Ch. 7: Interdependence*

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April 13, 2012

1 Introduction

Interdependence is one of the defining features of the social world and is apparent in many social science subfields and research questions. Methods textbooks often treat it as a difficulty for empirical analyses under the label "Galton's problem" because of Sir Francis Galton's famous comment at an anthropology conference at the end of the 19th century (Tylor, 1889, 270):

> "It was extremely desirable, for the sake of those who may wish to study the evidence for Dr. Tylor's conclusions, that full information should be given as to the degree in which the customs of the tribes and races which are compared together are independent. It might be, that some of the tribes had derived them from a common source, so that they were duplicates of the same original."

Thus, Sir Galton argued that the lack of independence of the units complicates comparative analyses. In their influential discussion of the comparative method, Przeworski and Teune (1970, 52) reformulated the issue as follows: "how many independent events can we observe? If the similarity within a group of systems is a result of diffusion, there is only one independent observation." However, interdependence is more than a source of methodological problems. It is an interesting subject of study in its own right. Indeed, many important literatures in the social sciences have examined the nature, sources, and consequences of interdependence among individuals, groups, organizations, states, and many other units. This chapter will first give an overview of some of the most important research questions with a focus on interdependence,

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such as institutional isomorphism, social influence, international conflict, democratic dominoes, transnational networks, policy diffusion and transfer, and federalism as policy laboratory. We then discuss the methods that can be employed to study these phenomena, namely, social network analysis, spatial regression, dyadic analysis, and qualitative approaches.

2 The study of interdependence in the social sciences

Interdependence is a classic question in social science, which has been studied from several, often overlapping perspectives. Rogers' (2003) classic book, first published in 1962 and now in its fifth edition, reviews the literature from a communication perspective and with numerous applied examples in many different areas, such as typewriter and computer keyboard types, hybrid corn, miracle rice, kindergartens, STOP AIDS campaigns, electric cars, fax and internet, modern math, cell phones, needle-exchange programs, among others.

In sociology, a classic concept is institutional isomorphism, namely, the tendency of organizations to become more alike to conform with their institutional environment. DiMaggio and Powell (1983) elaborated three types of isomorphism. First, coercive isomorphism denotes compliance with external constraints. The revision of financial reporting practices by large American companies following a change in regulatory requirements is a case in point (Mezias, 1990). Second, mimetic isomorphism means that organizations tent to adopt the practices prevalent in their peer group as a response to uncertainty about the effectiveness of different alternatives. For instance, Fligstein (1985) studied the spread of the multidivisional form (a particular type of organization) among large American firms for 1919 until 1979 and found that firms were more likely to adopt this type of structure if other firms in the industry also did so. Further research has shown that interlocks, that is, overlaps in the membership of companies' board of directors, are one of the main drivers of mimetic isomorphism (Davis and Greve, 1997). Third, normative isomorphism refers to the consequences of professionalization, namely, the fact that close and repeated interactions within professional groups give rise to common understandings about appropriate practices, where appropriateness may or may not be linked to effectiveness. For example, Fourcade (2006) described in detail how the development of economics conduced to the establishment of global professional standards.

Other sociological research has focused even more directly on interdependence by looking at various channels of social influence, that is, ways in which individuals influence one another. Many studies have found that a surprisingly large number of phenomena spread like diseases although, strictly speaking, they are not contagious. A famous (and controversial) study is Christakis and Fowler (2007), which uncovered social influence patterns in the case of obesity. The study leveraged data that enabled the researchers to reconstruct a large social network over 32 years and showed that a given person was significantly more likely to become obese if one of his or her friends had become obese in a previous period. Because the geographic distance between friends did not affect this influence, the authors argued that in this case social influence has more to do with the social acceptance of obesity than with more concrete behavioral effects such as eating habits or physical exercise. These arguments are powerful and have been applied to many other settings (Christakis and Fowler, 2009). However, they always tend to be vulnerable to the "homophily" counterargument, namely, that friends do not become more alike but, rather, people who are alike become friends. We will return to this point in Section 3. In another study, Liu, King and Bearman (2010) demonstrated, using fine-grained individual and geographical data from California, that children living very close to children previously diagnosed with autism were more likely to received the same diagnosis. The analysis could rule out alternative explanations and highlighted the effects of geographic proximity on the diffusion of information among parents. Social network studies have become more prominent in recent years and have been conducted at the intersection of the social, natural, and biological sciences (Watts, 2004; Christakis and Fowler, 2009). One reason for this trend has been the rise of online networks such as Facebook and Twitter, which not only do create new and powerful channels for social interaction, but also allow researchers to access an unprecedented wealth of data.

Interdependence is also at the core of many international relations problems. War and peace themselves are, of course, a manifestation of the fact that nation states must coexist in an interdependent world. One of the largest literature in international relations has focused on the so-called "democratic peace," that is, the idea that democracies do not fight one another, which we have already met in Chapter 3. In the last decades, the argument has been tested empirically in a large numbers of studies. These have established that, in effect, the likelihood that two countries enter into conflict is much smaller if they are both democratic (Maoz and

Russett, 1993; Danilovic and Clare, 2007; Gartzke, 2007). Most and Starr (1980) have explored other channels through which international conflicts may spread, as well as the possibility of both positive and negative diffusion. Beyond international conflicts, the literature has looked at the spread of various types of violent phenomena such as military coups (Li and Thompson, 1975), civil war (Salehyan and Gleditsch, 2006; Buhaug and Gleditsch, 2008), and terrorism (Horowitz, 2010). A classic argument in international relations is also that of "democratic dominoes" (Starr, 1991; Leeson and Dean, 2009), whose relevance has been highlighted by the "Arab Spring" of 2011, in which several dictatorship in North Africa and the Middle East have been overturned or put under considerable pressure in a chain reaction triggered by popular uprising in Tunisia. The metaphor of a domino was used by many commentators, such as the cartoonist Chappatte (Figure 1). It has also informed decision-making at critical historical junctures. For instance, US president Eisenhower used the metaphor to describe the possible spread of communist regimes after World War II: "You have a row of dominoes set up, you knock over the first one, and what will happen to the last one is the certainty that it will go over very quickly."[1] George W. Bush used the same argument as a rationale for second Iraq war: "The establishment of a free Iraq at the heart of the Middle East will be a watershed event in the global democratic revolution."[2] Research has demonstrated that, indeed, even controlling for many confounding factors, democratization events tends to be clustered both in space and in time, such that the probability that a country switches from autocracy to democracy increases significantly with the number of democratic neighbors (Gleditsch and Ward, 2006). However, the causal mechanisms remain unclear. Work on the spread of democracy in 19th-century Europe suggests that the driving force could be that neighboring transitions alter beliefs on the strength of the domestic autocracy (Weyland, 2010).

Similar to many sociological works, some international relations scholars have sought to measure interdependence with the tools of social network analysis. For example, Hafner-Burton and Montgomery (2006) constructed a network of membership in intergovernmental organizations (IGOs) and showed that the positions of states within this network affects the likelihood of conflict among them, while Cao (2010) used similar data to show that similar network positions

[1] Presidential news conference, April 7, 1954 (`http://goo.gl/d188v`, accessed January 17, 2010).

[2] President Bush Discusses Freedom in Iraq and Middle East, Remarks at the 20th Anniversary of the National Endowment for Democracy, United States Chamber of Commerce, November 6, 2003 (`http://goo.gl/QPFNN`, accessed January 17, 2010).

Figure 1: *Democratic dominoes* (`http://globecartoon.com/`).

increase the probability that two countries enact similar capital taxation reforms. Other research has used social network analysis to measure the extent to which countries in competition with one another, and whether this influences the diffusion of certain policies. For instance, Elkins, Guzman and Simmons (2006) showed that the probability that a country signs a bilateral investment treaty, which are intended to facilitate foreign investment, increases with the number of treaties signed by other countries with similar trade relationship, that is, that export similar goods to similar countries.

Public policy is another large social science subfield where interdependence is considered an important phenomenon. The general idea here is that interdependence between countries, federal states, cities, etc. causes policies to spread. There are several concepts denoting this phenomenon. The most important are "transfer" and "diffusion." Policy transfer can be defined as "the process by which knowledge about policies, administrative arrangements, institutions and ideas in one political system (past or present) is used in the development of policies, administrative arrangements, institutions and ideas in another political system" (Dolowitz and Marsh, 2000), while (international) policy diffusion occurs "when government policy decisions in a given country are systematically conditioned by prior policy choices made in other countries" (Simmons, Dobbin and Garrett, 2006). A third concept that is often mentioned in this context is policy convergence, defined as the tendency of policies in different units to become more alike (Bennett, 1991). However, it is important to note that policies can convergence for reasons unrelated to interdependence, for instance when different countries face similar problems.

Policy interdependence is a premise of classic defenses of federalism. For instance, in "New State Ice Co. v. Liebmann" (1932),[3] U.S. Supreme Court Justice Louis Brandeis famously defended the view that decentralization fosters innovation and the spread of best practices: "It is one of the happy incidents of the federal system that a single courageous State may, if its citizens choose, serve as a laboratory; and try novel social and economic experiments without risk to the rest of the country." This argument has been investigated empirically in a number of studies. Volden (2006), for instance, looked at the state-level implementation of the federal Children's Health Insurance Program and found that policies that were more successful in increasing the insurance rate among poor children (a major objective of the program) were more likely to be adopted in other states. In other words, states seemed to learn from one another, consistent with the hopes of Justice Brandeis. Other works, however, have argued that best practices spread only to the extent that they are compatible with the ideological predispositions of policy makers, which, moreover, may also be more inclined to adopt policies that have proven beneficial for reelection rather than those that are most effective to solve social problems (Gilardi, 2010). Besides learning, competition is another powerful driver of policy diffusion or transfer. The prototypical example is tax competition, which has been shown to be a real phenomenon, but does not produce a race to the bottom in tax rates because of the many economic, political, and institutional constraints faced by policy makers (Genschel and Schwarz, 2011). Explicit tax coordination is seldom achieved. In the European Union, the weak legitimacy of supranational institutions, coupled with the lack of a clear best practice, have prevented the emergence of a common tax policy despite the disadvantages of competition (Radaelli, 2000). On the other hand, even in the absence of formal coordination, sustained interaction of policy makers within networks can give rise to norms on acceptable levels of competition, as a comparison of tax rates in Swiss cantons has shown (Gilardi and Wasserfallen, 2011).

To conclude, interdependence is a central issue for many social science questions. But what kinds of research design allow us to study it empirically? We turn to this point in the next section.

[3] `http://goo.gl/CZPmi`.

3 How can we study interdependence empirically?

3.1 Measuring interdependence: Social network analysis

Social network analysis (SNA) is a major approach for the study of social relations. It focuses directly on relationships between actors rather than attributes of actors. The idea that units are interdependent is a crucial assumption here, whereas many statistical approaches, including those discussed in Chapter 3, make the opposite assumption. Thus, the underlying ontology of SNA is that the social world cannot be understood from a methodological-individualist position, but should be interpreted holistically, as an inherently interconnected web of relations.

Let us begin with a few definitions. A relation is a specific kind of contact, connection, or association (or "tie") between a given pair of actors (or "nodes"). Relations may be either directed (or asymmetric), if one actor send the link and the other receives it, or non-directed (or symmetric), if the link has a bi-directional nature. In addition, we can distinguish between dichotomous ties, which simply identify the presence or absence of a connection, and valued ties, which measure its intensity. These four types of connections are, in fact, quite intuitive, as these examples show:

Symmetric and dichotomous ties: shared language or religion (Elkins, Guzman and Simmons, 2006); shared borders (Gleditsch and Ward, 2006).

Symmetric and valued ties: number of directorate members that two companies have in common (Davis and Greve, 1997); number of events or organizations in which two actors co-participate (Hafner-Burton, Kahler and Montgomery, 2009).

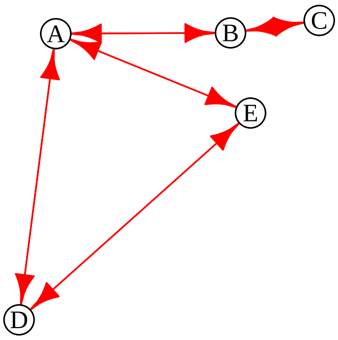
Asymmetric and dichotomous ties: perceived friendship (Christakis and Fowler, 2007).

Asymmetric and valued ties: export or import flows between two countries (Polillo and Guillén, 2005); commuting flows between cities or states (Gilardi and Wasserfallen, 2011).

Figure 2 shows how network data are structured and how they can be represented graphically. Specifically, the tables represent four sociomatrices, one for each type of tie. Each cell shows whether and, for valued ties, with what intensity each pair of actors is connected. The graphs display the same information visually and help to gain a first understanding of the properties of the network, such as its density and which actors occupy a more central position.

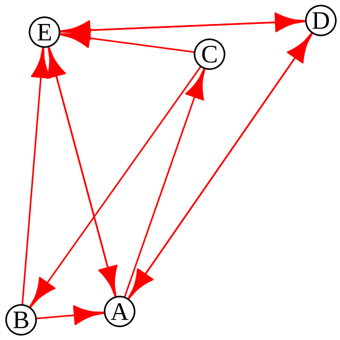
Symmetric, dichotomous
(Example: shared language)

	A	B	C	D	E
A	0	1	0	1	1
B	1	0	1	0	0
C	0	1	0	0	0
D	1	0	0	0	1
E	1	0	0	1	0



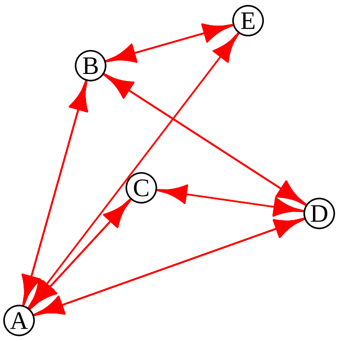
Asymmetric, dichotomous
(Example: perceived friendship)

	A	B	C	D	E
A	0	0	1	1	1
B	1	0	0	0	1
C	0	1	0	0	1
D	1	0	0	0	1
E	1	0	0	1	0



Symmetric, valued
(Example: co-participation in events)

	A	B	C	D	E
A	0	3	3	3	1
B	3	0	0	3	2
C	3	0	0	1	0
D	3	3	1	0	0
E	1	2	0	0	0



Asymmetric, valued
(Example: export flows)

	A	B	C	D	E
A	0	3	3	1	0
B	3	0	2	0	0
C	3	0	0	0	0
D	3	3	1	0	0
E	1	2	0	0	0

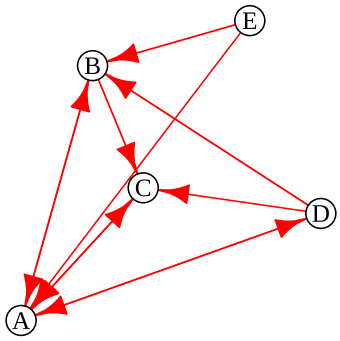


Figure 2: Sociomatrices and graphs.

Two main analytical perspectives can be applied to social networks. The first is holistic and is based on the properties of the networks ("global network analysis"), while the second focuses on the individual level and is based on actor-level measures ("ego-network analysis").

Global network analysis concentrates on the structural properties of one or, less frequently, more networks. This perspective examines questions such as how dense, bounded, or clustered a network is; whether it is diversified or limited in its size and heterogeneity; how narrowly specialized or broadly-based are its relationships; how direct and indirect connections and positions in networks affect behavior; and what are the structural contexts within which relationships operate. For instance, Fowler (2006*b*) examined the legislative network in the US Congress by looking at cosponsorship of legislation. In the US system, legislative bills must be presented by one, and only one, Representative or Senator (in the House or Senate, respectively). However, other legislators can co-sponsor bills that they have contributed to draft or that they want to support. Using data on 280,000 pieces of legislation and their corresponding 2.1 million cosponsorships, Fowler (2006*b*) could measure the connections among legislators in the US House and Congress from 1973 to 2004 and construct the network that they produce. The Senate network is shown in Figure 3. Further, he could highlight some structural characteristics of the network, such as the density of the connections. One way to measure the density of a network is to look at the pairwise distances between the actors, which denote the shortest path connecting two actors. To illustrate, in the top-left panel of Figure 2 the distance between A and B is 1 because they have a direct relationship, while that between A and C is 2 because to reach C, A has to go through B first. Using this idea, Fowler (2006*b*) showed that in the 2003–2004 House, the average distance between any two legislators ranges was 1.67 and that over 33% of the relationships were direct. The 2003–2004 Senate network was even denser, with an average distance of 1.27. The networks are also highly clustered, meaning that they are composed of groups of legislators that cooperate closely with one another. The clustering coefficient measures the probability that two actors that are linked to a given actor also have a connection between them. To illustrate, again using the top-left panel of Figure 2, the clustering coefficient would be higher if not only D and E, which are connected to A, were linked, but also, for instance, B and E. In 2003–2004, this coefficient was 0.6 in the House and as high as 0.9 in the Senate.

Ego-network analysis addresses the different roles played by the actors involved in various

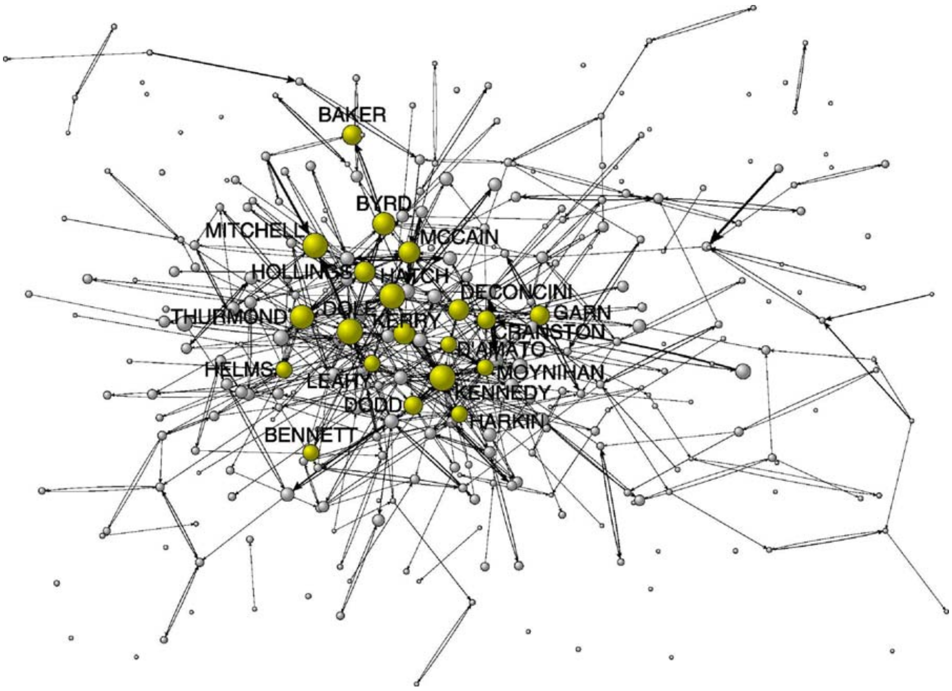


Figure 3: *Legislative cosponsorship network in the US Senate (2003–2004) (Fowler, 2006*b*, 463).*

types of social relations. There are several methods to assess the relative importance of individuals and their status or rank, notably centrality and structural and role equivalence. The centrality of an actor can be measured in different ways. Degree centrality represents the number of direct ties between an actor and other actors in the network. (Often, this measure is normalized to the total number of ties available in the network so that centrality measures can be compared across networks of differing size.) For instance, in the top-left panel of Figure 2, A is the most central actor because it is directly connected to three other actors, whereas B, D, and E have two direct links and C only one. Closeness centrality assesses how close an actor is to all the other actors in the network by looking at the length of the paths that connect it to the other actors. For instance, always in the top-left part of Figure 2, both A and B can reach all other actors with a maximum of two steps, while the other need three steps. Third, betweenness centrality attempts to determine which actors have a "mediating" role when evaluating the relational ties in the network. Actors are assigned values based on their probability of being a part of all communication paths. In our example, A is the gatekeeper for connecting D and E with B and C. Adapting these ideas to the specificities of cosponsorship data, Fowler (2006*b*) could identify the best connected legislators in the US Congress. The most central Senators are highlighted in Figure 3. Interestingly, Fowler (2006*a*) found that a legislative proposal tends to receive stronger support in Congress if its sponsor is more connected, which suggests that legislators who occupy a more central position in the network are more influential.

Structural equivalence measures the similarity of actor's roles and positions within the network. Two actors are structurally equivalent if they share the same ties with the same actors. For instance, in the top-right panel of Figure 2, B and D are structurally equivalent because they are both connected with A and D but disconnected from B, C, and D. On the other hand, role equivalence denotes the similarity of the types of relationships that actors have, whether they are with the same actors or not. As Polillo and Guillén (2005, 1779) illustrate, "when countries A and B trade in the same products but with a different set of countries, they are role equivalent but may not be structurally equivalent. Conversely, countries may be structurally equivalent but not role equivalent if they trade in different types of products but with the same set of countries." Many studies have found that actors tend to imitate other actors that are (role or structural) equivalent to them, which is often interpreted as evidence of competitive pressures (Polillo and Guillén, 2005; Cao, 2010).

In sum, social networks analysis offers a set of methods to measure the nature and structure of interdependencies. These methods are primarily descriptive in that they help uncover the characteristics of the network but do not establish connections between those characteristics and other variables of interest. However, network measures can also be used in combination with other approaches, which we discuss in the next sections.

3.2 Measuring the consequences of interdependence

3.2.1 Spatial regression

The predominant quantitative strategy to analyze the effects of interdependence on some outcome of interest is spatial regression (Ward and Gleditsch, 2008). At bottom, the method consists in adding to regression models a variable, called a "spatial lag," measuring the dependent variable in other units, weighted by their "proximity." Figure 4 shows how this works. The top panel shows the first component of a spatial lag, namely, the connectivity matrix, which contains information on how two units (in this case, countries) are related. The example shows the easiest case, that is, geographic proximity coded binarily, where 1 means that two countries

Connectivity matrix

	DEN	FRA	GER	ITA	SWI
DEN	0	0	1	0	0
FRA	0	0	1	1	1
GER	1	1	0	0	1
ITA	0	1	0	0	1
SWI	0	1	1	1	0

$$\underset{\text{connectivity matrix}}{\overset{\text{Row-standardized}}{\begin{pmatrix} 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 1/3 & 1/3 & 1/3 \\ 1/3 & 1/3 & 0 & 0 & 1/3 \\ 0 & 1/2 & 0 & 0 & 1/2 \\ 0 & 1/3 & 1/3 & 1/3 & 0 \end{pmatrix}}} \quad \underset{\text{variable}}{\overset{\text{Dependent}}{\begin{pmatrix} 28.0 \\ 34.3 \\ 21.9 \\ 33.0 \\ 6.7 \end{pmatrix}}} \quad = \quad \underset{\text{lag}}{\overset{\text{Spatial}}{\begin{pmatrix} 21.9 \\ 20.5 \\ 23.0 \\ 20.5 \\ 29.7 \end{pmatrix}}}$$

Figure 4: *Construction of a spatial lag. Corporate tax rates, 2006 (Cao, 2010).*

share a border, and 0 that they do not. While this example is very simple, it is crucial that the connectivity matrix contains information that allows researchers to capture theoretically meaningful interdependencies. (We will return to this point below.) Then, the bottom panel of Figure 4 shows that the spatial lag is constructed by first row-standardizing the connectivity matrix and then multiplying it with the dependent variable, which in this example are corporate tax rates. Row standardization means that each cell is divided by the sum of the corresponding row. This ensures that the sum of the row is one and the spatial lag can be interpreted very intuitively as the weighted average of the dependent variable in other units, where the weights are the values contained in the connectivity matrix.

For instance, for Italy the spatial lag is computed as follows:

$$0 \times 28 + 0.5 \times 34.3 + 0 \times 21.9 + 0 \times 33.0 + 0.5 \times 6.7 = 20.5.$$

In other words, the spatial lag is the average corporate tax rate among its two neighbors, France and Switzerland. Because spatial lags are fundamentally very intuitive, many researchers use them implicitly or without using this terminology. Any study with a variable measuring the (weighted) average of the dependent variable in other units includes, technically speaking, a spatial lag.

The spatial lag so constructed is then included in the analysis just like another variable.[4] From the perspective of the research design, the most crucial step is the definition of the weights. The starting point is often a relatively general type of geographic proximity, such as shared borders, distance between capital cities, to other measures of physical distance. For example, Buhaug and Gleditsch (2008) examined the diffusion of civil war by weighting conflict in other countries by the inverse of their distance as well as by a simpler measure, that is, the presence of an ongoing conflict in at least one neighboring state. Similarly, Berry and Berry's (1990) influential study of the diffusion of state lotteries in the US states relied on the number or share of lottery adoptions in neighboring states as the main explanatory variable.

Geographic distance is in many cases a perfectly reasonable starting point to measure interdependence. However, in the words of Beck, Gleditsch and Beardsley (2006), "space is more than geography." Weights should be defined with the purpose of measuring theoretically relevant connections among units. In this respect, geographic proximity is usually a proxy of many different types of interdependences and, consequently, it cannot be interpreted very precisely. Gilardi and Wasserfallen's (2011) study of tax competition in Switzerland illustrates the problem. Many analyses have found that the tax rates of one jurisdiction are positively correlated with those of its neighbors, which is often taken as support for the argument that jurisdictions are in competition with one another. However, it could be that neighbors are not competitors but sources of valuable information about the consequences of different tax policies, or that neighbors develop common understandings of appropriate tax rates. Gilardi and Wasserfallen (2011) tried to improve the operationalization of competition by using the number of commuters instead of shared borders in the construction of the connectivity matrix, the idea being that competition pressures increase with the feasibility of moving to another canton without switching jobs. Concretely, each cell in the connectivity matrix includes, instead of just 1 or 0 depending on whether two units are neighbors, the number of people commuting from the column unit to the row unit. Another example of the flexibility of the spatial lag setup is Simmons and Elkins (2004), which analyzed the worldwide diffusion of international economic policies with several connectivity matrices. One matrix is constructed with the correlation between countries' trade patterns, which is taken as a measure of competition; another gives more weight to countries

[4] The model estimation needs to consider several complications that are beyond the scope of this book. We refer interested readers to Ward and Gleditsch (2008).

that experience higher growth rates, which is a measure of success; others measure whether two countries share the same language, religion, and colonial heritage. Generally, all network measures discussed in Section 3.1 can be used as weights in the connectivity matrix.

There are a few technical limits in the construction of spatial lags, for instance if a unit has no connections (hence, all 0s in the corresponding row). In this case, the spatial lag is going to be 0 but this may or may not be meaningful depending on the specific application. Another problem arises if the weights can take both positive and negative values, in which case the spatial lag does not add up as expected. However, there is usually a fix for these technical hitches. The real problems are theoretical and, especially, practical. First, what is the best indicator for a specific type of interdependence? Second, can the required data be collected? While it is relatively easy to come up with good ideas, they often prove unfeasible because of data constraints.

In sum, the spatial regression approach provides clear guidelines for research design. Essentially, it builds on standard regression methods and adds one or more variables capturing theoretically relevant forms of interdependence through spatial lags. The key issue here is the construction of the connectivity matrix, which measures the connections among all units in the analysis. While there are some technical obstacles both for this step and for model estimation, the big issues are the theoretical definition of the weights and, in particular, the availability of appropriate data.

3.2.2 Dyadic approach

Another quantitative approach to interdependence is the dyadic approach, in which units are not actors, but pairs of actors. This definition of the units of analysis makes it easy to consider relational variables into account, which allows for a direct operationalization of various types of interdependence.

A dyadic data structure is well suited for the analysis of network data. For instance, in Christakis and Fowler's (2007) study of the spread of obesity units are pairs of individuals, which allows to incorporate in the dataset directly whether the first person ("ego") perceives the second ("alter") as a friend, whether the two people are mutual friends, whether they are married to one another, and so on. Crucially, the dependent variable is the obesity of the first

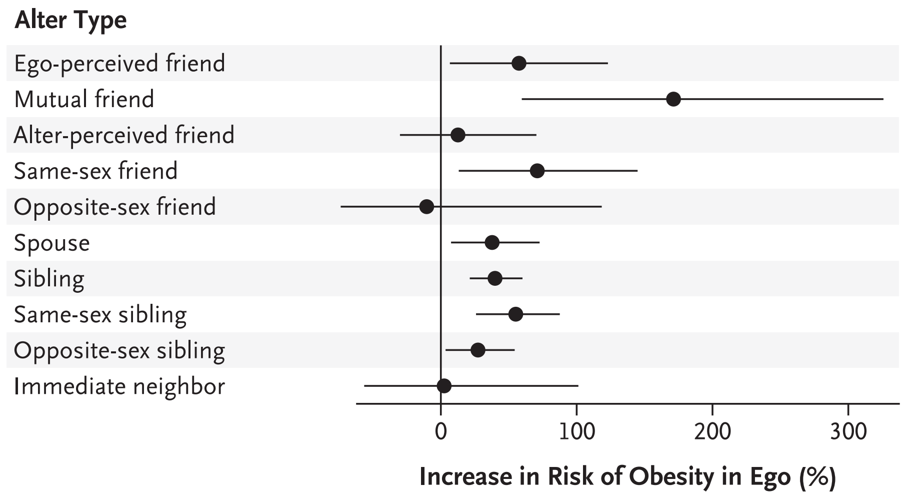


Figure 5: *Probability that an individual becomes obese as a function of obesity in its social network (Christakis and Fowler, 2007, 376).*

person, while the main explanatory variable is the obesity of the second. Figure 5 shows the results of the analysis. Generally, a person is more likely to become obese if his or her friends are obese, but the effect is stronger in case of mutual friendship than if only the first person identifies the second as a friend, and the effect disappears if it is the other way round. Both people being of the same sex also seems to play an important role. As mentioned earlier, the authors think that these findings are driven by obesity becoming more socially accepted if it is widespread among friends, which makes it more likely that a person makes less efforts to avoid becoming overweight. However, the results have been controversial, and we discuss the main issue in section 3.2.3.

The dyadic approach has been used extensively in the democratic peace literature, which can be used to illustrate its basic setup. Gartzke (2007) used non-directed dyads to study the role of capitalism in explaining the democratic peace. The dependent variable is the onset of a militarized interstate dispute between the two countries in the dyad. Democracy is measured by the highest and lowest values in the dyad, as well as by a dichotomous variable with a value of 1 if both countries are fully democratic. Because dyads are non-directed, "high" and "low" values cannot be attributed to a specific country. However, dyads can also be directed. For instance, Danilovic and Clare (2007) defined one country in the dyad as the "initiator" and the other as "target" of conflict. This means that each country enters the dataset twice, once as (potential) initiator and once as (potential) target. This makes it possible to measure which country attacks and which is attacked in the dependent variable. Similarly, explanatory variables can distinguish between different combinations of the democratic status in the dyad, that is, whether only one, both, or none of the countries are democratic. The big advantage of this approach is that it makes it possible to test relational arguments directly. Thus, Gartzke (2007) found that conflict is significantly less likely when both countries in a dyad have high financial and trade openness, which suggests that economic policy is an important driver of the democratic peace. Similarly, Danilovic and Clare (2007) refined the democratic peace argument by showing that the respect for individual freedoms strongly influence the absence of conflict between countries.

Volden (2006) adapted the dyadic approach to the study of policy diffusion. The task is not straightforward because, unlike in the case of interstate conflict or trade, the dependent variable is in this case not directly observable. That is, we are interested in whether one unit was influenced by other units, but such influence is essentially unobservable. Indeed, finding out whether there was any influence at all is one of the main goals of the analysis. Volden (2006) went around this problem by defining the dependent variable in terms of convergence between the two units in the dyad, and specifically of the first unit becoming more similar to the second. The analysis, then, attempts to find whether there are any factors that make the first unit systematically more likely to alter its policies in ways that move it closer to the second unit. As discussed earlier, Volden (2006) found that states were more likely to become more similar to other states that managed to increase insurance rates among children, which was one of the main goals of the policy under study. The dyadic approach makes it possible to test this argument directly because it can easily include variables measuring characteristics of the first unit, of the second unit, and of the relationship between the two. This is its main advantage. However, the definition of the dependent variable is somewhat artificial and without a single best alternative.

Figure 6 shows four alternative operationalizations of the dependent variable. The table represents an excerpt of a fictitious dataset, showing three dyads (A-D, B-D, and C-D) at two time periods. The policy has two dimensions, which are measured for both units of the dyad (i and$j$). Following Volden (2006), we define the dependent variable as increased similarity between i and j. However, there is no single way to operationalize this idea. A first option is

Unit_i	Unit_j	t	DV_1	DV_2	DV_3	DV_4	$\text{Policy}_{1,i}$	$\text{Policy}_{2,i}$	$\text{Policy}_{1,j}$	$\text{Policy}_{2,j}$
A	D	1			0.36		0.90	0.30	0.70	0.60
A	D	2	1	1	0.22	−0.14	0.60	0.40	0.70	0.60
B	D	1			0.45		0.30	0.40	0.70	0.60
B	D	2	1	0	0.41	−0.04	0.60	0.20	0.70	0.60
C	D	1			0.21		0.65	0.80	0.70	0.60
C	D	2	0	0	0.34	0.13	0.55	0.90	0.70	0.60

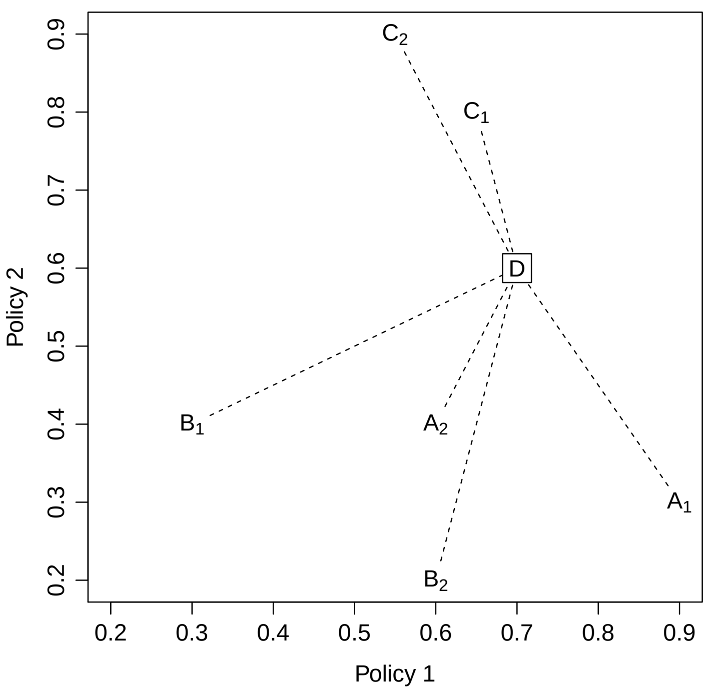


Figure 6: *Dyadic approach and policy diffusion: Construction of the dependent variable.*

simply to say that i becomes more similar to j if there is convergence on at least one dimension of the policy. If this is the case, DV_1 is coded 1, and 0 otherwise. Using this definition, both A-D and B-D are coded 1. A second option is to require that the the first unit becomes more similar to the second on at least one dimension and does not become more dissimilar on another (DV_2). If we apply this rule, A-D is still coded 1, but B-D must be coded 0 because B moves away from D on the second dimension of the policy. The third option is more complex. Here, we can situate the units in a multidimensional policy space and measure their distance continuously, as shown in the bottom panel of Figure 6. The dependent variable can use distance directly (DV_3), or we can further compute the difference in distance between the two time periods (DV_4). This list shows that, in the dyadic approach, the operationalization of the dependent variable is not straightforward. Therefore, it is crucial that researchers discuss the alternatives in detail and try different implementations when there is no clear best option (that is, in the majority of cases).

A byproduct of the dyadic approach is that the number of observations increases dramatically. This is not necessarily a good thing, because the increase is due to a rather artificial manipulation, not to a real increase of the number of cases. Relatedly, complex interdependencies emerge between observations that can complicate the analysis. Also, the construction of the dependent variable in policy diffusion applications creates its own set of problems. These methodological issues are beyond the scope of this volume, and interested readers are referred to specialized articles on the subject (Green, Kim and Yoon, 2001; Gilardi and Füglister, 2008). Finally, we note the spatial approach discussed in section 3.2.1 can be implemented also within a dyadic data structure (Plümper and Neumayer, 2010).

In terms of research design, the bottom line is that focusing on pairs of countries can provide considerable analytical leverage when the dependent variable itself is dyadic (conflict, trade, etc.) or, in a diffusion study, when the redefinition of the dependent variable in dyadic terms makes sense. The latter is more likely to be the case when the policy has several dimensions, which are difficult to handle in a normal setup. When these conditions hold, the dyadic approach allows the researchers to integrate interdependencies directly into the analysis, which is a significant advantage. However, the price to be paid is the increased complexity of the data structure and the methodological complications that come with it.

3.2.3 The problem of homophily

Evidence of diffusion has been uncovered by countless studies. However, such evidence could also be produced in cases where diffusion is extremely implausible, such as acne, height, and headaches (Cohen-Cole and Fletcher, 2008). This problem points to the well-known "homophily" principle, namely, "that a contact between similar people occurs at a higher rate than among dissimilar people" (McPherson, Smith-Lovin and Cook, 2001, 414). This phenomenon could be documented for sociodemographic characteristics like race, ethnicity, and age; for acquired characteristics such as education, occupation, religion, and behavior; and for internal characteristics such as attitudes, abilities, beliefs, and aspirations (McPherson, Smith-Lovin and Cook, 2001, 419–429). Moreover, homophily pertains not only friendship *formation*, but also friendship *dissolution* (Noel and Nyhan, 2011). Thus, on the one hand, people who share some characteristics tend to become and stay more connected (homophily). On the other hand, more connected people tend to take up each other's characteristics (diffusion, contagion). Telling the two phenomena apart empirically is difficult, and some authors have argued that it is almost impossible with observational (that is, non-experimental) data (Shalizi and Thomas, 2011). At a general level, the problem is related to the distinction between descriptive and causal inference discussed in Chapter 4. To the extent that claims of diffusion or contagion are causal, it is paramount that homophily can be ruled out. However, this is usually unfeasible because homophily can take so many different forms, some of which are latent, that is, the cannot observable. This leads Shalizi and Thomas (2011, 216) to conclude that "there is just no way to separate selection from influence observationally," which is a rather bleak assessment. On the other hand, there is no consensus on the actual magnitude of the problem and scholars are actively researching ways to overcome or limit it.

The homophily critique is most directly relevant to studies of interpersonal networks because that is the context where the phenomenon is most likely to be an issue. However, more generally, it means that researchers should always consider carefully the extent to which the connections among units are exogenous or, on the contrary, can be influenced by the outcomes under study. Geographic proximity is an example of exogenous connections, (but, as mentioned earlier, they are difficult to interpret theoretically), while joint membership in (international) organizations is potentially endogenous. For instance, countries sharing many memberships in organizations could appear more likely to adopt similar policies, but they might be more likely to join the same organizations if they have similar policies. Here, the issue is less intractable than in the case of interpersonal networks because it is possible to find evidence that membership is exogenous. For instance, membership in some organizations has a pure geographical basis, or it can be shown that self-selection is unrelated to the specific policy under consideration. The qualitative methods discussed in section 3.3, especially within-case analysis, can be particularly helpful in this context. While always potentially problematic, homophily will generally be both less extensive and more manageable in interstate than in interpersonal networks. However, the usual complications of causal inference, discussed in Chapter 4, still apply.

3.3 Qualitative approaches

The majority of research designs for the study of interdependence rely on quantitative tools. However, it is obvious that quantitative methods alone cannot give a full picture of this (or any) phenomenon and that qualitative research designs can make a distinct contribution. In particular, two approaches seem particularly fruitful, namely cross-case analysis and process tracing (Starke, 2011). Both are well-established methods in the social sciences and we have already discussed them in Chapter 3. However, their application to the specific question of interdependence has been examined less in depth than it has been the case for the other methods presented in this chapter. Counterfactual approaches could also be useful for the analysis of interdependence (Starke, 2011). However, in practice, they have not been used as extensively as other methods. As we have seen in Chapter 3, this conclusion applies also to other areas of the social sciences. However, when used in combination with other methods, they can certainly help strengthen the analysis.

Following Starke (2011), we can usefully differentiate between two questions that are relevant for the study of interdependence and assess the various methods accordingly. First, how can we establish whether interdependence matters in a given context? Even if we can observe, descriptively, that a even phenomenon spreads, we need to make sure that interdependence drives it, and not other factors such as internal characteristics or common pressures. Second, what is the nature of interdependence? For instance, the diffusion literature discussed in section 2 distinguishes theoretically between mechanisms such as learning, competition, and emulation.

How can the different methods help us to differentiate among them empirically?

Starting with cross-case analysis, the most fruitful case selection strategy is probably the "diverse-cases" approach, which "has as its primary objective the achievement of maximum variance along relevant dimensions" (Gerring, 2007, 97). A traditional method of difference (or, equivalently, most-similar-systems design, MSSD) could in principle be adopted, namely, by selecting cases with different outcomes, similar control variables, and different diffusion variables. Alternatively, the method of agreement (or most-different-systems design, MDSD) would require that cases differ on the outcome and on key diffusion variables, but are similar on the control variables. However, Mill's methods often do not work well in practice because cases seldom fit cleanly in the theoretical schemes. By contrast, the diverse-cases strategy, while no magic solution, gives more flexibility to select cases that vary on several interesting dimensions. Answering the first question ("does interdependence matter?") will be difficult because the small number of cases makes it very hard to control for alternative explanations, but cross-case analyses give more leverage to answer the second ("what is the nature of interdependence?"). For instance, Weyland (2007) argued that bounded learning was the main driver of the spread of health and pension reforms in Latin America. His argument is that policy makers strive to learn from the experience of other countries but rely on cognitive shortcuts instead of analyzing all available evidence systematically. One piece of evidence in support of this idea comes from a cross-case comparison showing that the learning process was more superficial in countries that could not rely on extensive expertise (Weyland, 2007, 220):

> Countries with especially limited technical capacity, such as Bolivia and El Salvador, therefore imported most of the Chilean privatization scheme. Nations with ample, long-standing expertise, such as Costa Rica, introduced substantial modifications but nevertheless instituted the core innovation of the Chilean model, namely, privately managed individual pension accounts in the obligatory social security system.

This quote shows both the strengths and weaknesses of qualitative cross-case analysis. On the one hand, the comparison highlights a co-variation that can be directly linked to the theoretical expectations. On the other hand, alternative factors cannot be ruled out convincingly. This is why most qualitative studies combine cross-case comparisons and within-case analysis.

The analysis of interdependence within cases is definitely the strongest dimension of qualitative approaches. This step corresponds to what is known as process tracing. As Bennett (2008, 704–705) explains (see also the discussion in Chapter 3), "[p]rocess tracing involves looking at evidence within an individual case, or a temporally and spatially bound instance of a specified phenomenon, to derive and/or test alternative explanations of that case. [...] [It] is the technique of looking for the observable implications of hypothesized causal processes within a single case." Although there are few standard procedures for process tracing, which makes it difficult to outline clear prescriptions for researchers, there is no doubt that a fine-grained focus on process and mechanisms is the most important contribution that qualitative work can offer to the understanding of interdependence. Thus, qualitative research should strive to uncover crucial "causal-process observations," that is, "an insight or piece of data that provides information about context, process, or mechanism, and that contributes distinctive leverage in causal inference" (Brady and Collier, 2004, 277). For instance, Weyland (2007) showed in detail how pension privatization in Chile played an important role for reforms in other Latin American countries. In Bolivia, a crucial event was the Finance Minister's budget director's attending a keynote speak by the architect of Chile's pension privatization; similarly, in El Salvador the Chilean model was put on the agenda through a consultant who was involved in the Chilean reform, and who was originally hired to assist with a smaller-scale project (Weyland, 2007, 101). By contrast, contacts with experts and policy makers from Argentina and Colombia, which also had introduced reforms of the pension system, were much more limited (Weyland, 2007, 105–106). In some instances, researchers may even uncover "smoking guns" supplying very strong evidence. For example, in his study of national tax blacklists, Sharman (2010) provides examples of countries that literally copied and pasted legislation from others. The most striking case is Venezuela (Sharman, 2010, 625):

> [T]he Venezuelan legislation made reference to the wishes of the Mexican legislature and the need to be consistent with the Mexican constitution. Worse still, the original Mexican list had included Venezuela, and thus by copying the Mexican list, Venezuela succeeded in blacklisting itself.

Biedenkopf's (2011) study of the effects of EU environmental legislation on the United States is also a good example of how within-case analysis can yield insights into the relevance and nature of interdependence. For instance, similar to Weyland (2007), Biedenkopf (2011) is interested in whether policy makers learn from the experience of other countries. One piece of evidence supporting the learning argument is that in many cases, US policy makers (both at the federal and at the state level) were quite familiar with the details of EU rules and not just with the general concept. Another argument is that, under some circumstances, policy makers may be more sensitive to the symbolic features of the policy than to the actual evidence of its effectiveness. Interviews could find some support for this idea:

> [A] number of interviewees described California as striving to be trendsetters. According to one interviewee; 'They don't like falling behind' and according to another: 'California does not want to be perceived as a laggard internationally'." (Biedenkopf, 2011, 220)

These "causal-process observations" are less dramatic than those uncovered by Sharman (2010), but they do help to understand how and to what extent interdependence matters and are a distinctive contribution of qualitative approaches.

In sum, qualitative approaches to interdependence are less developed than their quantitative counterparts but have specific strengths that can yield unique insights into the nature of interdependence, especially when cross-case comparisons are combined with within-case analysis and, possibly, counterfactual reasoning. While they cannot measure interdependence as reliably as quantitative approaches, they allow to uncover detailed elements of the phenomenon to which quantitative methods are almost completely blind.

4 Conclusion

Interdependence is a fundamental characteristic of the social world. Sometimes it is treated, under the "Galton's problem" rubric, as a source of complications for comparative research. However, interdependence is an interesting subject of study in its own right, which can be and has been investigated in a wide range of social science subfields, including communication, sociology, international relations, public policy, federalism, and others. Moreover, the list of phenomena for which interdependence is a relevant angle for research is virtually unlimited. Research designs for the study of interdependence should pay attention to several dimensions. Descriptively, social network analysis is the method of choice to measure the connections among units and the structural properties of the network that they constitute. More explanatory research questions would ask what the consequences of interdependence are. Here, information on interdependence can be integrated in regression models through spatial or dyadic frameworks. Like for other research questions, separating correlation and causation is not straightforward, but the problem is complicated here by "homophily," namely, the fact that not only do actors who are more connected tend to become more alike, but those who are more alike tend to become more connected in the first place. Qualitative approaches can make a distinct contribution to the study of interdependence through focused cross-case comparisons and, especially, within-case analysis. Even though they are currently less developed than quantitative options, they have an unparalleled capacity to test important assumption and uncover crucial pieces of information that can go a long way to confirm or disprove the relevance and nature of interdependence in a variety of contexts.

In conclusion, students of interdependence face many methodological problems. However, ignoring interdependence is certainly no better option than taking it into account as accurately as possible with the current methodological state of the art. The importance of the topic certainly justifies (indeed, it requires) further efforts to elucidate the nature and consequences of interdependence.

5 Questions

1. Read closely five articles in your field of study. To what extent could interdependence be an interesting angle to complement or extend these works? What types of interdependence could matter? Develop a research question.

2. Try to formalize these interdependencies with a connectivity matrix / sociomatrix. What are the relevant units, and how could their relationships be measured?

3. Now think about the dependent variable, that is, the phenomenon that is subject to interdependence. How would you redefine it if you were to use a dyadic approach?

4. Make a list of causal-process observations that, ideally, you would like to find in a within-case analysis. Try to connect them with different types of interdependence as explicitly as possible.

5. Think about the ways in which qualitative and quantitative approaches could be combined to answer your research question.

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