

Information, Technology and Information Worker Productivity: Task Level Evidence

Sinan Aral, *NYU Stern School & MIT Sloan School of Management*

Erik Brynjolfsson, *MIT Sloan School of Management*

Marshall Van Alstyne, *Boston University & MIT*

Introduction

Information workers now account for as much as 70% of the U.S. labor force and contribute over 60% of the total valued added in the U.S. economy (Apte & Nath 2004). Ironically, as more and more workers focus on processing information, researchers have less and less information about how these workers create value, and managers have greater difficulty measuring, managing and optimizing work. Unlike bushels of wheat or tons of steel, the real output of most information workers is difficult to measure. Counting meetings attended or memos filed is not closely linked to the value these activities create. But, as the information content of work increases, the role of information becomes increasingly central to our understanding of the performance of individuals, groups and organizations. This research explores the relationship between information, technology and information worker productivity, using detailed empirical evidence to examine how IT use and information seeking habits affect individual level output. Our findings not only uncover relationships among IT use and skill, communication behaviors, social networks, and productivity, but they also shed light on the underlying mechanisms that drive performance.

Our study focuses on executive recruiters, or “head hunters,” whose primary work involves

filling clients’ job openings. Output is precisely observable in this setting because accounting data provide complete and detailed records of project-level and individual-level revenues, the number of projects completed, project duration, the number of simultaneous projects, and project and individual-level characteristics. With the company’s and employees’ cooperation, we also monitored email usage and conducted detailed surveys and interviews focusing on activities, skills, behaviors, and perceptions relevant to information work.

If information influences productivity, its distribution and diffusion patterns are likely to affect the relative productivity of individuals and groups. The understudied yet fundamental question at the heart of the relationship between social network structure and economic performance is: Are individuals and groups in favorable structural positions actually more productive?

Our results demonstrate that information flows and IT use do in fact predict significantly higher levels of economic productivity.

Research Setting: The Role of Information and Technology

We studied a medium-sized executive recruiting firm over five years, with fourteen regional offices throughout the U.S. The employees occupy three basic positions – partner, consultant and researcher, and conduct their ‘searches’ in teams. The core of executive recruiters’ work involves retrieving and understanding clients’ requirements and matching candidates to those requirements.

This matching process is information-intensive and requires activities geared toward assembling, analyzing, and making decisions

based on information gathered from various sources including team members, other firm employees, contacts outside the firm, and data on potential candidates in the internal proprietary database, external proprietary databases, and public sources of information. Recruiters earn revenue for the firm by filling vacancies, rather than billing hourly. Therefore, the speed with which vacancies are filled is an important intermediate measure of workers' productivity. Contract completion implies that the search team has met the client's minimum thresholds of candidate fit and quality, and given controls for differences across characteristics of contracts (e.g. job type, location), project duration (in addition to the real dollar output value of each contract) can be interpreted as a quality controlled measure of team and worker productivity. The firm uses IT in essentially two ways: 1) as a communication vehicle (e.g. phone, voicemail, and email) and 2) as a central repository of information and knowledge about ongoing projects, potential candidates and internal task coordination. Both of these functions facilitate the information exchanges teams require to systematically assemble, analyze, codify and share knowledge about candidates and clients.

Data

Data for this study include three separate data sets from the firm and one from outside the firm. The first is exact internal accounting records of: (i) revenues generated by individual recruiters, (ii) contract start and stop dates, (iii) projects handled simultaneously by each recruiter, (iv) labor costs and compensation, (v) project team composition, (vi) job levels of recruiters, and (vii) job levels of placed candidates. The second set of data covers 10 months of complete email history captured from the corporate mail server. The third data set contains survey responses on information-seeking behaviors, perceptions, experience, education, human factors, and time allocation. The fourth data set involves independent controls for placement cities to normalize for project difficulty. Together, these data provide a

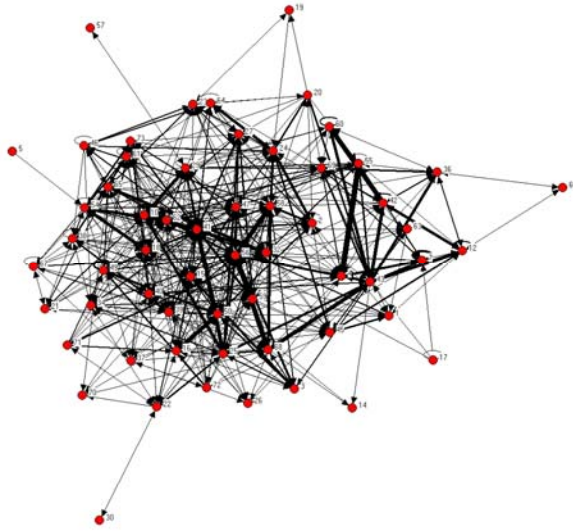
desktop-level view of information flows and IT use that we matched to precise measures of individual performance. Aggregating individual revenues also provides a complete picture of firm-level revenues.

Following our qualitative assessment of the role of IT in the firm's production process, we concentrated our measurement of IT around (a) the intensity and skill with which employees used the ESS system, and (b) the frequency of use of different modes of communication in maintaining contacts and seeking information.

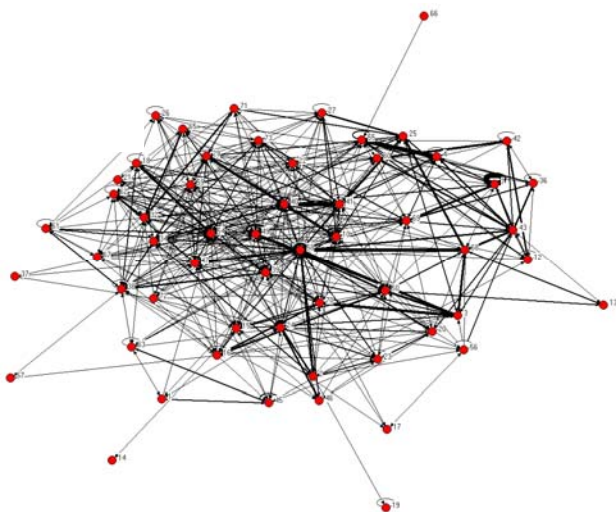
To measure information flows, we constructed variables for both the levels and structure of email traffic. Measures of the level of email traffic count the total number of emails sent and received, individuals' network size, and their in-degree and out-degree, which measure individuals' frequency weighted number of contacts. Measures of communication structure include the 'betweenness centrality' of an individual's email network (Freeman 1979), which measures the probability that the individual will fall on the shortest path between any two other individuals linked by email communication and the 'constraint' of the network (Burt 1992: 55), which measures the degree to which an individual's contacts are connected to each other (a proxy for the redundancy of contacts):

We examine degree and betweenness centrality measures as proxies for the likelihood of being privy to a useful piece of strategic information, and structural holes to capture the efficiency with which teams and individuals have access to non-redundant information.

Figure 1. Below, we use email messages to map the social network at this firm. Each node represents an individual in our data set, while the thicknesses of the links represent the amount of email traffic between individuals over two four week periods.



October 2003



January 2004

Our data allow us to construct a detailed model of the production process of executive recruiters, and to test the impact of IT and information flows on intermediate process metrics and final output measures. We conduct both individual and project-level analyses that examine the specific mechanisms through which IT and information affect the production process of information workers.

Drivers of Production

We determined through interviews that, in our setting, the key driver of production is the

number of projects completed per unit time. As recruiting teams complete projects, they generate revenue for the firm. The results demonstrate that the number of completed projects per day is a strong driver of individual information worker revenue generation. The coefficient indicates that the individual worker's share of the revenue generated from a day's work on an (eventually) completed project is worth, on average, \$2,149.19 dollars per day for the firm.

We then tested the second fundamental hypothesis of our model: that both revenues and completed projects are driven by the number of projects an individual works on per unit time, and by the length of time it takes to finish projects on average. We examined the relationship between multitasking, average duration, revenues and completed projects. The results demonstrate that more simultaneous projects and faster completion times (shorter duration) are associated with greater project completion and revenue generation per person per day.

We also find that the relationship between multitasking and output is non-linear, that is, more multitasking is associated with greater revenue generation and project output to a point, after which there are diminishing marginal returns, then negative returns to increased multitasking. We considered four possible explanations for this inverted-U shaped relationship, and let the data speak to which is the most likely.

Relationships between IT, Information Flows and Multitasking

To test whether IT use and skill, and properties of the flow of information in workers' email traffic are related to the intermediate output variables shown to drive production, we first tested the relationship between our IT and information flow variables and project-level multitasking.

The data showed that teams whose members were heavy multitaskers communicated with more people over email, and significantly fewer people over the phone. We also see from the data that teams who use the ESS system more to gather information work on more projects simultaneously. As synchronous technology (i.e. telephone) reduces multitasking while asynchronous technology (i.e. email, and to a lesser extent, ESS) supports multitasking, a manager seeking to juggle more projects might favor information access patterns that do not require coordinated scheduling. We also tested the analogous relationships between workers' email traffic and their amount of multitasking.

All four measures of communication levels demonstrate strongly that heavy multitaskers communicate more over email.

When considering the structural properties of worker's email traffic, more multitasking is associated with greater betweenness centrality – a proxy for the probability of being privy to a given piece of information flowing through the communication network of the firm. Heavy multitaskers are in the 'thick' of the flow of information and are likely to be 'in between' a larger number of pairs of other employees in terms of their communication structure. In day-to-day terms, it pays to be a communications middleman. Peripheral individuals, with lower information flows, show fewer projects per unit time. Similarly, employees with 'redundant contacts' multitask less. Those entangled in closed networks (networks whose members are all closely tied together) work on fewer projects simultaneously. To untangle constrained social networks, organizations can diversify team assignments and job rotations. Both the level and the structure of information flows correspond strongly with multitasking behavior and structural parameters remain significant even when controlling for total email volume in the model.

Summary and Conclusion

In an effort to reveal the fine-grained relationships between IT use, patterns of

information flows, and individual information worker productivity, this project focused on studying task level practices at an executive recruiting firm. The analysis included both project-level and individual-level performance using: (1) detailed accounting data on revenues, compensation, project completion rates, and team membership for over 1,300 projects spanning 5 years, (2) direct observation of over 125,000 e-mail messages over a period of 10 months by individual workers, and (3) data on a matched set of the same workers' self-reported IT skills, IT use and information sharing. These detailed data enabled an extremely thorough econometric evaluation of a multistage model of production and interaction activities at the firm, and an analysis of the relationships among key technologies, work practices, and output. The findings showed that (a) IT use is positively correlated with non-linear drivers of productivity; (b) the structure and size of workers' communication networks are highly correlated with performance; (c) an inverted-U shaped relationship exists between multitasking and productivity such that, beyond an optimum, more multitasking is associated with declining project completion rates and revenue generation; and (d) asynchronous information seeking such as email and database use promotes multitasking while synchronous information seeking over the phone shows a negative correlation. Overall, these data show statistically significant relationships among technology use, social networks, completed projects, and revenues for project-based information workers. Results are consistent with simple models of queuing and multitasking and these methods can be replicated in other settings, suggesting new frontiers for IT value and social network research.

Acknowledgments

We are grateful to the National Science Foundation (Career Award IIS-9876233 and grant IIS-0085725), Intel Corporation, the Marvin Bower Fellowship, and the MIT Center for Digital Business for generous funding.

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CONTACT INFORMATION

MIT Center for Digital Business
MIT Sloan School of Management
3 Cambridge Center, NE20-336
Cambridge, MA 02142
Telephone: (617) 253-7054
Facsimile: (617) 452-3231

David Verrill, Executive Director
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