Information, Technology and Worker Productivity:  
* A Research Initiative of the Center for Digital Business, MIT

**Executive Summary**

We use internal corporate data to quantify how technology, business intelligence and the flow of information in firms impacts productivity and bottom line business value. We focus our efforts on the largest and most understudied sector of the European and U.S. labor force: Information Workers.

Information workers now account for as much as 70% of the U.S. labor force and contribute over 60% of the total output in the U.S. economy. Ironically, as more and more of the workforce focuses on processing information, we have less and less information about how they create value. In particular, the output and production process for information workers such as managers, consultants, researchers, marketers, lawyers and accountants remain poorly modeled and measured. Accordingly, the new frontier for economic productivity research requires opening the black box of the traditional firm to understand how information workers produce value and how management practices and information technologies can enhance the productivity and value creation of information workers.

What are the key metrics in measuring information worker productivity? Can information work be explicitly linked to revenues? Do certain management practices (e.g. job rotation, multitasking project assignment, and training) or organizational structures (e.g. decentralization of decision rights, team structure) enhance information worker productivity? Does the use of IT lead professionals to complete their tasks more quickly? Does it allow a given worker to do more tasks in a given time? How do skill levels affect these relationships? If an important role of IT is its use in obtaining and sharing information, how are social networks and communications flows within the firm affected by IT's use? How does the movement of information itself impact productivity?

To explore these questions and to understand the production process and levers of value creation in information work, we created a research program at the Center for Digital Business entitled ‘Information Worker Productivity.’ The goal of the IWP initiative is to conduct detailed studies of information worker productivity in different industries, to publish economic research on the management practices and organizational structures that optimize productivity and to report specific results relevant to field sites back to participating firms. Participating organizations are provided access to unprecedented economic and statistical analyses of their own information worker production processes and actionable conclusions drawn from the research that can help the organization improve productivity per employee and the overall profitability of the firm.

We recently completed our first study in a medium sized executive recruiting firm where we measured the per day revenue generation of each employee. In this setting, we were able to model the production process and estimate with confidence what drove the productivity of individuals and teams. Using newly developed tools and techniques, we
were able to conclude, for example, that “an individual worker’s share of the revenue generated from a day’s work is worth on average $2,048.67 dollars per day to the firm” and that “a one standard deviation increase in project level multitasking (~ 3 extra projects) reduces project completion rates on average by 15%.” To further our research, we are now seeking new funding and partners in new industries.

We also estimated the precise productivity and performance contributions of employees’ IT use and skill, their relative positions in the firm’s social network structure, and the diversity of information they send and receive in email. In future work, we intend to expand the scope of our research dramatically to include measurement of firms’ network traffic, data use and phone use, and the impact of these factors on the quality of decision making.

Our First Case Study: Executive Recruiting

In our first study we focused on executive recruiters, or “head hunters,” whose primary work involves filling clients’ job openings. Because projects completed by each recruiter and the corresponding revenue impact are explicitly measured in the firm’s accounting statements, the problem of output observability can be largely addressed in this setting. We collected data on complete project level and individual level accounting records of revenues generated per person per project, the number of projects completed, project duration, the number of simultaneous projects, and project and individual level characteristics. Furthermore, we obtained the express cooperation of the recruiters themselves and their employers to allow us to monitor their email usage and conduct detailed surveys of their activities, skills, technology use and behaviors. We wrote and developed capture software and then took multiple steps to maximize data integrity and levels of participation. New code was tested at Microsoft Research Labs for server load, accuracy and completeness of message capture, and security exposure. The project went through nine months of human subjects review prior to launch and content was masked using cryptographic techniques to preserve individual privacy.

We also collected survey responses on information seeking behaviors, perceptions, experience, education, human factors, and time allocation. Survey questions were generated from a review of relevant literature and interviews with multiple recruiters. Experts in survey methods at the Inter-University Consortium for Political and Social Science Research vetted the survey instrument, which was then pretested for comprehension and ease-of-use. Our IT variables focus on the use of the technology, not merely its presence, and include direct, message-level observation of communications volume, the size and shape of email contact networks, professed ability to use database technology, and relative time spent on various tasks. When combined with interviews and visits, these data enabled us to specify and estimate several equations relating technology, skill, worker characteristics, task completion and revenue generation.

Finally, the characteristics of the city in which a position is to be filled can influence contract completion speed. Crime rates, weather conditions, the cost of living and other city characteristics may increase or decrease the attractiveness of a position in a given city from the perspective of the candidate pool. In order to control for variance
explained by these factors we collected a large independent data set on city characteristics for all the cities in our sample. Together, these data provide a desktop level view of information work practices in conjunction with measures of individual performance. The sum of individually secured contracts provides a complete picture of firm-level revenues.

**Modeling Information Worker Productivity in Executive Recruiting**

We developed a model of the executive recruiting production process and then modeled the impacts of management practices, IT use and skill, and the structure and flow of information in the firm on productivity and project efficiency using both production function frameworks and hazard rate models of project duration.

We developed measures of multitasking based on the multitasking profiles of each individual employee over every day of the five year time span of the study. A multitasking profile characterizes the other projects an employee was engaged in while working on a given focal project. This profile not only accounts for the number of simultaneous contracts assigned to an employee during a given day, but also tracks an employee’s relative share of project effort, the job types of other projects they are working on (e.g. the job classes of the projects and the cities in which they are based), and the dollar value of each project to the firm. We were privileged to have access to specific data about the project profile of each individual employee on each day of the five year study period and objective proxies for the share of effort devoted to booking hours and billing hours for each employee and each project portfolio. With these data we also constructed a measure of multitasking that tracks the average number of other projects a project team is working on during a focal project.

We measured the relationship between IT, information flows and multitasking to determine whether heavy IT users or those more skilled at using IT were multitasking more or shortening their project duration. We also examined whether the level and structure of email traffic predicted the number of simultaneous tasks a project team conducted during a given focal project and used this variable to examine the relationship between greater multitasking, project duration and revenue generation.

**Results of Our First Study**

In this study, the new tools and techniques we employed provided a powerful microscope which reveals the relationships among information, technology, and individual information worker productivity in a way that would be impossible with any

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1 We collected city level data on tax rates for sales, income and property, the aggregate cost of living, home ownership costs, rate of home appreciation, air quality, water quality, number of superfund sites near the city, physicians per capita, health care costs per capita, violent and property crime per capita, public education expenditures per capita, average student to teacher ratio, an index of ultraviolet radiation levels, risk indices for earthquakes, tornadoes and hurricanes, the average number of sunny, cloudy, and rainy days per year, average number of days below freezing per year and average commute time to work.
amount of firm, industry or country-level data. We were able to estimate the following relationships in this particular firm with greater than 95% confidence:

- **An individual worker’s revenue generation per day is worth on average $2,048.67 dollars per day to the firm.**
- **For the two main tasks of executive recruiters—booking new clients and executing contracts—different levels of worker generate different levels of revenue:** on average, “Partners” generated $475 more per day for the firm than “Researchers” from executing contracts. “Consultants” generated $25 more per day for the firm than “Partners” from executed contracts. (“Partners” contributed significantly more than “Consultants” when considering landing new clients).
- **More multitasking and faster project completions were associated with greater revenue generation per person per day:** A one standard deviation increase in multitasking was associated with a .64 standard deviation increase in completed projects and a .92 standard deviation increase in revenues generated. A one standard deviation increase in project duration was associated with a .08 standard deviation decrease in completed projects and a .14 standard deviation decrease in revenues.
- **Multitasking was strongly correlated with longer project duration and slower completion rates.** A one standard deviation increase in project level multitasking (~ 3 extra projects) reduced the completion rate on average by about 15%.
- **Holding the level of multitasking constant, teams that use IT more to gather information complete projects about 10% faster on average.**
- **Teams high in multitasking but low in IT use take 13% longer to finish projects than teams low in multitasking and low in IT use.**
- **Teams whose members were heavy multitaskers communicated more over email and significantly less through face to face interaction or over the phone.**
- **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.**
- **Employees with ‘redundant contacts’ multitask less.** Employees entangled in closed networks (networks whose members are all closely tied to each other) work on less projects simultaneously.
- **Employees in unconstrained networks have access to more diverse information and are therefore more productive.**

These are some examples of the types of results we seek. The contributions of this research appear at three different levels:

- **First, we show that information work need not defy measurement.** On the contrary, we identify a context with objective measures of white collar output as well as IT use and information flows associated with that output.
Second, we use this increased detail to peer inside the black box production function of information workers. We develop and validate a multitasking and duration model of individual projects that allows us to examine the associations between information, technology and the intermediate steps in performing white collar tasks. We also develop and validate a hazard rate model of project completion. Thus we directly explore the association between using technology and the ability to juggle more tasks and complete them faster.

Third, we find statistically significant evidence of the drivers of information worker productivity.

In sum, we demonstrate a substantial program of correspondence among information, technology, and performance in this setting. The tools and techniques developed in this study can be readily applied to other settings where email or databases are used and project level information work is performed, including sales, consulting, law, medicine, software development, venture capital, investing, underwriting and architecture, among others. This portends a radical improvement in the coming decade in our understanding of the relationship between IT, information work and value creation.
Research Team Biographies

Sinan Aral
Sinan Aral is a PhD candidate at MIT, and a Professor at the NYU Stern School of Business. His research follows two streams, both aimed at understanding the role of information and technology in generating business value and improving economic productivity. Stream 1: Measuring the impact of IT investments on firm productivity and performance. Stream 2: Measuring information worker productivity and the influence of IT on social structure and social networks in organizations and business ecosystems. Sinan’s work has been nominated for several best paper awards in information systems and economics. Prior to MIT, Sinan was a Fulbright Scholar, and worked as the assistant to the director of the Department of Southern Mediterranean Relations at the European Commission in Brussels and as a technology consultant for various firms. He is a Phi Beta Kappa graduate of Northwestern University and holds masters degrees from the London School of Economics and Harvard University.

Erik Brynjolfsson
Erik Brynjolfsson is the Director of the Center for eBusiness at MIT, and the George and Sandi Schussel Professor of Management at the MIT Sloan School. Professor Brynjolfsson was among the first researchers to measure the productivity contributions of information technologies and his research has been recognized with six “best paper” awards by fellow academics. He lectures worldwide on business strategy, pricing models and intangible assets. He is Editor of the Ecommerce Research Forum, and several books including Understanding the Digital Economy (MIT Press) and Strategies for eBusiness Success (Jossey-Bass). Professor Brynjolfsson is an associate member of the MIT Computer Science and Artificial Intelligence Laboratory and previously served as a visiting professor at Stanford Business School and an instructor at Harvard University. He holds Bachelors and Masters degrees from Harvard University in Applied Mathematics and Decision Sciences and a PhD from MIT in Managerial Economics.

Marshall Van Alstyne
Professor Van Alstyne holds joint appointments at Boston University and MIT, and works in the area of Information Economics. His research interests include the economics of networks, valuing information, equity and growth effects of information sharing, and integration effects of technology. The underlying theme is information: how to value it; how does it affect productivity, product design and competitive advantage; what happens when it is shared; and, how does it alter property rights. He graduated from Yale (BA) and MIT (MS & PhD). His work has received an NSF Career award, best paper award, and been featured often in the popular press.