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Effectiveness of Connected Legislators*

Abstract

Important work has been done to measure legislative effectiveness in the U.S. Congress and to explain the individual characteristics that drive it. Much less attention, however, has been devoted to study the extent to which legislative effectiveness depends on the legislators' social connections. We address this issue with a new model of legislative effectiveness that formalizes the role of social connections; and we test its predictions using the network of cosponsorship links in the 109th-113th Congresses. We propose a new empirical strategy that addresses network endogeneity by implementing a two-step Heckman correction based on an original instrument: the legislators' alumni connections. We find that social connections are a significant determinant of legislative effectiveness. We also study the influence of legislators' characteristics in shaping the network effects. In doing so, we provide new insights into how social connectedness interacts with factors such as seniority, partisanship and legislative leadership in determining legislators' effectiveness.

Marco Battaglini
Cornell University and EIEF
battaglini@cornell.edu

Valerio Leone Sciabolazza
University of Naples, Parthenope
valerio.leonesciabolazza@uniparthenope.it

Eleonora Patacchini
Cornell University
ep454@cornell.edu

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1 Introduction

Understanding what makes legislators effective, both in absolute and relative terms, is clearly a question of practical and theoretical importance. From a normative perspective, understanding effectiveness may help us design more efficient political institutions. From a positive perspective, it may help explain the determinants of politicians' success and therefore their career paths. It is therefore not surprising that there is a large literature devoted to measuring and explaining legislative success (see, among others, Volden and Wiseman [2014]). This literature has investigated the extent to which idiosyncratic talent, skill sets, seniority, demographics (gender and race, in particular), institutional and party positions play a role in the process of passing legislation both at the state and federal level.

While most of this literature has focused solely on legislators' individual characteristics, journalistic accounts and political commentators have traditionally privileged the importance of social connections, portraying successful politicians as masterful "networkers." As a result, recent work in political science and economics has aimed to link social connectedness to legislative effectiveness. In a seminal contribution, Fowler [2006a] has shown that measures of legislative success correlate positively with politicians' connectedness in the network of cosponsorships. In Fowler's definition, politicians' connectedness depends on the number of cosponsorships their bills receive and a measure of their bills' quality. This line of research has been continued by Tam Cho and Fowler [2010], Kirkland [2011] and Kirkland and Gross [2014], who use cosponsorships as their source of information on network connections. Craig [2017], in contrast, has constructed network connections using cosigners of Congressional "Dear Colleague" letters, and has shown that "team players" are better at gathering support in the form of cosponsorships, but they do not have greater success in advancing their legislative agendas.

A key issue with the current literature on social connectedness and legislative effectiveness is that it relies on measurements of social connections that are naturally endogenous. Legislators are certainly strategic in choosing with whom to cosponsor and with whom to partner in sending "Dear colleague" letters. This strategic self-selection makes it difficult to interpret the correlation between legislative effectiveness and social connectedness, since omitted variables (such as social skills) may drive both social connections and legislative success. A positive correlation between centrality and effectiveness that is found while ignoring these issues may be spurious; similarly, the lack of a correlation may not rule out a causal relationship.

In this paper, we build on this early literature suggesting a role for social connections in determining legislative effectiveness, but we explicitly deal with the problem of the endogeneity of social networks and study the causal connections between them and legislative effectiveness. Specifically, we make two contributions. First, we propose a simple model of legislative effectiveness in Congress that formalizes the role of social connections and generates simple testable predictions. Second, we propose a new empirical strategy to test these predictions. The strategy to deal with network endogeneity consists of implementing a Heckman correction based on an original instrument: the legislators' alumni connections. The advantage in using this technique is that it allows us to control for the presence of individual-level unobserved factors. A politician's ability is a prominent example. More effective politicians may be both more likely to attract cosponsors and more likely to have attended the same prestigious schools.

In the model we propose, legislative effectiveness depends on three factors: the legislator's characteristics, the effort directly exerted by the legislator, and the legislative effectiveness of all the legislators with whom the legislator has social connections. This last factor reflects the idea that if legislator i has cultivated a social relationship with j (for example, by contributing to the reelection campaign of legislator j through her/his own PAC or by playing golf with her/him), then i may conscript j to her/his own cause. Therefore, existing social connections make i more productive. Once equilibrium effort levels are taken into account, we show that our model has a unique Nash equilibrium in which the legislators' effectiveness levels are uniquely defined and are proportional to a standard measure of centrality developed in the sociological literature: the weighted Katz-Bonacich centrality (Bonacich [1987]).

We then test the model predictions using data from five recent election cycles: the 109th Congress (election cycle 2004) to the 113th Congress (election cycle 2012). We measure each Congress representatives's legislative performance using the Legislative Effectiveness Scores (LESs) for members of the U.S. House of Representatives, developed by Volden and Wiseman [2014]. This is a general metric of individual legislative effectiveness in the U.S. Congress, which identifies differences across legislators in formulating meaningful bills and moving them through the legislative process from introduction to the ultimate signing into law. As mentioned above, we deal with the endogeneity of available measures of social connections in Congress by implementing a two-step procedure. In the first step, alumni connections and other relevant legislators' characteristics (gender, party, seniority, etc.) are used to explain the map of cosponsorship linkages. In the second step, the residuals of the first stage (that incorporates unobservable variables explaining the existence of legislative networks in Congress), are included in the regression used to estimate our model. In our alumni network, two Congress members are connected if they graduated from the same institution within a given time window. The idea behind our approach is that shared educational experiences have long-lasting effects on the propensity for socialization later in life (see Cohen et al. [2008], Cohen and Malloy [2014], Battaglini and Patacchini [2018] among others).

Three main results emerge from our analysis. First, we find that, consistent with the theory, Congress members' Bonacich centralities have highly significant effects on their Legislative Effectiveness Scores. This result is robust to many natural controls suggested by the existing literature, including seniority, measures of relative institutional power inside the

House, electoral success, and political ideology.[1] Our model generalizes and includes as a nested case, previous empirical models that ignore social connections: it therefore allows us to formally show that social connections significantly improve the model's fit. This suggests that social connections should be added to the list of factors identified by Volden and Wiseman [2009] as predictors of legislative success.

Second, we provide a decomposition of social connections in *weak ties* and *strong ties* following Granovetter [1973] and Kirkland [2011]. Strong ties form between similar types of agents (same cultural background, demographics, etc.), and thus they have a relatively small potential for information transmission. Weak ties, on the contrary, form between heterogeneous agents, so they may be instrumental in the transfer of information or the discovery of other productive complementarities. Kirkland [2011] suggests that members of Congress rely on weak ties to forge legislative coalitions. We find evidence supporting this conjecture.

Third, our analysis provides insights into the mechanisms through which variables previously identified as important affect legislative effectiveness. We find that ethnic minorities appear to benefit more than the average Congress member from social interactions, whereas Congress representatives with higher seniority and committee chairs receive fewer benefits from interacting with others than other members of the Congress.

Our work is related to two strands of literature. First, there is the traditional literature on legislative effectiveness that focuses on the questions of how to measure effectiveness, its determinants and its effects. This literature has highlighted factors such as seniority, leadership position in Congress and the parties as unambiguous drivers of effectiveness (see for example, Anderson et al. [2003], Cox and Terry [2008], Volden and Wiseman [2009]). Other factors have been highlighted but have proven more controversial, such as electoral

[1] Results are also robust to incorporating in the first stage information on the structural characteristics of the social network using Exponential Random Graph Models to estimate the likelihood of the observed cosponsorship network. See Section 5.

safety, ethnicity and gender (see for example, Jeydel and Taylor [2003], Bratton and Haynie [1999]).

Second, our work contributes to the literature on social networks in Congress. As said, a number of works have investigated the correlation of legislative success and measures of social centrality using data from cosponsorships (Fowler [2006a] and Kirkland [2011]) and "Dear Colleague" letters (Craig [2017]).[2] This pioneering literature first highlighted the importance of social links to legislative success but has not investigated the problem arising with the endogeneity of social networks and therefore has not studied the causal link between observed measures of social connectedness and legislative success.[3]

A recent literature has employed a variety of strategies to control for the endogeneity of social networks in Congress and other legislative assemblies. Masket [2008], Rogowski and Sinclair [2012] and Harmon et al. [2017] use seat assignments and office allocations to study voting behavior. Cohen and Malloy [2014] and Battaglini and Patacchini (2018) use the alumni networks to study voting behavior in the U.S. Senate and PAC electoral contributions in the U.S. Congress, respectively.

The remainder of this paper is organized as follows. Section 2 presents the theory underlying our analysis, its testable implications, and the empirical approach used to test them. In Section 3, we describe the data. In Section 4 and 5, we discuss the empirical results and a number of robustness checks. Section 6 concludes.

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[2] Previous studies providing evidence that legislators are embedded in social relationships that may be functional in achieving their goals were based on personal interviews with members of one legislature. See Patterson [1959], Caldeira, Clark, and Patterson [1993], Arnold, Deen, and Patterson [2000] and People [2008].

[3] Another strand of literature has used memberships to informal Caucuses to capture social networks, see Young [1966] and Bogue and Malaire [1975]. More recently, an analysis of the Caucus system in the House of Representatives has been presented by Victor and Ringe [2009].

2 Theory and empirical strategy

In Section 2.1, we first discuss the main theory driving our analysis and its general implications in terms of testable hypotheses. In Section 2.2, we then present a formal model to make the hypothesis precise and guide the empirical analysis. In Section 2.3, we use the predictions of the model to precisely define our econometric approach.

2.1 Theory

At the core of our theory of legislative effectiveness is the idea that the success of a member of Congress in passing legislation does not only depend on her/his individual characteristics and abilities. Legislative work is a cooperative activity in which success is determined by the ability of the legislator to work with other legislators, both in the same party and across the aisle. This cooperative work takes various forms. Part of this cooperation consists in trading favors: legislator i supports legislator j's pet projects expecting that j returns the favor. Since these interactions cannot be codified in official (and thus enforceable) "contracts," they can be supported only in the presence of reciprocal trust. Social connections obviously make this type of interactions easier because they help to relax the credibility constraints needed for cooperation. There is ample evidence that social connections facilitate the trading of favors. A number of papers have studied the relationship between social networks and floor voting (see Masket [2008], Rogowski and Sinclair [2012], Harmon et al [2017]). The vote-trading hypothesis has been explicitly studied by Cohen and Malloy [2014], who show U.S. Senators are more likely to vote with other connected Senators in their alumni network when they have high demand for the votes and the cost of supplying the votes for connected Senators is low.[4]

A different form of cooperation between Congress members is information sharing: here

[4] Cohen and Malloy [2014] measure the demand for votes on the basis of how close the vote is and the cost of supplying the vote on the basis of how relevant the related bill is on the Senator's constituent firms.

too, social connections help as a lubricant, relaxing the incentives to disclose truthful information. Communication networks have been conjectured by Fiellin [1962] and Matthews and Stimson [1975] and more recently studied by Victor and Ringe [2009] and Ringe et al. [2013], who have shown that members of Congress form relationships from which they gain information using legislative member organizations (LMOs).[5]

Finally, social connections are important in determining legislative effectiveness because they affect the cohesion of parties (or factions within parties). For example, Parigi and Sartori [2014], using data from the Sixth Legislature of the Italian Parliament (1972–1977), show how national cleavages played a key role in determining strong ties in the Italian Parliament (as measured by cosponsorships).[6]

In all these cases, socially connected members of Congress are better positioned to acquire useful information and mobilize support for their cause, and are thus more effective. Our goal is to show that the impact of social connections on all of these activities leads to higher legislative effectiveness. These considerations lead us to our first hypothesis:

H1: *Socially connected members of Congress are more effective in pursuing their legislative goals.*

An immediate corollary of H1 is that including information on social connections may improve the ability to predict which legislators are effective in Congress.

H2: *Including social connections improves the fit of a model predicting the effectiveness of members of Congress and the determinants of their effectiveness.*

We should note that improving the fit of a model predicting legislators' effectiveness is not only important for measurement purposes, but it may have significant positive and nor-

[5] See also Box-Steffensmeier et al. [2018a] who show that "Dear Colleague" letters can be used to broadcast interest group signals. Hagenbach and Koessler [2010] provide a more thoretical point of view.

[6] On this aspect see, among others Whalke et al. [1962], Caldeira and Patterson [1988].

mative implications. The importance of social connections for effectiveness and the presence of homophily in social connections –that is the tendency for members of Congress with similar characteristics to form bilateral social connections– may indeed constitute a significant barrier to the success of members of Congress from underrepresented groups.

There are two key problems in attempting to test these two hypotheses. Addressing these problems constitutes the core of our contribution. The first problem consists of how to measure social connections, since these relationships are not typically observable by the "econometrician" or, if observable, they are only partly observable. The second problem consists of identifying what features of social connections are important for legislative success.

We start by discussing the second question. There are many features of a network that may matter in helping legislators in pursuing their goals. This is reflected in the many measures of centrality devised in the literature on social networks. It should be noted that our interest is not in studying the social network per se, but in studying its impact on a representative's actions, specifically their effectiveness. A measure of centrality that has constitently emerged as key in describing how social connections affect behavior of the members of the network is the Bonacich centrality, or one of its variants (Bonacich [1987], Calvó-Armengol et al. [2009]). It is intuitive to assume that a member of Congress is central if she/he is connected to other members of Congress who are central; and the centrality of a member of Congress depends on the level of centrality of the other connected members. The weighted Bonacich centrality measure does exactly this, by expressing centrality in a recursive way: as a function of the characteristics of the member of Congress and a weighted sum of the centralities of the other connected members of Congress, where the weights are given by the intensity of the social connections. More specifically, for a given network matrix $G = (g_{i,j})_{i,j=1}^{n}$, the Bonacich centrality b_i of legislator i, is defined as:

$$b_i = A_i + \delta \sum_{j=1}^{n} g_{i,j} b_j \tag{1}$$

where A_i captures i's personal characteristics, $g_{i,j}$ is the social link between i and j. The conditions described in (1) for all i, define a system of equations in which the centrality of each member of Congress is defined by the centralities of the members to whom she/he is connected. The key parameter δ depends on how important social externalities are for effectiveness. When social externalities are unimportant, i.e. when $\delta = 0$, then effectiveness depends only on the member's personal characteristics, described by A_i. When instead social externalities are positive, $\delta > 0$, then the solution of (1) can be expressed in matrix notation as $\mathbf{b}(\boldsymbol{\delta}, \mathbf{G}, \mathbf{A}) = [I - \delta G]^{-1}\mathbf{A}$, where $\mathbf{b}(\boldsymbol{\delta}, \mathbf{G}, \mathbf{A}) = (b_1(\delta, G, A), ..., b_n(\delta, G, A))'$ and $\mathbf{A} = (A_1, ..., A_n)'$. In the political science literature, Battaglini and Patacchini [2018] have shown that legislators' ability to attract PAC contributions depends on their Katz-Bonacich centralities. In the following subsection, we will provide a formal model rationalizing why the Katz-Bonacich centralities are the relevant measure of centrality when studying the effectiveness of the member of Congress.

H3: *Effectiveness in Congress is positively correlated with the Katz-Bonacich Centrality of the member of Congress.*

A key question in our analysis is how effectiveness and the effect of social spillovers on effectiveness depends on the individual characteristics of the members Congress. There is an established literature that has studied the individual characteristics affecting legislative effectiveness. When studying the relationship between these characteristics and the social network in which the legislators operate, two natural hypotheses emerge. First, we expect to find the same qualitative results on the effect of individual characteristics of members of Congress, but if we do not explicitly include social spillovers in the analysis, then we may overestimate the importance of these characteristics. Some characteristics (such as party affiliation, being a committee chair, seniority) have both direct and indirect effects on effectiveness, since they are also determinants of social connections. If, therefore, we ignore social connections, then we may obtain estimates that incorporate the indirect effects in the direct estimates.

H4: *When social spillovers are considered, the effect of individual characteristics of members of Congress on legislative effectiveness is expected to be qualitatively the same as in analyses without social spillovers. Ignoring social spillovers, however, may lead to an overestimation of individual effects.*

The second question regarding legislators' heterogeneity concerns how the importance of social ties depends on the characteristics of the legislators.

H5: *Underrepresented groups have a higher marginal benefit from an increase in social connections.*

The predictions here, however, depend on the nature of the social interactions, and a variety of other effects can also prevail. For example, it is possible that the marginal effect of social connections is independent from the characteristics of the legislator. It is also possible that the marginal effect of a social connection is higher precisely for those legislators who are in the majority and dominate the legislative process.

A final important question concerns the types of social connections that matter for the members of Congress. By working across party lines, legislators are able to expand their sphere of influence beyond those who are already predisposed to support them. Kirkland [2011] provides a theory of how this process might work. The foundations for this line of research were laid by Granovetter [1973], who explores the role of infrequent but meaningful relationships in social networks. Kirkland's theory posits that, in the cosponsorship network, legislators are linked to colleagues who commonly support the same pieces of legislation because of factors like ideology, party, and demographics, and to other Congress members that are less similar to them, with whom they sometime cooperate for specific policy goals. In the repeated interaction with similar colleagues, a Congress member forms strong ties in the cosponsorship network. These strong ties represent the base of support of a legislator: those who would back the legislator's agenda even if they were not linked by a strong tie. At the same time, legislators establish weak ties with whom they have sporadic interactions. According to Kirkland [2011], weak ties are crucial for increasing legislative success because they allow a legislator's influence to spread beyond his or her base of support.

H6: *Weak ties are more important than strong ties in determining the effectiveness of members of Congress.*

2.2 A formal framework

Consider a Congress comprised of n legislators, where $\mathcal{N} = \{1, ..., n\}$ is the set of legislators. Each legislator has a pet legislative project that she/he wants to implement. The goal of each legislator is to maximize her/his legislative effectiveness, measured by the probability of implementing the project. We assume that legislator i's legislative effectiveness E_i is a function of i's characteristics, her/his effort and the legislative effectiveness of all the legislators that i has befriended. This may allow i to conscript j to her/his own cause. Specifically, we assume:

$$E_i = A_i + \varphi\sqrt{\sum_j g_{i,j} E_j} \cdot l_i \tag{2}$$

Equation (2) represents the "production function" for legislative effectiveness. The first term, A_i, is a fixed effect idiosyncratic to i. This term may include a variety of characteristics that have been highlighted in the existing literature as important for effectiveness: the legislator's seniority (Volden and Wiseman [2009], for example), sex and race (potentially in the presence of discrimination) and the legislator's position in the committee system and party hierarchy (Anderson et al. [2003], Cox and Terry [2008], for example). The second term, which is new in our model, captures the importance of social connections. The social network is described by a $n \times n$ matrix G with the generic element $g_{i,j}$ that measures the strength of the social influence of legislator j on legislator i. In (2), we assume that there is a complementarity between i's effort l_i and the effectiveness of the legislators in i's social circle, as measured by the weighted average of the effectiveness of the legislators with whom i has a social link. We normalize the social weights so that $g_{i,j} \in [0,1]$ for any i, j and $\sum_i g_{i,j} = 1$ for any i. This normalization simply means that legislator j has a total budget of resources to "help" connected colleagues: it is presumable that a legislator with many connections will have less time per connection. Assuming that effectiveness takes a value in $\left[0, \bar{l}\right]$ for some $\bar{l} > 0$, it is easy to see that a sufficient condition for $E_i \in (0,1)$ is that $\overline{A} + \varphi\bar{l} < 1$, an assumption that we will maintain throughout the analysis, where $\overline{A}$ is the upper bound on A_i.

A strategy for a legislator is described by a function $l_i : \mathcal{T} \rightarrow [0,1]$, mapping i's type A_i to an effort level. We assume that when the floor opens for business, each legislator i chooses her/his own level of effort l_i simultaneously, taking as given the social network and her/his own expectations of the other legislators' effectiveness. Given this, the levels of effectiveness are endogenously determined by (2). In the online appendix (Section 1, pg. 1) we prove the following result:

Proposition 1. *There is a unique equilibrium in which legislator i's legislative effectiveness* is *equal to*

$$b_i(\varphi^2/2, G, \mathbf{A}) = [I - \left(\varphi^2/2\right) \cdot G]^{-1}\mathbf{A}, \tag{3}$$

that is the weighted Katz-Bonacich centrality of legislator i in network G with discount factor $\varphi^2/2$ *and weights* $A = (A_1, ..., A_n)'$.

From a theoretical point of view, a key novelty in the analysis presented above is the fact that legislators choose the optimal legislative effort l_i taking as given their rational expectations of the other legislators' levels of effectiveness. This approach is similar to that in general equilibrium theory in economics where consumers choose their optimal consumption taking prices as given: here legislators choose their levels of effort taking the other legislators' centralities as given. As in general equilibrium theory (where prices are endogenous since they need to clear markets), here the levels of effectiveness are endogenous since they must satisfy the externality equation (2) given the optimal effort levels.

When there are no social spillovers (i.e., $\varphi = 0$), Proposition 1 tells us that legislative effectiveness is determined exclusively by the individual characteristics of legislators:

$$(E^1(G, \mathbf{A}), ..., E^T(G, \mathbf{A}))' = \mathbf{A}.$$

In the presence of social spillovers among connected legislators (i.e. $\varphi > 0$), however, the effectiveness of any legislator depends on the characteristics of all other legislators, with each legislator weighted using their distance in the network (the weights given by the rows of $[I - (\varphi^2/2) \cdot G]^{-1}$). The standard model is nested as a special case of the more general model (with $\varphi = 0$), and so we are able to test if social connections improve the fit of our estimates of $\mathbf{E}$.

2.3 Empirical Model

Assume that we observe data from $\bar{r}$ Congresses $r = \{1, ..., \overline{r}\}$, each comprised of n Congress members and characterized by a network $G_r = \{g_{i,j,r}\}$. Moreover, assume the vector of characteristics of legislators in Congress r, $\mathbf{A}_r = (A_{1,r}, ..., A_{n,r})'$, is a linear function of a vector of Congress member i's characteristics in Congress r:

$$\mathbf{A}_r = \alpha + X_r \boldsymbol{\beta} + \boldsymbol{\varepsilon}_r, \tag{4}$$

where $\boldsymbol{\varepsilon}_r = (\varepsilon_{1,r}, ..., \varepsilon_{n,r})'$ is a vector of i.i.d. shocks, $\boldsymbol{\beta} = (\beta_1, ..., \beta_k)'$ is a vector of coefficients and α is a constant term. Given (4), the model prediction (3) for Congress r can be represented as:

$$\mathbf{E}_r = \alpha + \phi \cdot G_r \mathbf{E}_r + X_r \boldsymbol{\beta} + \boldsymbol{\varepsilon}_r \tag{5}$$

where, for simplicity we denote $\phi = \varphi^2/2$. System (5) is a spatial autoregressive system that can be easily estimated given G_r and $\mathbf{X}_r$. When bringing this model to the data, however, we face a key challenge: the social network G_r is likely endogenous and determined by variables that also affect $\mathbf{E}_r$. If these characteristics are omitted in X_r or are unobservable, then the estimation results are biased.

To address this concern, we implement a Heckman correction of (5) with a two-stage estimation strategy. The idea is to explicitly account for a possible correlation between unobserved factors driving network formation and outcomes. Identification in Heckman selection models is notoriously difficult, especially in environments like ours in which networking in Congress is driven by the goals of the politicians. We therefore rely on an original instrument: the network of the legislators' alumni connections. These connections offer an instrument which rests on plausible assumptions: the network is exogenous to the political process, but still relevant even many years after the Congress members attend school (a fact that is well known in general and that we will document for our specific case below).[7]

For the first step, we estimate a standard dyadic model of link formation (see, e.g., Fafchamps and Gubert [2007)]).[8] When used in our context, the link $g_{i,j,r}$ between two Congress members i and j in Congress r is explained by distances between i and j in terms of characteristics according to the model:

$$g_{i,j,r} = \delta_0 + \delta_1 w_{i,j,r} + \sum\nolimits_l \delta_{l+1} |x_{i,r}^l - x_{j,r}^l| + \eta_{i,j,r}, \tag{6}$$

where $x_{i,r}^l$ for $l = 1, ..., L$ are i's characteristics and $w_{i,j,r}$ denotes connections in the alumni network. The link $g_{i,j,r}$ is equal to the number of i's bills cosponsored by j over the total

[7] Observe that the Heckman selection model would be identified even without exclusion restrictions. Identification, in this case, exploits non-linearities specific to the network structure of our model. The dyad-specific regressors used in the first stage (the network formation stage) are expressed in absolute values of differences: these differences in characteristics do not appear in the outcome equation.

[8] To check for robustness, in Section 5 we also present results from an alternative approach based on Exponential Random Graphs.

number of bills cosponsored by j; and the link $w_{i,j,r}$ between two Congress members i and j in Congress r is equal to the number of educational institutions attended by both i and j within four years from each other over the total number of institutions attended by j.[9]

As standard in the literature on dyadic link formation, we assume:

Assumption 1. *Assume that* $\varepsilon_r = (\varepsilon_{1,r}, ..., \varepsilon_{n,r})'$ *and* $\eta_r = (\eta_{i,1,r}, ..., \eta_{i,n,r})'$ *are jointly normal with* $E(\epsilon_{i,r}^2) = \sigma_\epsilon^2$, $E(\epsilon_{i,r}\eta_{i,j,r}) = \sigma_{\epsilon\eta}$ *for all* $i \neq j$, $E(\eta_{i,j,r}\eta_{ik,r}) = \sigma_\eta^2 \; \forall j = k$, *and* $E(\eta_{i,j,r}\eta_{i,k,r}) = 0 \; \forall j \neq k$.

Assumption 1 implies that the selection effect (i.e. the correlation between unobservable characteristics determining link formation and unobservable characteristics driving the outcome as measured by $\sigma_{\epsilon,\eta}$) is the same for all politicians. Under Assumption 1, it can be shown that the expected value of the error term conditional on the link formation is $E(\epsilon_{i,r}|\eta_{i,1,r}, \ldots, \eta_{i,n-1,r}) = \psi \cdot \sum_{j\neq i} \eta_{i,j,r}$, where $\psi = \sigma_{\epsilon\eta}/\sigma_\eta^2$. It follows that our model can be written as:

$$\mathbf{E}_r = [I - \phi G_r]^{-1} \cdot [\alpha \cdot \mathbf{1} + X_r\boldsymbol{\beta} + \psi\boldsymbol{\xi}_\mathbf{r} + \boldsymbol{\varepsilon}_r] \tag{7}$$

where $\xi_{i,r} = \sum_{j\neq i} \eta_{i,j,r}$ with $\boldsymbol{\xi}_\mathbf{r} = (\xi_{i,r}, ...\xi_{n,r})'$. The term $\psi\boldsymbol{\xi}_\mathbf{r}$ now captures the selection bias.

An advantage of model (7) is that it allows us to control for the presence of *individual-level unobserved factors*. As discussed in the introduction, a politician's intrinsic ability is a prominent example. More able politicians who are more effective may be more likely to attract cosponsors and may also have attended a more prestigious school. Another example may be unobserved features of the educational institutions attended by i. The term $\xi_{i,r}$ includes *all unobserved characteristics* of legislator i that help explain her/his connections in (6).

[9] Since most universities make significant efforts to connect alumni graduating in nearby cohorts, we also consider a network link definition based on an eight year time window. Results are qualitatively unchanged, and available upon request.

For a sample of n agents at each Congress r, stack the data by defining $E = (E_1', \cdots, E_{\bar{r}}')'$, $\epsilon = (\epsilon_1', \cdots, \epsilon_{\bar{r}}')'$, and $\alpha = (\alpha_n', \cdots, \alpha_n')'$ as a $n\bar{r}$-dimensional vectors, $X = (X_1', \cdots, X_{\bar{r}}')'$ as a $n\bar{r} \times k$ matrix, and $G = \text{diag}\{G_r\}_{r=1}^{\bar{r}}$ as a $n\bar{r} \times n\bar{r}$ matrix. For the entire sample, the model is:

$$\mathbf{E} = [I - \phi G]^{-1} \cdot [\alpha \cdot \mathbf{1} + X\boldsymbol{\beta} + \psi\boldsymbol{\xi} + \boldsymbol{\varepsilon}] \tag{8}$$

Given the social network G, the covariates $\mathbf{X}$ and the correction $\boldsymbol{\xi}$, we can estimate the parameters of interest ϕ, α, $\boldsymbol{\beta}$, and ψ by nonlinear Least squares (NLLS) using (8).[10]

Inference is complicated because the selectivity term $\boldsymbol{\xi}$ is a generated regressor from a previous estimation and no closed form solution is available for the NLLS standard error estimates in a network context. We use bootstrapped standard errors with 500 replications. Because of the inherent structural dependency of network data, the design of the resampling scheme needs special consideration. The residuals in the vector $u = \left[I - \widehat{\phi}G\right]^{-1} \boldsymbol{\varepsilon}$ in (8) are not i.i.d., and thus one cannot sample with replacement from this vector. We thus use the residual bootstrap procedure in spatial econometrics (e.g., Anselin [1990]) where resampling is performed on the structural errors $\boldsymbol{\varepsilon}$, since they are assumed to be i.i.d. (see model (5)).[11]

3 Data

We measure each Congress member's legislative performance using the Legislative Effectiveness Scores (LESs) for members of the U.S. House of Representatives, developed by Volden and Wiseman [2009]. Each representative's score is based on how many bills each legislator introduces, as well as how many of those bills receive action in committee, pass

[10] An OLS estimation of this system would not be consistent because of the simultaneity which is endemic in spatial autoregressive models (see, e.g., Anselin [1988]).

[11] In practice, having in hand the residual vector u, the vector of structural errors are derived from $\boldsymbol{\varepsilon} = \left[I - \widehat{\phi}G\right] u$. They are resampled Congress by Congress.

out of committee and receive action of the floor of the House, pass the House, and ultimately become law. Data are available online from the Legislative Effectiveness Project (http://www.thelawmakers.org). We use information from five recent election cycles: from the 109th Congress (election cycle 2004) to the 113th Congress (election cycle 2012).

In line with existing theories of Congressional politics, Volden and Wiseman [2009] argue that legislative effectiveness is a function of innate abilities, a cultivated set of skills and institutional positions. The Legislative Effectiveness Project thus provides data on the legislators' observed characteristics that are theoretically important for lawmaking effectiveness. Nine factors are identified. The first one is the number of years served as a member of the Congress. As legislators spend more time in Congress, they are expected to become better, and more effective, at lawmaking.

Consistent with the acquisition of skills over time, the second factor is previous legislative experience. Legislators who have previously served in the state legislatures may be more effective than legislators without similar experiences.

The subsequent three factors (party influence, committee influence, and legislative leadership) capture the effect of institutional positions on the legislative process. The bills endorsed by Congress members in prestigious institutional positions are more likely to receive attention by their own (and other) parties and committees. By the same reasoning, committee chairs and members of the most powerful committees (Appropriation, Budget, Rules and Ways and Means) could also have greater legislative effectiveness. Volden and Wiseman [2009] find that the high level of effort required by the members of these committees, however, results in a number of endorsed bills which is lower than the average House member, thus making the relationship with their LES scores negative. Party leadership is also an important variable, with opposite effects for leaders of the majority or minority party. Majority party leaders are more likely to receive attention and have their bills pass the House. Minority Party leaders, in contrast, find it more difficult relative to other members of their party. Being Speaker of the House may also result in less effectiveness, given that the LES score is based on how far legislators' bills advance in the legislative process and the Speaker traditionally introduces few, if any, bills.

The sixth factor captures ideological considerations. The Legislative Effectiveness Project data is merged with the Vote View project data (http://voteview.com). It provides data on legislators' preferences for extreme or moderate policies. These preferences are captured by the absolute value of the first dimension of the *DW-nominate score* created by McCarty et al. [1997], which measures a legislator's distance to the center in terms of ideology. A number of legislative politics studies suggest a negative correlation between this variable and legislative success, reflecting the idea that moderate policies obtain a larger consensus among the members of the House (see, e.g. Krehbiel [1992], Wiseman and Wright [2008]).

The seventh factor captures the demographic characteristics of members in Congress. The experiences of female and ethnic minority legislators in terms of effective lawmaking are different from the average Congress member, though the existing literature has not reached a consensus about the sign and the sources of these differences (Jeydel and Taylor [2003]; Volden and Wiseman [2009]; Volden et al. [2013]).

The eighth factor is the size of the Congressional delegation, which counts the number of districts in the state Congressional delegation (and thus the number of Congress members in the House from the same state). Legislators coming from larger Congressional delegations may be more effective since they can find coalition partners among the members of their delegations. In contrast, the presence of more legislators interested in the same issues (the interests of the state) may result in a lower number of bills advanced in the legislative process for each legislator.

The last factor is electoral competition, as measured by the margin of victory. If voters value politicians' legislative effectiveness, then one would expect a positive relationship between legislators' levels of effectiveness and their margins of victory. The existence and sign of this relationship, however, is still a matter of debate. It is possible that vulnerable legislators spend their energy on campaigning, while legislators in safe districts commit more time to the lawmaking process (see, e.g. Volden and Wiseman [2009]).

Our analysis considers all of the legislator characteristics indicated in the Legislative Effectiveness Project. The control set X_r in model (8) includes the number of years spent in Congress, margin of victory, DW-ideology, the size of the state Congressional delegation, party, chairmanship, majority and minority party leadership, whether the Congress member is the Speaker of the House, gender and race. Because the information on previous legislative experience is missing for a large share of politicians (more than 20%), we add this control as a robustness check in Section 2.2 (pg. 2) of the online appendix for the subsample of Congress members for whom the variable is available. The information on committee membership is also exploited in that section. While Volden and Wiseman [2009] use a dummy variable capturing membership in the most powerful committee, we include a full set of committee fixed effects as a robustness check. Members of the same committee who work on the same topic are likely to be connected in our network since they likely cosponsor the same bills and also likely to have similar LES scores. The committee fixed effects control for these common shocks.

We construct a legislative network using data on cosponsorship from the Library of Congress data information system, THOMAS (http://thomas.loc.gov). We define two members of Congress as linked if they have cosponsored the same bill. Each network includes roughly 433 Representatives (including midterm replacements). As a result, we obtain a sample of 2,176 connected Congress members. Figure 1 illustrates the cosponsorship network of the 113th U.S. Congress where each node corresponds to a politician and the size of the node is proportional to her/his LES.[12]

[12] The layout of the network was generated by the algorithm lgl (large graph layout) implemented in the R package "igraph." To make the picture clearer, we are plotting a link only for $g_{i,j}$ that are in the top

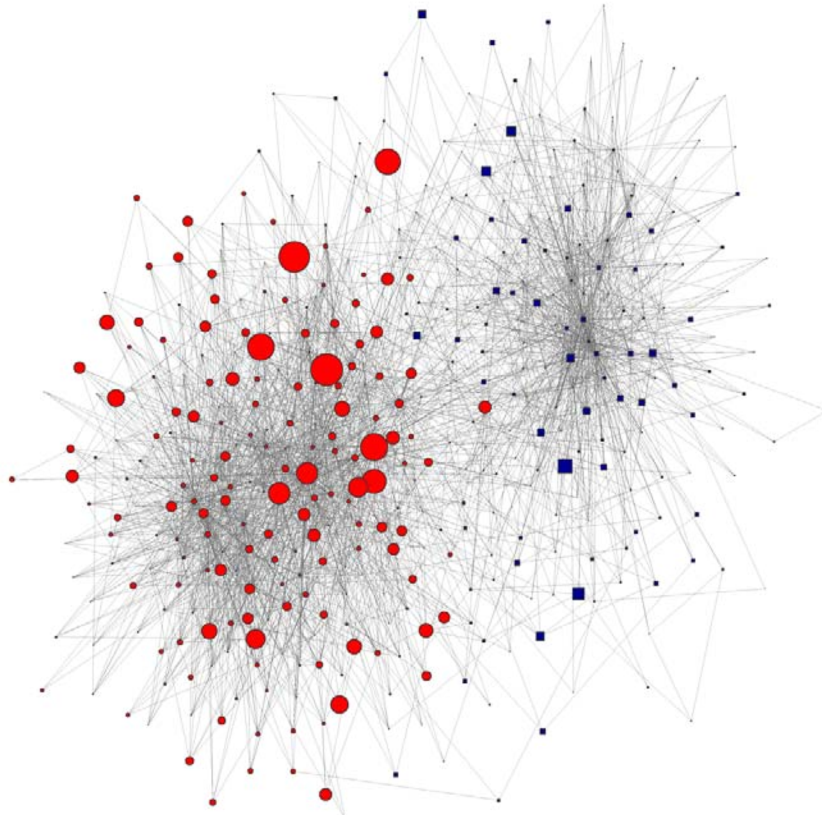

Figure 1: Legislative effectiveness and the cosponsorship network in the 113th Congress. Republicans are represented by circles, Democrats by squares.

We obtain information on high schools and higher education institutions attended for both undergraduate and graduate degrees from the Biographical Directory of the United States Congress (available online at http://bioguide.Congress.gov/biosearch/ biosearch.asp) and construct a membership network based on educational experience.[13] A tie between

5% in terms of weight (number of cosponsored bills). Effectiveness levels are larger for Republicans because they constitute the majority in this Congress.

[13] We use academic institutions attended for both undergraduate and graduate degrees. In dealing with multiple campuses, we matched each satellite campus as a separate university (e.g., University of California at Los Angeles, San Diego, and Berkeley are treated as separate universities). We match specialized schools to the university. We drop observations where a specialized school name could match multiple universities (e.g., School of Management).

two Congress members exists if they graduated from the same institution within four years of each other. Appendix Table A1 provides a detailed description of the variables used in this study, together with summary statistics for our sample.

4 Estimation Results

We begin our empirical analysis by showing that the alumni networks are still relevant in the cosponsorship network even many years after the Congress member attended school. This exercise constitutes the formal "first step" of the approach described in Section 2.3. Column (1) of Table 1 presents the OLS estimation results of model (6) in which we include all the explanatory variables previously highlighted by the literature (see discussion in Section 3). We find that two politicians that attended the same educational institution are more likely to cosponsor the same piece of legislation than two politicians who attended different institutions or the same institution at different times, keeping constant similarities in terms of observed characteristics. In Column (2) of Table 1, we also include a variant of our model in which we control for school fixed effects, showing that the results remain qualitatively unchanged.

Table 2 presents the results of the "second step" in the two-step Heckman approach described in Section 2.3. The results are obtained using standard weighted least squares regressions that are detailed in the online appendix (Section 2.2, pg. 2).[14] As a benchmark, Column (1) reports the OLS estimates of the traditional model in which legislative effectiveness is explained using only legislators' characteristics (ignoring the fact that Congress members are connected). This is the specification used by Volden and Wiseman [2009]. Although we use more recent data, most of the estimates remain in line with their findings.

[14] Because in the first stage the politicians' individual characterstics are used with a functional form different than in the second stage, they all act as excluded variables. For this reason, in the last row of Table 2 we report the test for weak instruments in the case of multiple instruments proposed by Stock and Yogo [2005]. The test reveals no evidence of weak instrument problems.

Consistent with the recent evidence that women's legislative behavior does not differ from men's (Lawless et al. [2018]), we do not find statistical differences in the effect of gender on legislative success. The remaining columns provide evidence on the importance of network externalities. Column (2) presents the NLLS estimates of our model (equation (5)) using the cosponsorship network without controlling for network endogeneity. The estimates reveal a positive and statistically significant estimate of ϕ, which suggests the presence of externalities in line with hypothesis H1.

We formally test whether the model fit improves with the addition of network effects (relative to the traditional linear regression in which $\phi = 0$, in Column (1), Table 2) using a partial F-test.[15] The F-test rejects the hypothesis that the model with $\phi \neq 0$ does not provide a significantly better fit than the model with $\phi = 0$ (F value 350.95, $p < 0.01$). This evidence supports hypothesis H2. Column (3) presents the estimation results when controlling for network endogeneity (equation (7)), using the residuals from equation (6) in Column (1) of Table 1. It appears that the estimate of the selection correction term is statistically significant and negative. This is consistent with the presence of unobservable characteristics that are positively correlated with, legislator i's legislative effectiveness, but negatively correlated with variables that affect other legislators' inclinations to cosponsor bills proposed by i (or vice versa). For example, i may have a very specialized knowledge, so sponsors only few bills, but very effectively. The partial F-test comparing the fit of the model without correction versus the fit of the model with correction shows that the fit further improves when adding the correction (F value 59.42, $p < 0.01$). The important result here is that the estimate of our target parameter ϕ maintains its statistical significance and positive sign, confirming H1 (and H2).

[15] Let RRS_1 define the residual sum of squares of the unrestricted model [Column (1)] and p_1 the number of parameters. Let RRS_2 the residual sum of squares of the restricted model [Column (2)], and p_2 the number of parameters. The partial F-test statistic $F = [(RRS_1 - RRS_2)/p_1 - p_2]/(RRS_1)/n - p_1$ will have an F distribution with $(p_1 - p_2, n - p_1)$ degree of freedom.

Finally, Column (4) presents the estimation results using the correction for network endogeneity when adding in the network formation model school fixed effects (Table 1, Column (2)). The results show that the evidence remains qualitatively unchanged, confirming that our target parameter ϕ is positive and statistically significant.

The coefficients on most of the control variables retain the same sign and statistical significance across models, Column (1)-Column (4). However, the interpretation and magnitude of these effects differ. Indeed, if $\phi > 0$ (in model (7)), then the marginal effect of the k-th covariate is not β_k, but $(I - \phi G)^{-1}(I\beta_k)$, which is an $n_r \times n_r$ matrix with its (i, j)-th element representing the effect of a change in x_{jk} on y_i. The important difference is that the marginal effects are heterogeneous across individuals, since they depend on the individual's position in the network. In Table A1 in the online appendix, we show the magnitudes of the diagonal elements of this matrix and compare them with the OLS marginal effects. As conjectured in hypothesis H4, the evidence presented in this table suggests that traditional estimates of the effects of these characteristics on legislative effectiveness which ignore those externalities risk overstating their importance by omitting a relevant variable, social connectedness.

In Section 2.2 of the online appendix (pg. 2), we present different specifications of model (7) as robustness checks. Since the data generating process for the DW-nominate score is roll call votes and the bills that become law (and thus included in the computation of the LES) are subject to roll calls, we remove the DW-nominate score from the specification.[16] Next, we include in model (7) dummies for all the Congressional committees (21 dummies), and a control for politicians' previous legislative experience.[17] The estimation results for these model specifications are presented in Table A2 of the online appendix. The estimated

[16] We should note, however, that only a minimal part of the bills considered in the construction of LES arrives to the floor, and thus it is affected by roll call votes (approximately 3%).

[17] This is one of the nine factors indicated by Volden and Wiseman [2009] as drivers of legislative effectiveness. The Legislative Effectiveness Project dataset, however, does not report this information for about 20% of the politicians in our sample. Therefore, we did not include it in our previous analysis to preserve the sample size.

externality remains positive and statistically significant in all cases, indicating that our evidence of network effects is not driven, for example, by common shocks at the level of the committee. Details of these robustness checks are contained in Section 2.2 of the online appendix (pg. 2).

In Table A3 in the online appendix, we compare the explanatory power of our theory-driven centrality measure with standard centrality measures. The results show that the measure of network externality supported by Proposition 1 has the highest explanatory power, supporting hypothesis H3. Additional details on this exercise are contained in Section 2.3 of the online appendix (pg. 4).

In the previous analysis, we have assumed that the network externality is described by a single parameter, φ, that is the same for all agents. However, it is plausible to assume that network externalities are heterogeneous. For example, the degree to which an agent is "useful" to others may depend on whether or not the agent is a committee chair or has high seniority. The ability to "use" other legislators may also be heterogeneous. By extending the model to allow for these effects, we can study the determinants of these heterogeneous social externalities (which may be an important component of power in Congress). In Section 2.4 of the online appendix (pg. 5), we describe a new general methodology to study these heterogeneous social effects. In line with hypothesis H4, Table 3 shows that ethnic minorities appear to benefit more than the average Congress member from social interactions, whereas Congress members with higher seniority and committee chairs receive fewer benefits from interacting with others than other members of Congress. The results for the remaining characteristics are reported in Table A5 of the online appendix.

An important political factor which deserves special attention is the role of parties in fostering or hindering social connections among legislators. For example, is it more useful for a Republican to befriend a fellow Republican or to befriend a Democrat? A natural conjecture is that intraparty connections are more useful than interparty connections, especially in the polarized landscape that has developed in Congress since the 1970s. However, having some support from the other party may be essential to advance bills through the legislative process. Addressing this question is paramount for understanding the role of social connections in Congress. In Section 2.5 of the online appendix (pg. 7) we provide a decomposition of the estimate of the social spillover between legislators from the same party and legislators from different parties. Table A6, Column (1) in the online appendix shows that the two estimates are very similar in magnitude (and the difference is not statistically significant), indicating that connections with those outside one's own party are as important as connections within one's own party. This evidence supports the hypothesis that more effective legislators are those able to find support also from outside their own party. It is interesting to note that the increasing polarization of politics in the U.S. Congress since the 1970s was paired with a drastic reduction in its aggregate productivity (see, for example, Mann and Orstein [2016] on this). Our results may contribute to an understanding of why the increase in polarization has led to a reduction in aggregate productivity.

The fact that ties across parties are as important or even more important than ties within parties is in line with Kirkland's [2011] theory of the role of weak ties in Congress. In order to test this theory (summarized in hypothesis H6), in Section 2.6 of the online appendix (pg. 8) we split the cosponsorship network into a network of strong ties and a network of weak ties. To this goal we have adopted two definitions to qualify the strength of a tie. The first comes from Kirkland's work. We classify a strong tie as any connection between two legislators that is stronger than the mean strength of a connection plus one standard deviation (see Kirkland [2011]). The second definition is more directly inspired by Granovetter [1973] and it adds an additional requirement: the number of shared cosponsors of i and j has to be greater than the average number of shared cosponsors between each legislators' pair in a Congress, plus one standard deviation. The estimation results are reported in Columns (2) and (3) of Table A6 in the online appendix. The results show that when using the second definition

(Column (3)) weak ties have a 23.70% higher impact on legislator effectiveness than stronger ties. When using the first definition (Column (2)) the difference in the magnitude of the effects is small, but in both cases it is statistically significant. In line with Kirkland's theory (and hypothesis H6), this evidence points to the fact that weak ties between legislators are the most useful in increasing legislative success.

We conclude the analysis by studying two other potential determinants of the effect of social ties on legislative effectiveness: the presence of divided government; and the stage of the legislative process. First consider the role played by a divided government. With divided government, lawmaking naturally requires more time and energy. Mayhew [1991] started a literature investigating the consequences of the higher level of institutional friction associated with divided government. The natural question, so far not addressed by the literature, is the following: is networking more important when the cooperation of (a part of) the opposition party is needed to legislate? To answer this question, we have estimated a specification of our model where Congress fixed effects are replaced by a dummy variable equal to one for Congresses in which the party controlling the executive branch is different from the party controlling one or both the houses of the legislative branch (the 110th, 112th and 113th Congresses). The results of this analysis are reported in Table A6, Column (5), in the online appendix. They show no difference for the effect of personal relationships in shaping legislative effectiveness in divided and unified governments. Perhaps interesting, we also find a non-significant effect of being in a divided government on legislative effectiveness. These results are in line with the view that divided government is neutral on legislative productivity (Conley [2007]; Mayhew [1991]).

To study the role of legislative stages, in Section 2.7 of the online appendix (pg. 9) we present an analysis of the effect of the social network for different legislative stages following the classification by Volden and Wiseman [2009]. The results of the analysis are summarized in Table A7 in the online appendix. They show that network effects are positive and significant for all stages of the legislative process. Interestingly, looking at the control variables one can see that the characteristics making legislators effective change along the stages of the legislative process. More senior representatives, committee chairs, and minority leaders acquire a sizable importance premium at a later stage of the legislative process. Legislators with more extreme ideologies are more active in proposing bills, but their extremism does not help in advancing those bills through the legislative process. Finally, we observe that females are more penalized in the early stages.

5 Using Exponential Random Graph Models in the First Step

One limitation of the approach presented above is that it does not include important structural network characteristics in the estimation of the social network in the first step. In the linear model, it is indeed not possible to incorporate all complex higher order effects (such as the propensity to form ties between individuals sharing one or more contacts, or a different likelihood to form new ties for low and high degree nodes). From an econometric point of view, this is not a problem in our analysis. Indeed, we do not need the most accurate estimates of the drivers of link formation in our first step: we just need the residuals because they capture omitted variables that may bias the estimates in the second step. This, as shown in Section 2.3, guarantees consistent estimates.

Information on the structural characteristics of the network can be incorporated in the analysis if we use an Exponential Random Graph Model (ERGM) in the first step. An ERGM, however, does not give us a pointwise estimate of a network that can be used in the second step. Instead it provides an estimate of the probability distribution from which the observed network is likely to be drawn. Nonetheless, we can take advantage of ERGMs in a modified two-step approach as follows. Using an ERGM estimate of the distribution of networks, we can extract a vector of network realizations and use it to obtain an associated vector of estimates of the spillover effects. This procedure will not generate a pointwise estimate of the parameter of interest; it will however generate a distribution of estimates which will be informative of the true value. The distribution can be used to evaluate our key prediction that the social spillover as measured by ϕ is positive.

In the ERGM specification, the set of variables designed to capture key characteristics of the structural properties of the cosponsorship network are: *Geometric Weighted Edgewise Shared Partners* (GWESP) and the *Geometric Weighted In-Degree* (GWIDegree) variables (Hunter et al. [2006], Snijders et al. [2006]). GWESP is used to model transitivity effects (e.g. the propensity for i and j to have shared collaborators) controlling for diminishing marginal effects of additional shared cosponsors. GWIDegree measures the change in the likelihood given the degree of the nodes involved, but with marginally decreasing weighting as degree increases. It can be interpreted as a proxy of popularity effects in the network. Details regarding the implementation of the ERGM are discussed in Section 3 of the online appendix (pg. 10).

Figure 2 illustrates the distribution of estimated social spillovers (i.e. φ) from the vector of network realizations simulated as described above. The distribution in Figure 2 shows that all of the estimates are positive, consistent with the analysis of Section 4.[18]

A final concern that one may have is that in estimating the ERGM we are omitting some unobserved but relevant variable, a typical and unavoidable problem of ERGM analysis. A correction for this problem has been proposed by Box-Steffensmeier et al. [2018b], who suggested a generalization of ERGM, the Frailty Exponential Random Graph Model (FERGM) and a test to verify if a FERGM performs better than an ERGM. Using the test provided by Box-Steffensmeier et al. [2018b] we show that, in our specific application, the use of the ERGM provides a better fit than the FERGM. The results are reported in the online

[18] The ERGM estimates are in Table A7. Figure A1 displays a battery of Goodness of Fit tests (GOF, Hunter et al. [2008]) showing that the ERGM provides a good fit for the cosponsorship network.

appendix (Section 3, pg. 10).

6 Conclusions

This paper presents a simple theory of legislative effectiveness in which a legislator's performance depends not only on her/his own characteristics and effort, but also on the legislative effectiveness of the legislators with whom she/he has social connections. Using data from five recent Congresses, we structurally estimate this model and test for the importance of social connections in determining legislative effectiveness.

Consistent with the theory, we find that Congress members' weighted Katz-Bonacich centralities have a significant effect on their levels of legislative effectiveness. We find that ethnic minorities appear to benefit more than the average Congress member from social interactions, whereas Congress members with higher seniority and committee chairs receive less benefits from interacting with others than other members of the Congress. When we focus on the role of parties, we find that connections with those outside one's own party are as important as connections within one's own party, supporting the hypothesis that more effective legislators are those able to find support also from outside their own party. This reflects a more general phenomenon that weak ties among legislators are more important than strong ties in legislative effectiveness because they help with the forging of larger coalitions. For this too we find supporting evidence. Finally, we find that network effects are significant in all stages of the legislative process, but they appear to become more important in the later stages.

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TABLE 1. Network formation

	(1)	(2)
Link in Alumni network	4.0917*** (0.1736)	4.031*** (0.1698)
Gender (both female)	-0.1008*** (0.0102)	-0.0597*** (0.0109)
No White (both)	0.3892*** (0.011)	0.5275*** (0.0125)
Party (1 = Democrat)	2.1627*** (0.0098)	2.1747*** (0.0097)
Seniority	-0.0302*** (0.0011)	-0.0469*** (0.0012)
Vote Share	-0.4967*** (0.0209)	-0.6207*** (0.0211)
Distance to the Median	-1.5616*** (0.0263)	-1.4393*** (0.0273)
Size of Congr. Deleg.	-0.0173*** (0.0003)	-0.0216*** (0.0003)
Committee Chair (1 = Yes)	-0.6221*** (0.0165)	-0.5191*** (0.0172)
Majority Leader (1 = Yes)	-0.5418*** (0.0213)	-0.5188*** (0.0222)
Minority Leader (1 = Yes)	-0.1819*** (0.0216)	-0.1342*** (0.0226)
Speaker (1 = Yes)	0.5585*** (0.0757)	0.3841*** (0.0783)
Congress fixed effects	Yes	Yes
School fixed effects	No	Yes
R2	0.0800	0.1218
N. Obs.	945,382	945,382

Notes. The dependent variable is defined as the number of *i*'s bills cosponsored by *j* over the total number of bills cosponsored by *j* (multiplied by thousands). OLS estimated coefficients are reported. An intercept is included. Standard errors (in parentheses) are clustered by dyad. *, **, *** indicate statistical significance at the 10, 5 and 1 percent level.

TABLE 2. Main estimates

	Dep. Var.: Legislative Effectiveness Score (LES)			
	(1)	(2)	(3)	(4)
Φ		0.4447***	0.8321***	0.5788***
		(0.0344)	(0.0559)	(0.0709)
Gender (1=Female)	0.0128	-0.0255	-0.0304	-0.0256
	(0.0493)	(0.0669)	(0.0769)	(0.0788)
No White (1=Yes)	-0.1643**	-0.1588*	-0.1089	-0.1313
	(0.0577)	(0.0836)	(0.0912)	(0.0895)
Party (1 = Democrat)	-0.2762***	-0.1791**	-0.1173	-0.1632*
	(0.0605)	(0.0837)	(0.1065)	(0.0927)
Seniority	0.0251***	0.0177	0.0228**	0.0153
	(0.0052)	(0.0109)	(0.0108)	(0.0104)
Vote Share	0.2193**	0.0780	-0.0013	0.0420
	(0.0877)	(0.1096)	(0.1290)	(0.1149)
Distance to the Median	-0.4084**	-0.4232**	-0.3208*	-0.4058**
	(0.1276)	(0.1730)	(0.1869)	(0.1737)
Size of Congr. Deleg.	-0.0048***	-0.0048**	-0.0034	-0.0041**
	(0.0011)	(0.0017)	(0.0021)	(0.0018)
Committee Chair (1 = Yes)	1.9669***	1.8693***	1.6109***	1.8212***
	(0.1146)	(0.1624)	(0.1533)	(0.1414)
Majority Leader (1 = Yes)	0.4083**	0.1820	-0.0483	0.1248
	(0.1250)	(0.1667)	(0.1706)	(0.1657)
Minority Leader (1 = Yes)	-0.3910***	-0.3972**	-0.2937*	-0.3946**
	(0.1143)	(0.1845)	(0.1780)	(0.1670)
Speaker (1 = Yes)		0.4447***	0.8321***	0.5788***
		(0.0344)	(0.0559)	(0.0709)
Unobservables (ξ)			-0.4129***	-0.1590**
			(0.0734)	(0.0697)
Intercept	0.9976***	0.6933***	0.2540*	0.5722***
	(0.0937)	(0.1171)	(0.1468)	(0.1246)
Congress fixed effects	Yes	Yes	Yes	Yes
Partial F-test		350.95***	59.42***	8.80***
[p-value]		[2.2e-16]	[1.9e-22]	[0.0006]
F-Test Weak Instrument			5138,5**	434.3**
[p-value]			[< 0.05]	[< 0.05]
N. Obs.	2,176	2,176	2,176	2,176

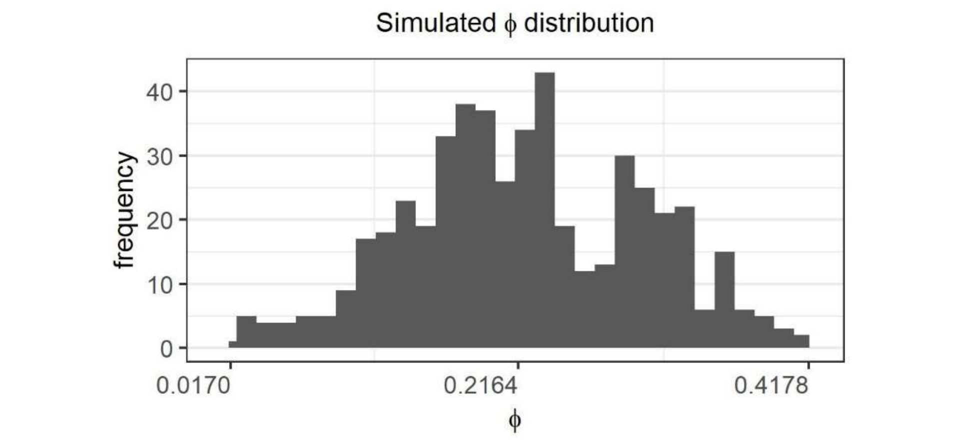
Notes. NLLS estimated coefficients are reported in columns (2) - (4). OLS estimated coefficients are reported in column (1). Robust standard errors (in parentheses) are reported in column (1). Robust standard errors in columns (2) - (4) are bootstrapped with 500 replications. A precise definition of control variables can be found in Table A1 in the appendix. *, **, *** indicate statistical significance at the 10, 5 and 1 percent level. The partial F-test in column (2) shows the goodness of fit of the model in column (2) vs column (1). The partial F-test in column (3) shows the goodness of fit of the model in column (3) vs column (2). The partial F-test in column (4) shows the goodness of fit of the model in column (4) vs column (3). The F-Test for Weak Instruments in columns (3) and (4) compares the residual sum of squares of the first stage of respectively the model in column (3) (column (1) in Table 1) and the model in column (4) (column (2) in Table 1) with and without the excluded instruments. In the case of multiple instruments, the distribution of the test is nonstandard. The critical values are tabulated in Stock and Yogo [2005].

TABLE 3. Heterogeneous effects

	Dep. Var.: Legislative Effectiveness Score (LES)					
	Non-white (1 = Yes)		Seniority		Committee Chair	
	φ	η	φ	η	φ	η
	(1)	(2)	(3)	(4)	(5)	(6)
θ_0	0.8532***		0.6170***		0.7860***	
	(0.0559)		(0.0907)		(0.0472)	
θ_1	0.1583*		-0.0338**		-0.5977***	
	(0.0899)		(0.0120)		(0.1564)	
γ_0		0.8429***		0.7192**		0.6727***
		(0.0936)		(0.2715)		(0.2020)
γ_1		0.0733		-0.0159		-0.4448
		(0.3983)		(0.0340)		(0.4941)
Gender (1=Female)	-0.0417	-0.0304	-0.0346	-0.0320	-0.0279	-0.0255
	(0.0809)	(0.0874)	(0.0892)	(0.0952)	(0.0884)	(0.0876)
No White (1=Yes)	0.0300	-0.1032	-0.1064	-0.1063	-0.1070	-0.1226
	(0.1028)	(0.0893)	(0.1059)	(0.1022)	(0.1031)	(0.0960)
Party (1 = Democrat)	-0.1176	-0.1079	-0.1418	-0.1393	-0.1222	-0.1153
	(0.0981)	(0.0950)	(0.1069)	(0.0961)	(0.0952)	(0.1055)
Seniority	0.0225**	0.0229**	-0.0024	0.0216**	0.0234**	0.0228**
	(0.0099)	(0.0097)	(0.0115)	(0.0105)	(0.0100)	(0.0108)
Vote Share	-0.0089	0.0024	0.0154	-0.0027	0.0243	0.0035
	(0.1135)	(0.1115)	(0.1219)	(0.1307)	(0.1189)	(0.1210)
Distance to the Median	-0.3297*	-0.3151	-0.3235*	-0.3274*	-0.3412*	-0.3295
	(0.1804)	(0.1919)	(0.1844)	(0.1935)	(0.1767)	(0.2260)
Size of Congr. Deleg.	-0.0034*	-0.0034*	-0.0035*	-0.0036*	-0.0039*	-0.0040*
	(0.0019)	(0.0020)	(0.0020)	(0.0019)	(0.0020)	(0.0021)
Committee Chair (1 = Yes)	1.6228***	1.6102***	1.5225***	1.6108***	0.8205***	1.6080***
	(0.1493)	(0.1520)	(0.1598)	(0.1581)	(0.2225)	(0.1633)
Majority Leader (1 = Yes)	-0.0598	-0.0506	-0.0514	-0.0479	-0.0360	-0.0371
	(0.1754)	(0.1613)	(0.1717)	(0.1852)	(0.1634)	(0.1737)
Minority Leader (1 = Yes)	-0.3170*	-0.2946	-0.2759	-0.2944	-0.3051*	-0.2871
	(0.1769)	(0.1822)	(0.1825)	(0.2012)	(0.1815)	(0.1828)
Speaker (1 = Yes)	-1.0365	-1.2595	-1.2844	-1.3573	-1.3041	-1.1568
	(0.9492)	(0.9706)	(0.9877)	(0.9531)	(0.8990)	(0.8855)
Unobservables (ξ)	-0.3891***	-0.4142***	-0.4248***	-0.4106***	-0.4194***	-0.3332**
	(0.0612)	(0.0823)	(0.0710)	(0.0836)	(0.0697)	(0.1238)
Intercept	0.2371*	0.2388	0.4126**	0.2840**	0.2931**	0.3513*
	(0.1341)	(0.1572)	(0.1529)	(0.1445)	(0.1353)	(0.1863)
Congress fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
N. Obs.	2,176	2,176	2,176	2,176	2,176	2,176

Notes. NLLS estimated coefficients and standard errors (in parentheses) are reported. Standard errors are bootstrapped with 500 replications. A precise definition of control variables can be found in Table A1 in the appendix. *, **, *** indicate statistical significance at the 10, 5 and 1 percent level. According to the theoretical equation (4) in the online appendix, θ_0 and θ_1 indicate the ability of the legislator to "use" the effectiveness of her/his socially connected peer, while γ_0 and γ_1 indicate the usefulness of the effectiveness a legislator to her/his socially connected peers.

Figure 2. Estimated Network effect using ERGM



Notes. The figure reports the distribution of the spillover effects (Φ) when using the estimates from Table A8 in the online appendix. Ticks on the X-axis show minimum, median and maximum values for Φ.

APPENDIX

Table A1: Summary Statistics

	Variable Definition	Mean	St. Dev
Legislative success rate (LES)	Weighted average of the number of bills introduced, that received any action in committee and beyond committee, passed the House, and became law, sponsored by a Congress member. It differentially weights commemorative, substantive and significant legislation. Created by Volden C. and Wiseman A. E. (2014).	1.0081	1.4700
Gender (1=Female)	Dummy variable taking value of one if the member of Congress is female.	0.1723	0.3778
No White (1=Yes)	Dummy variable taking value of one if the member of Congress is Afro-American or Latino, and zero otherwise.	0.1388	0.3458
Party (1 = Democrat)	Dummy variable taking value of one if the member of Congress is a Democrat.	0.5051	0.5001
Seniority	Number of consecutive years in the House of Representatives.	5.7877	4.4372
Vote Share	Election margin of victory of the member of Congress.	0.3526	0.2488
Distance to the Median	Distance to the center in terms of ideology measured using the absolute value of the first dimension of the DW-nominate score created by McCarty et al. (1997).	0.5004	0.2236
Size of Congr. Deleg.	Number of seats assigned to Congress member's State of election.	19.0988	15.4628
Committee Chair (1 = Yes)	Dummy variable taking value of one if the member of Congress is a chair of at least one committee.	0.0455	0.2084
Majority Leader (1 = Yes)	Dummy variable taking value of one if the member of Congress is member of the majority party leadership, as reported by the Almanac of American Politics.	0.0253	0.1570
Minority Leader (1 = Yes)	Dummy variable taking value of one if the member of Congress is member of the minority party leadership, as reported by the Almanac of American Politics.	0.0244	0.1542
Speaker (1 = Yes)	Dummy variable taking value of one if the member of Congress is speaker of the House.	0.0018	0.0428
State legislative experience (1 = Yes)	Dummy variable taking value of one if the member served in state legislature.	0.5193	0.4997
State legislative professionalism	Squire's index of state professionalism relative to Congress (Squire, 1992).	0.1473	0.1864
Divided Government (1 = Yes)	Dummy variable taking value of one for Congresses in which the party controlling the executive branch is different from the party controlling one or both the houses of the legislative branch (i.e., 110^{th}, 112^{th} and 113^{th} Congress).	0.5965	0.4907
N. obs.		2,176	2,176