*. Berkeley: University of California Press.
- Tilly, C. (2000). Errors, durable and otherwise. *Comparative Studies in Society and History*, 42, 487–493.
- Tilly, C. (2001). Relational origins of inequality. *Anthropological Theory*, 1(3), 355–372.
- Tilly, C. (2004). Observations of social processes and their formal representations. *Sociological Theory*, 22(4), 595–602.
- Todd, P. E., & Wolpin, K. I. (2003). On the specification and estimation of the production function for cognitive achievement. *The Economic Journal*, 113(485), F3–F33.
- Todd, P. E., & Wolpin, K. I. (2007). The production of cognitive achievement in children: Home, school, and racial test score gaps. *Journal of Human Capital*, 1(1), 91–136.
- Tollison, R. D. (1982). Rent seeking: A survey. *Kyklos*, 35(4), 575–602.
- Tomaskovic-Devey, D. (1993a). The gender and race composition of jobs and the male/female, white/black pay gaps. *Social Forces*, 72(1), 45–76.
- Tomaskovic-Devey, D. (1993b). *Gender & racial inequality at work: The sources and*

- consequences of job segregation*. Cornell University Press.
- Trivers, R. L. (1972). Parental investment and sexual selection. In B. G. Campbell (Ed.), *Sexual selection and the descent of man* (pp. 136–179). London: Heinemann.
- Trivers, R. L., & Willard, D. E. (1973). Natural selection of parental ability to vary the sex ratio of offspring. *Science*, 179(4068), 90–92.
- Udehn, L. (2001). *Methodological individualism: Background, history and meaning*. London: Routledge.
- United Nations. (2005). *The inequality predicament: Report on the world social situation*. New York: United Nations, Department of Economic and Social Affairs.
- United Nations. (2013). *Inequality matters: Report on the world social situation*. New York: United Nations, Department of Economic and Social Affairs.
- Vertigans, S. (2007). Militant Islam and Weber's social closure: interrelated secular and religious codes of exclusion. *Contemporary Islam*, 1(3), 303–321.
- von Wright, G. H. (1971). *Explanation and understanding*. London: Routledge & Kegan Paul.
- Walker, L., & Davis, P. (2013). Modelling "marriage markets": A population-scale implementation and parameter test. *Journal of Artificial Societies and Social Simulation*, 16(1), 6. Retrieved from <http://jasss.soc.surrey.ac.uk/16/1/6.html>
- Walker, S. P., & Shackleton, K. (1998). A ring fence for the profession: advancing the closure of British accountancy 1957-1970. *Accounting, Auditing & Accountability Journal*, 11(1), 34–71.
- Weber, E. (2007). Social mechanisms, causal inference, and the policy relevance of social science. *Philosophy of the Social Sciences*, 37(3), 348–359.
- Weber, M. (1922). *Wirtschaft und Gesellschaft*. Tübingen: Mohr.
- Weber, M. (1978). *Economy and society: An outline of interpretive sociology*. Berkeley: University of California Press.
- Weeden, K. A. (2002). Why do some occupations pay more than others? social closure and earnings inequality in the United States. *American Journal of Sociology*, 108(1), 55–101.
- Weeden, K. A., & Grusky, D. B. (2014). Inequality and market failure. *American Behavioral Scientist*, 58(3), 473–491.
- Weiss, R. M., & Miller, L. E. (2010). The social transformation of American medical education: Class, status, and party influences on occupational closure, 1902–1919. *Sociological Quarterly*, 51(4), 550–575.
- Welsh, S., Kelner, M., Wellman, B., & Boon, H. (2004). Moving forward? complementary and alternative practitioners seeking self-regulation. *Sociology of health & illness*, 26(2), 216–241.

- Wikström, P. O. H., & Sampson, R. J. (2003). Social mechanisms of community influences on crime and pathways in criminality. In B. B. Lahey, T. E. Moffitt, & A. Caspi (Eds.), *The causes of conduct disorder and serious juvenile delinquency* (pp. 118–148). New York: Guilford Press.
- Wimsatt, W. C. (2006). Reductionism and its heuristics: Making methodological reductionism honest. *Synthese*, 151(3), 445–475.
- Woodward, J. (2002). What is a mechanism? a counterfactual account. *Philosophy of Science*, 69, 366–377.
- Woodward, J. (2003). *Making things happen: A theory of causal explanation*. Oxford: Oxford University Press.
- Wright, E. O. (2000). Metatheoretical foundations of Charles Tilly's Durable Inequality. *Comparative Studies in Society and History*, 42, 458–474.

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