

Network Structure and Information Worker Productivity: New Evidence from the Global Consulting Services Industry

Lynn Wu
MIT Sloan School
lynnwu@mit.edu

Sinan Aral
NYU Stern School
of Business
sinana@mit.edu

Erik Brynjolfsson
MIT Sloan School
erikb@mit.edu

Ching-Yung Lin
IBM Research
chingyung@us.ibm.com

Introduction

This study presents new empirical evidence on the relationship between information worker productivity and social capital generated from social networks. As the information content of work increases, studying how information workers generate value and output is becoming increasingly important. While past empirical studies have focused on the productivity impact of information technology for manufacturing industries, there is very little empirical evidence on the production function of information workers, such as consultants, researchers, lawyers and accountants. Aral et. al (2006, 2007) and Aral and Van Alstyne (2007) provide some of the first empirical evidence demonstrating how executive recruiters use information technology and their social networks to generate value. Similarly, Wu et. al (2008) studied the impact of face-to-face communication networks on the productivity of hardware configuration specialists. In this study, we extend these studies by studying consultants. Since a large number of information workers, such as consultants and lawyers generate revenues by logging “billable hours,” studying consultants can broaden our understanding of how information workers generate value.

We derived the social networks of 5000 employees from their electronic communications at a large information technology firm over 3 years. In total, there are about 300,000 people in the aggregated social network. We focus our study on the 1029 consultants in our sample and collect detailed data on the 2952 projects these consultants participated from June 2007 to July 2008. To our knowledge, this is the largest dataset ever constructed to study the impact of social networks on information worker productivity. The sheer volume of the data allows us to more precisely estimate how population level topology in a network contributes to information worker productivity, after controlling for human capital, work characteristics and demographics. Specifically, we uncover four key results. First, we find that the structural diversity of social networks is positively correlated with performance, corroborating previous work (Aral et al. 2006, 2007, Aral and Van Alstyne 2007). Second, network

size is positively correlated with higher productivity. However, when we separate network size into in-degree and out-degree, we find that while in-degree is positively correlated with higher work performance, out-degree is not correlated with performance in the project network - where each node is a project not a person. Third, for both the employee and the project network, knowing many executives is positively associated with work performance. However, having many managers on a project is negatively correlated with project revenues. Fourth, we find that betweenness centrality is negatively correlated with individual productivity while it is positively correlated with project revenues.

Theory and Data

We conducted extensive interviews with 12 consultants of various roles and countries to understand different factors that go into the production function of a consultant. From these interviews, we find that resource utilization and revenues generated through billable hours are the most appropriate productivity measures. In addition to utilization and billable hours, the hourly wage a consultant can command also affects the revenue. Although the hourly wage for different types of tasks is fixed for each project, good consultants are often selected to execute projects that have high visibility and revenue potential. We hypothesize that a socially diverse networks enable information workers to become aware of high-value projects and to increase their chance of being selected for these projects. To gauge the network structure of an information worker, we employ network in-degree, out-degree, betweenness centrality and structural diversity to approximate the range of a worker's network. We also calculate the number of managers with whom the consultant has direct contact. We hypothesize that close relationships with managers offer consultants even more opportunities to participate in high-value projects. Furthermore, we compare the characteristics of networks constructed using employees and projects. In the employee network, each node represents an employee and each link between two nodes represents the frequency of their communications. For the project network, each node is a project and each link between two nodes represents the total communications between members of the two projects. We hypothesize that the network characteristics that are most conducive for project networks may differ from those of the employee networks, since the ability of employee to generate revenues depends both on the ability to bill hours and the ability to work on high valued projects, while project revenue generation largely depends on the number of billable hours.

Empirical Methods and Results

We employ a linear regression model to examine the effect of network characteristics on revenues for both employee and project networks.

$$\text{Revenue}_{it} = \alpha + \beta_1 \text{hours} + \beta_2 \text{in-degree} + \beta_3 \text{out-degree} + \beta_4 \text{betweenness} + \beta_5 \text{constraint} + \beta_4 \text{personal_characteristics} + \beta_5 \text{job_characteristics} + \beta_6 \text{regional_characteristics} + \varepsilon$$

Table 1: Person-level Email Networks		Table 2: Project-level Email Networks	
Dependent Var.	Personal Revenues	Dependent Var.	Project Revenues
Controls: Average Project Complexity, Line of Business, Months, Regions, job level		Controls: project Complexity, Line of Business, Months, Regions, average job level	
Hours	111.8*** (2.078)	Hours	117.7*** (1.351)
In Degree	98.91*** (36.00)	In Degree	-298.2*** (39.74)
Out Degree	112.9*** (39.93)	Out Degree	19.40 (19.97)
Betweenness	-397886*** (93160)	Betweenness	2.75e+07*** (5.51e+06)
Betweenness range	-- --	Betweenness range	225060** (100615)
Constraint	-859.6*** (292.5)	Constraint	-1813*** (401.6)
Direct Links to managers	2231*** (554.5)	Direct Links to managers	5284*** (2023)
isManager	3616*** (802.7)	isManager	-9989** (4070)
Gender	81.88 (158.5)	Average Gender	813.7*** (186.5)
Observations	7458	Observations	2108
R-squared	0.741	R-squared	0.913

We first test the relationships between network structure and individual employee productivity (Table 1). As expected, the number of hours billed is highly correlated with revenues generated. The number of direct contacts measured using in-degree and out-degree is positively correlated with revenue generation. Network cohesion is shown to be negatively correlated with productivity, corroborating the results of previous email network studies (Aral et. al 2006, 2007, Aral and Van Alstynne 2007) where structurally diverse networks are found to be positively associated with productivity. While having a large network size is positively correlated with revenue generation, knowing more managers is shown to have additional positive effects on revenue generation, suggesting that

knowing people in positions of power offers consultants opportunities to participate in more projects and especially higher valued projects.

We then tested the relationship between project network characteristics and project outcomes (Table 2). Similar to the employee network, network constraint is shown to be negatively correlated with productivity, suggesting network diversity is conducive for generating project revenues. Interestingly, network size in the project network, measured using in-degree, is negatively correlated with productivity, while the opposite is found in the employee network data. We suspect that communications between projects may indicate interruptions during project execution. The cognitive cost of switching tasks can impede the consultant from billing more hours. Knowing more managers who are not working on the same project is positively correlated with project revenues, since the ability to access to powerful and resourceful managers can facilitate project execution. However, having many managers in the same project is negatively associated with project revenues. Without a clear leadership role, internal debates among managers about how to execute the project may impede consultants from actually doing the work and thus decrease their billable hours.

Betweenness centrality for the project network is positively associated with revenues but is negatively correlated in the employee network. We hypothesize that betweenness centrality provides a project with the positional advantage of quickly obtaining the information needed for execution. However, in the employee network, consultants not only communicate to get the project done, they also devote time and energy to find future projects and especially projects with higher revenue potential. Project managers with high value projects are also selective in choosing the best consultants available since the success of the project may generate repeat business that also have high values. Our interviews indicate that, to ensure the project is executed smoothly, project managers tend to choose consultants they personally know in order to minimize the chance of choosing inadequate consultants. Thus, having direct contacts as oppose to indirect contacts is more beneficial for individual productivity than for project productivity.

Conclusion and future work

By analyzing one of the largest organizational electronic communication networks ever collected and combining it with detailed performance data, we show initial evidence that social capital generated from social

networks are positively correlated with information worker productivity. By constructing social networks at both the individual and project levels, we demonstrate that network characteristics that are conducive for performance in the individual network differ from those that are salient in the project network. In the future, we intend to perform robustness checks, and identify other intermediate mechanisms that link network structure to productivity. Currently, we use a single cross-sectional network in our study, but our data is by nature longitudinal. We plan to construct dynamic networks and use random effect and fixed effect model to eliminate any time invariant heterogeneities.

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