EXPLORING THE CONTRIBUTIONS OF HUMAN AND SOCIAL CAPITAL TO PRODUCTIVITY

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ABSTRACT

This paper investigates how human and social capital contribute to individual productivity in three organizations. We study firms that complete all their tasks in projects, two of the firms are R&D institutes with main emphasis on economic and social analyses. The employees in all firms initiate and organize their projects. We collected archival data from the firms on performance, human capital, tenure, gender of all employees, and their project activities. In one firm the dependent variable is performance defined as number of projects completed, in the second firm we use hourly contribution from project work, and an index of publications is the performance variable in the third organization. We used a questionnaire on the internet in one organization to map the social networks of the participants and interviewed everybody in the other two firms. Using effect screening regressions we find that social capital is the most important factor to determine productivity. We found mixed effects from human capital, only in one firm did human capital have a noticeable effect on productivity. Controlling for human capital and social capital, tenure has no effects on productivity. We found that men are more productive than women in two of the firms. In the third firm, women were slightly more productive than men.

INTRODUCTION

Productivity is a crucial concern for business organizations, because it may be the most important driver for achieving satisfactory results and significant cost-advantage over competitors. We argue that human and social capital contribute to individual productivity. Human capital is the competence held by people, whereas social capital is contributions from people we interact with during work and problem solving (Burt 1992b; Coleman 1988; Lin 2001). In this paper we measure human and social capital and estimate the effects on productivity in project work, in which routines play a minor role, and each project participant has discretion in coming up with their own solutions.

Although desirable, productivity is not an easy issue for organizations for at least two reasons. 1) Measurement of productivity can be problematic and 2) what causes productivity is not always clear (March and Sutton 1997). From a managerial and economic perspective, productivity is mainly a function of three variables: technology, labor and organization. Any variable, individually taken, adds to or deducts from productivity: up-to-date, modern equipment and systems; professional, skilled human capital; coherent and adequate coordination, efficient work routines, each can be a source of incremental and dramatic change in productivity. Apart from the relative contribution of each variable, the interplay and the mutual impact of each other fuel changes in productivity both at macro and micro level. Economists and business scholars recognize that these two different levels of analysis are both needed, but nevertheless analyzing what contributes to productivity at these levels remain mostly separate.

The relative impact on productivity of human capital and interdependencies with technology and organization are to some extent unclear. A possible way to tackle this issue is to recognize that productivity has an individual, a social, and an organizational component (systems and technology), as early investigations by organization scholars remind us (Burns and Stalker 1961). As collective, cooperative efforts make firms' output possible, it is clear that differences at the human capital level are only a partial explanation for variances in productivity, other factors also contribute. We focus on the interplay of human and social capital, by studying organizations in which the organizational component embedded in routines and technology, plays a minor role, if any at all.

Most work on productivity and human capital analyze firm level performance. These studies rarely measure human capital, except at the executive level (Pennings et al. 1998). Other studies analyze the effects of human resource practices on performance (Huselid et al. 1997; Richard and Brown 2001). One recent study found positive effects of commitment-based human relations practices on knowledge sharing and hence productivity (Collins and Smith 2006). A few study the direct effects of human capital on performance, finding a weak link between firm level measures of human capital and firm performance (Hitt et al. 2001).

Available literature and research convincingly show the positive impact of social capital on social and economic action. In a business organization social capital is an important source of productivity. To get things done, workers and professionals need to mobilize others' support and advice, well beyond the hierarchical structure of the firm (Gabbay and Leenders 1999). Although hierarchy is a powerful way of mobilizing others, two features make its sole use potentially inef-

fective. First, no matter how powerful bosses are and hierarchical the organization might be, subordinates might affect the final outcome in different ways, by delaying execution, partially oppose decisions, and by defensive or opportunistic behavior (March and Simon 1958; Williamson 1975). Second, as the nature of jobs evolves over time making team-work necessary, the sole reliance on a command and control structure does not guarantee success.

Many studies look at contributions to performance by social capital from a firm or industry level (Ahuja 2000; Powell 1998; Powell et al. 1999). Fewer studies relate social capital to individual level productivity. Coleman (1988) suggested that social capital could produce human capital. He assumed that people during interaction learned from each other. Boxman, De Graaf, and Flap (1991) estimate a model in which human capital weakly produces social capital. Human and social capital interact in producing income, but returns on human capital decrease when there is access to abundant social capital. Meyerson (1994) finds that social capital influences income, but only strong ties create this effect. Other studies find that social capital makes technical advice available during diffusion of innovations and transfer of knowledge (Hansen 1999; Harkola and Greve 1995). Podolny and Baron (1997) find that social capital measured as structural holes[1] gives managers a more rapid promotion rate. Burt (1997) shows that social capital has positive effects on managers' careers if there are few people doing comparable work. None of these studies actually look at productivity, they look at how individuals reach goals by using social capital. Burt (2000) reviews several studies including five of his own, showing that performance effects are largely derived from structural holes. These structural effects on performance holds in differ-

1. Structural holes in a network is defined as lack of constraint in establishing relations between ego and alters that are not connected to each other; by filling a hole ego acts as a broker, or combines resources from other actors.

ent cultural settings (Burt et al. 2000), and are largely based on brokerage (Burt 2004). Mehra and colleagues (2001) found that centrality in networks predicted performance; occupying a central network position was a result of maneuvering into central positions during a longer period. Finally, Reagans and Zuckerman (2001) find that social networks can explain performance differences better than demographic diversity, see also (Reagans et al. 2004).

Work on human and social capital and how they influence productivity abounds, but these two streams of research have progressed mostly separated from each other with a few exceptions (Kogut and Zander 1996; Lee et al. 2005; Pennings et al. 1998; Uzzi 1997), mainly for theoretical and conceptual reasons. Some researchers have looked at human resource practices related to social capital and performance, finding that human resource management can influence access to and use of social capital, which may enhance performance (Leana and Van Buren 1999; Reagans et al. 2004). The dual, interwoven presence of human and social capital makes it hard to learn which most adds to productivity in these settings. This paper studies how employees combine human and social capital in their project work. We will first discuss how human capital contributes to productivity, then turn to social capital to discuss the various ways in which it contributes to productivity. Then we will present three empirical settings estimating effects of human and social capital.

THEORY

Human Capital

Human capital literature focuses on attributes an individual possesses as e.g. education and experience. These attributes represent an asset both at individual and at organizational level. For an individual, more education and experience provide a satisfactory position in the job market, and shield one's position against environmental turbulence. More human capital leads to higher compensation and personal rewards: workers with more education and experience tend to be paid more than those with less. Not surprisingly, investments in education become a personal asset, that gives lifelong returns (Becker 1964). However, this relationship is not clearly proven (Weiss 1995). For the organization, employing skilled workers makes satisfactory outcome possible and allow better repositioning if environmental jolts occur. The sum of individual competencies (skills are used interchangeably) represents the stock of human capital of an organization. Note that the concept of human capital and research on human capital and productivity, tend to ignore under which conditions organizations actually activate, combine, and use competencies of individuals (Hall 1988; Pfeffer 1994). Surprisingly, recent literature focussing on knowledge-intensive companies share a similar view. This literature focuses more on employee competence and on rough measures of internal structures (Sveiby 1997), thus ignoring the social side of any organization and its impact on performances.

Human resource management strives to advice organizations to hire individuals that have skills needed to get tasks accomplished. Organizations try to optimize the composition of human capital and change this composition according to task requirements. By summing up skills and com-

petencies of an individual it is possible to assess her level of human capital. By piling up skills and competencies of several workers it is possible to estimate the level of human capital an organization can mobilize to serve its purposes (Aaker 1996; Goold et al. 1994). Although these two are different units of analysis, human capital literature assumes a common framework. Individuals and organizations are treated as perfectly interdependent. Studying productivity, the human capital approach attributes increases in productivity to higher education levels of the work force. Econometricians try to explain human capital effects on productivity on a macro level by controlling for a set of other factors (Foray and Lundvall 1996; Temple 2001). However, the human capital approach falls short in convincingly explaining processes by which attributes of individuals contribute to organizational productivity. The relationship between personal attributes or human capital in general and organizational performance becomes problematic, if not tautological; better resources ought to deliver better results (March and Sutton 1997).

Most studies on productivity and human capital have been done in settings with few controls on intervening variables. Organizational resources, hierarchical controls, and routines all affect productivity. To estimate effects of human capital apart from other influencing factors, we need to study organizations in which work heavily depends on individuals and their expertise. Organizations that have problem solving tasks as their prime activity, would satisfy this condition. Quite often such work takes place in project groups. Depending on the specific tasks at hand, different types of human capital may be more or less productive. One study of R&D organizations found that scientists having a Ph.D. have higher productivity than those with Master degrees (Wells and Pelz 1976). Since this study there have been very few attempts to measure effects of human capital directly on performance despite arguments about the importance of competence in

R&D and other problem solving work. Some settings may require general human resources that cover several areas of knowledge; other settings may require highly specialized professionals to solve the tasks of the organization. Some work requires combining different skills to complete a project, but the degree of specialization may impede cross-disciplinary communications (Pinkus et al. 1997). Assuming that an organization is able to compose work groups containing the necessary skills with individuals that can communicate with each other, we would expect the human capital component to contribute to productivity, particularly if impeding structures are absent. Thus, the composition of human capital in work groups and organizations have additive effects on productivity. The more competence an individual possesses the more she will contribute to completing tasks.

Hypothesis 1 Human capital has direct effects on productivity, people with more and deeper skills will have higher productivity than people with less human capital.

To test this hypothesis we need a quasi-experimental setting where it should be possible to measure effects of human capital on individual performance apart from how organizational rules or structures may impede or enhance productivity on an unequal basis.

Parts of human skills are created through work experience. Since it is easier to get reliable measures of experience than of skills, several studies have looked into how experience influences productivity. Most studies find that people get more productive with more experience (McDaniel et al. 1988; McEnrue 1988; Quinones et al. 1995; Tesluk and Jacobs 1998). Some find that this relationship is curvilinear, reaching a peak after some years and then declining (Wells and Pelz 1976; Hoffman et al. 1992; Hunter and Hunter 1984). The evidence seems to suggest that more

experience leads to more productive workers. However, other factors that covary with experience may produce such results. One is that experience is a proxy measure for competence. Over time people acquire more skills, and these make them more productive. If skill can be measured more accurately, we should not find effects from tenure. The other factor is that over time people acquire more and better social capital, which helps them boost productivity. If there are no good measures of social capital, this factor may confound the results from experience. Therefore, we suggest two hypotheses, one following the literature, which would predict increase in productivity with tenure, and one that takes confounding factors into consideration, which leads to no direct effects of tenure:

Hypothesis 2 Tenure (number of years experience) is positively related to productivity.

Alternative: There is no relation between tenure and productivity.

Social Capital

Definitions. We define social capital according to Lin (2001: 19): "investment in social relations with expected returns in the marketplace." This definition reflects most writings on social capital (Bourdieu 1983; Bourdieu and Kreckel 1983; Burt 1992a; Coleman 1988; Lin 1982; Portes 1998). Burt (2000) distinguishes two classes of models of social capital. One is based on closure and is derived from the writings of Bourdieu and Coleman, the other perspective focuses on structural holes and advantage through social structure that accrues through brokerage or combination of resources (Burt 2005).

The closure model views social capital as an advantage resulting from a protected structure, like a closed network that gives its members access to resources that are denied outsiders. According to Bourdieu, social capital is "the aggregate of actual or potential resources that are linked to a possession of a durable network of more or less institutionalized relationships of mutual acquaintance and recognition… a 'credential' which entitles them to credit, in the various senses of the word" (Bourdieu, 1983: 249). Social capital is not an attribute of individuals, nor a property, for it is shared between (at least) pairs of actors. However, the level of social capital an individual can access, is an outcome of position in social networks and investment strategies, aimed at nurturing and reproducing–to be leveraged later to achieve specific goals.

According to Coleman (1988, 1990), social capital encompasses both the notion of dyadic relationships and the overarching social structure. As a special form of capital, that can be distinguished from physical and human, social capital is a property of social relationships and a resource actors possess and share. Therefore, also organizations and individuals have different levels of social capital as well as different abilities to take advantage of it.

Social Capital and Productivity in Project Work. Scholars emphasize that social capital may be instrumental and help actors both in a social and in an economic sense, which often are interwoven and hardly detachable from one other. Social capital has four main effects. 1) Getting information (Granovetter 1973; Granovetter 1983); 2) transfer of knowledge, innovation, and diffusion of technology or practices (Ahuja 2000; Brown and Duguid 1991; Powell 1998; Wenger 1998); 3) combining complementary knowledge and helping solving problems (Greve and Salaff 2001; Teece 1986; Von Hippel 1988); and 4) brokerage (Burt 1992a; Burt 2005).

These effects may be present simultaneously to a larger or lesser extent depending on the task at hand. Thus, the effects may vary depending on the needs and the human capital of those accessing social capital. Reagans and Zuckerman (2001) found that R&D teams benefitted from social capital. Similar findings have been reported for work groups (Sparrowe et al. 2001).

Social capital is an important resource for individuals and organizations, as it complements other resources that individuals and organizations control. Since our study applies social capital to productivity, we look at cooperation in social networks to solve complex tasks. There are two important aspects to productivity contributions from social capital. One is using social relations to mobilize people to contribute to a project. Established social relations contain the necessary trust and knowledge about each other that facilitate communication and enhance cooperation (Coleman 1988; Krackhardt 1992). The other is using team members' social capital to augment and complement the knowledge of the team. A network of individuals has a collective knowledge base that possesses more knowledge than that residing within any single individual. Each person's network position, the network structure, and composition of participants determine the degree of shared knowledge and to what extent knowledge can be combined or coordinated among a set of experts (Walker 1985). During the execution of complex tasks single individuals or teams may not have the required knowledge to complete a task, and they have to link their capabilities to the complementary resources of other persons. Drawing on their social capital, individuals may mobilize other people to help solving problems (Greve and Salaff 2001; Rogers and Larsen 1984; Saxenian 1994).

Social capital contributes to productivity through interactions between people. However, since social capital is part of a larger network, the resources of any person in the network influences their closest relations. Thus, the value of social capital may not depend on how many contacts an actor has, but on the structure of relations within the network and the contacts of their relations (Burt 1992a). A closely-knit network of friends who all communicate with each other may not be very productive because of redundancy (Granovetter 1983). Therefore, we need to consider indirect ties as well as direct ties when we evaluate social capital. Some people may have few direct ties, but these may be connected to several others, and therefore may contribute more than a larger group of people all tied to each other. Thus, the productive value of social capital depends not only on direct contacts, but also on indirect links, which is reflected in the structure of the network. To the extent that social capital augments human capital by adding solutions, help, suggestions, etc. to ongoing work processes, or if it provides complementary resources, the effect of social capital is additive to human capital. Accessing social capital adds productivity beyond what human capital contributes, hence a hypothesis specifying additive effects.

Hypothesis 3 Social capital has direct effects on productivity, people with more social capital will have higher productivity than people with less social capital.

Different levels of human and social capital may interact to produce joint effects on productivity. When social capital interacts with human capital, there is a transfer of knowledge, that creates higher productivity. Some people may have less human capital but more social capital, or vice versa. In some problem solving interacting with others can contribute directly to productivity by finding viable solutions. In other circumstances we deal with complex problem solving that requires joint development of solutions (Uzzi 1997). Learning depends on what people already

know, new knowledge has to connect to existing knowledge so that people can interpret and put this knowledge into an existing frame of reference (Weick 1979; Weick 1995). When people use their contacts to help solve complex problems, social capital contributes to productivity only if the discussion partners are able to understand each other and together create new solutions. In these cases, an individual may need much human capital to take advantage of social capital, and her relations (social capital) need to be competent to contribute. If people interact to solve complex problems, we expect an interaction effect between human and social capital, so that much (low) human capital together with much (less) social capital increases (decreases) productivity:

Hypothesis 4 During complex problem solving, human and social capital interact to increase productivity.

METHODS

To be able to measure individual performance and relate this to human capital or competence, we need a setting where the organization does not impede the use of human resources by its structure and procedures. The set of standard operating procedures or rules that the organization applies also contributes to productivity (Cyert and March 1963; March and Olsen 1989; Starbuck 1983). However, they may also impede productivity (March and Simon 1958). The use of rules may to some extent eliminate differences in human capital by prescribing tasks and procedures. Rules enable production independently of human capital. Most managers act as if human capital does not matter, they rely on organizational procedures. Relying on organizational procedures is less effective if organizations have to provide new solutions to unexpected problems and oppor-

tunities. This is the case of knowledge intensive organizations, whose primary task is to produce knowledge or recombine existing knowledge in a non standard way.

To test our hypotheses we need a quasi-experimental setting, with minimum impediments to people's motivation to develop and use their skills. In organizations that do not use rules to execute work, we should find direct relations between human and social capital and performance. Therefore, we have picked three organizations that apply no strict guidelines or procedures to their employees to help them execute their tasks.

Data and Respondents

The organizations. This study uses data from three organizations that do R&D and consulting. The first, GESTO,[2] is an Italian service providing and consulting firm for building related services. GESTO's business concept is that "we can take care of everything that takes place in a building." From cleaning services, they added a wide range of services as for example telephone installation, operating, and maintenance, computer services, and business consulting. To do their range of business services, they draw on people with altogether 91 different, itemized skills. All work at GESTO is project work. The employees initiate and organize projects, mobilize team members and complete projects. Anyone can initiate, organize and participate in more than one project at the same time. Once a team is established, the members organize their project work to adapt to the demands of the project and to take other project obligations into consideration. The only hierarchical and structural element in this organization is the steering committee that evalu-

2. GESTO in Italian means to manage.

ates projects. All organizational resources are accessible to all employees through Lotus Notes that contains their databases. Access to external information depends on the project team members and their external contacts. People are rewarded for project participation according to three variables: 1) economic performance of the project, 2) judgment of the leader, and 3) judgment of the steering committee.

The two Norwegian firms do applied research and consulting within the fields of economics and other social sciences for public institutions and private firms. As in GESTO employees initiate and carry through their own projects, sometimes customers bring in projects. The employees put together their own teams, mostly smaller teams for each project. Some work on projects alone. The firms also do their own research funded through public research funds. One firm (ALPHA) does more applied research and consulting, than the other (BETA) that emphasizes applied research and no consulting. BETA is smaller than ALPHA, but it is collocated with a large business school that also has a major economics department. There is extensive cooperation between BETA and the business school. This study focuses on BETA full-time employees only, since they are full-time researchers and more comparable to ALPHA and GESTO employees.

GESTO and ALPHA are profit seeking organizations, whereas BETA is nonprofit. Project participation is the only activity that is rewarded in the two former firms, except a couple of support functions in GESTO that are exempt from project work. In BETA, rewards are tied to academic excellence as much as project participation.

Sources of data. We use three independent sources of data on GESTO. 1) Interviews were done personally and on e-mail. We interviewed key actors (the founder and the most tenured members), as well as a sample of new entrants to obtain qualitative data. Altogether we talked with nearly half the GESTO employees twice, between January and July 1996 and January 1997 and June 1997. Interviews were taped, transcribed, and checked by respondents. The interviews provided information on how GESTO is organized and how they initiate and carry out projects.

Similarly we talked to the management of ALPHA and BETA, and interviewed all employees. Their employees pursue research contracts, apply for funding, and engage in long term projects or relationships with sources that need R&D. The data for these two firms cover 2004-5. Some of their data is also available on their web-sites (publications).

2) We accessed GESTO's databases of projects and personnel to cover project data from April 1996 including February 1997. The GESTO databases contain detailed information about projects, the title and main objectives, a brief description, time and length, whether the project was completed or suspended, whether it had an external client or was done for internal purposes, the names of the initiators, team leaders, and participants. GESTO has a list of skills and skill levels of each employee and their tenure, the firm determines their skill levels according to a rating scheme; employees participate in the final rating. We obtained degrees from the employees at ALPHA and BETA through interviews. Databases from ALPHA gave us information on tenure, project participation, and earnings and work hours on projects. BETA databases gave information of projects and publications.

3) Our questionnaire mapped the social networks of the GESTO employees by asking the respondents to indicate who they used as contacts to initialize and complete projects from a name list of everybody in the company. The questionnaire was distributed on the internet in March 1997, and all 52 employees responded. The quantitative analysis covers the period from April 1996 including February 1997. However, only 52 out of the 77 people (67.5%) listed were still working with the company when we distributed our questionnaire. The loss of one-third within a year, is high turnover. Some of the turnover occurs because GESTO employees set up their own companies or stay with a customer after finishing a project. There is not a similar turnover at the Norwegian firms. We made name lists of all employees in ALPHA and BETA to generate social network data, and we interviewed everybody during August-October of 2004, and December 2004 and January 2005. The name lists include everybody in the organization, and during interviews we added names of external contacts that the respondents used for setting up and working on projects.

The Dependent Variable: Individual Productivity

We test the hypotheses that human and social capital increase productivity using regression analysis. In GESTO the more productive individuals will have more opportunities to participate in a larger number of projects. However, since rewards depend on the value of the project, there is also an incentive to participate in more valuable projects, which may last longer and demand more time than shorter projects, and not necessarily to complete several smaller projects. Most GESTO workers participate in more than one project simultaneously. The mean number of days for projects in GESTO is 19.3, SD = 12.7, the median is 17 days. Most of the GESTO employees

participate in both longer and shorter projects. Using number of projects as a dependent variable is the best measure we have of productivity in GESTO. There are six participants that did not participate in projects. They are exempt from project participation because of other tasks. Two people have been there for about two years doing other work than these projects. Four persons are newly hired into the organization. Some people were not employed during the whole period, therefore, we adjusted the number of projects based on how many days people had been employed during this period. This gives 51 people from GESTO for whom we have productivity measures (Mean = 14.43, SD = 13.61, Median = 10.5). We did not have a similar turnover issue at the other two firms.

Since project work is team based, we may ask if the dependent variable is an expression of team performance more than individual performance. The GESTO database lists number of projects completed by individuals, the reason is that there are no fixed project teams. Each team is set up independently of past teams' histories. The participation in teams is set by what expertise the project needs, and who is available on full or part time basis. Since people can participate in more than one project simultaneously, it makes sense using the individual measure of project completion as a dependent variable. People are also rewarded individually.

The average ALPHA employee finishes 20 projects during one year (Mean = 19.74, SD = 9, Median = 20). For ALPHA we have data on the hourly value of project participation (returns to the firm). The productivity measure at ALPHA is the hourly contribution (in NOK) of each individual from project work to the organization (Mean = 911, SD = 213, Median = 930). A similar measure would not make sense in BETA, since they spend all budgets and work on a non-profit

basis. Productivity at BETA is based on publications of research. BETA emphasizes scientific publication, and their employees publish more research papers than ALPHA employees. We use an extensive list of all types of publications to generate the dependent variable. The publication index adds the number of different publications weighted by their efforts. We use the following weights: Papers published in international academic journals 4, articles in Norwegian or Nordic academic journals 3, Book chapters in internationally distributed academic books 3, BETA research reports 2, BETA working papers 1 (Mean = 5.63, SD = 6.39, Median = 4).

The Independent Variables

The three independent variables are: 1) The human capital or competence of each individual, 2) Tenure to measure effects of experience, 3) Measure of social capital; we use Degree centrality, which is the number of direct contacts. We discuss the properties of these measures below. We use data on Gender (M, F) as a control variable recorded and used as an indicator variable.

Human Capital. Personnel data bases of GESTO listed the educational background, tenure, number of different skills, and the level of expertise for each skill. There are 91 different skills (s) in the GESTO database; some require higher education and experience, others are more easily acquired. GESTO divides skill levels into five grades: Freshman, Potential, Expert, Professor, and Guru. We weighted each skill (j) by assigning a number from 1 to 5 (w) for each skill, Freshman to Guru. Then we multiplied each skill with its skill level, and added the weighted skills, for each respondent (i).

Human capital(i) = $\sum s_j w_j$

This produced a scale for human capital, which was normalized to range from 0 to 100. We use the natural logarithm of normalized human capital to achieve a near normal distribution. Most of the different skills each person possesses are related to each other. Since some of the skills require higher university degrees, it is unlikely to find a large range of different skills. Here are two examples of skills. The first is a set of administrative skills: Billing assistance services, business consultants management, credits recovery, documents management, human resource management, internal consulting, self training, start-up assistance service, suppliers' payment management, voyager assistance. She has a Guru rating on 2 of the skills, Professor on 5, Expert on 1, and Potential on 2 skills. Another example is a man with computer related skills: Bell jet (telephone based service), hardware management, interactive training services, reception, software management, switchboard management, voyager assistance, xerox/fax/printers management. He has a Guru rating on 2, Professor on 3, and Expert on 3 skills.

This measure may look like summing apples and oranges, and yes, it is. However, apples and oranges sum up to fruit, and just like we count number of different fruit or vegetables we eat, we can also count different skills. The advantage of this measure is that it signals the combination of versatility and depth, the more skills an individual has, the higher the number of projects she can participate in. Similarly, the higher the skill level of each skill, the more attractive a person is for project participation. We also expect that highly skilled people will finish a task quicker, and therefore, be able to participate in more projects. ALPHA and BETA hire people with university degrees. ALPHA has employees with three degree levels: Bachelor, Master or M. Phil., and

Ph.D. In BETA we only find Master (M.Phil.) and Ph.D. levels. These indicate the formal education.

Tenure is calculated from the beginning and ending dates for those who left the companies. For those still working with GESTO, we computed tenure from start of employment until termination or as ending on April 3, 1997. This date is chosen since it is the day after the last recorded project we have in the database. Tenure is recorded as number of days since their employment and we use the natural logarithm of tenure to achieve a normal distribution of the variable. For ALPHA we have exact dates of employment and the year they received their degree. We calculate tenure as days between employment and December 31, 2004. Tenure days and years since degree correlate: $r^2 = 0.41$. To achieve a normal distribution we use the natural logarithm of Tenure. For BETA we also use number of years employed, which correlates strongly with the year of their latest degree: $r^2 = 0.83$. Several researchers did their doctoral theses while employed at BETA.

Social Capital. We generate network matrices from the complete sets of 52 GESTO employees that responded to our survey, they are part of the social capital of project participants whether they did project work or not. The reason we include them is that they also participate in giving advice on how to set up projects, and they give advice during project work. The complete set of relations in the network influences the centrality measures for everybody in the network doing project work. For ALPHA and BETA employees, we have complete network matrices for internal contacts. External contacts are listed as the perimeter of the network, which is the outer boundary of the network.

There is no single accepted norm for measuring social capital. Relations that have high value for one may not for another. Evaluating the knowledge of all the network contacts may not correspond to their usefulness to the different needs of their contacts. Respondents' evaluation of their contacts also creates problematic comparisons across respondents (Snijders 1999). What one respondent experiences as a valuable contact may not be useful to another. For these reasons, we decided to use centrality measures to indicate social capital. Access is a key factor in organizing; serendipity plays a minor role. Therefore, there are several types of relations that are valuable to get ideas to projects, help in setting them up, advice during project work, and simply being visible in a production system that depends on voluntary mobilization of participants.

We collected data for the network analysis of social capital in GESTO with a questionnaire through the Internet to each employee; all 52 employees responded. The questionnaire mapped the relations among the GESTO employees. Respondents described the interactions they had with others. The questions cover the following topics: a) General contacts while initiating a project, b) Get advice during project work, c) Give advice during project work, d) Contacted by alters during last 2 months, e) Contacted alter while initiating project, f) General advice relations, and g) Social relations. All these different interactions have implications for working out initiatives, mobilizing project participants, doing the project work, and helping others. Some of these have direct effects on productivity, while others have indirect effects, like giving advice, building trust, and socializing. By being visible in a network an individual may be asked to participate in a project group. Therefore, the social or friendship relations are relevant. Productivity is not only

a function of what you do, it is also a function of selection, or what opportunities you get to produce at all. If you are not selected to a project team, productivity will necessarily be lower.

This gives seven matrices of network relations (m = 7) among 52 participants (n= 52). The data from the questionnaires represent the relations of each question (m) for each GESTO member (n). The 7 matrices are highly correlated. We entered all relations (m) into n x n matrices, representing the multiplex relations (n x n x m). We combined relations to analyze the multiplex social network, because all types of interactions may influence access to projects and their execution, and hence, they are relevant as contributors to productivity. We used UCINET software for the network analysis (Borgatti et al. 2002).

We collected two types of network relations from ALPHA and BETA employees. The interview covered their academic degrees and field, and number of years employed. For social capital we asked: 1) who they got advice from during setting up a project proposal, and 2) with whom they talked for general advice on projects and research questions. These organizations have 50 and 23 employees, excluding people who were or had been on leave during the last year. The network data cover both internal and external contacts. Most employees in ALPHA set up their own projects and the variable Degree for project advice is the most discriminating. Not everybody in BETA set up their own projects, some collaborated with other people in their projects. Therefore, we use Degree for general advice for the BETA researchers.

There are several different measures of centrality, each has different properties (Freeman 1979; Wasserman and Faust 1994). There are two different centrality measures that we consider in this

study. Both measures are classified as Radial measures since they measure aspects of cohesion in a network surrounding an actor (Borgatti and Everett 2006). One measures your direct contacts: Degree centrality. This takes into account the number of people you talk to directly and thus expresses effects of volume. It is a simple measure of social capital, however, it assumes that each contact can be weighted equally for all respondents. The second measure takes network reach into account to calculate network centrality in sociocentric networks. This is Closeness centrality, which uses optimal paths between all respondents. Closeness centrality is built on Farness, which is the number of nodes you go through while reaching everybody else in optimized paths. As the walk between nodes is essential this measure is influenced by length of the walk (Borgatti and Everett 2006). Closeness centrality will take into account the indirect effects of the network. Your direct contacts may have a set of valuable connections to several people that you are not connected to. These connections may influence the usefulness of your contacts. It is better to have a few well connected direct contacts, than many contacts with few connections to the rest of the network (Burt 2000). Too many direct contacts may take too much time for less productive activities (Hansen et al. 2001). In this research we are analyzing the effects on productivity from advice relations, hence an emphasis on volume and not length of reach. Direct contacts may have an effect on productivity through their advice relations, and therefore, we use Degree centrality. All centrality measures are robust against measurement errors as missing nodes or edges (relations between nodes), in this study we have relatively sparse networks, which makes them more robust than dense networks for edge deletion, or missing relationships between nodes. For other errors more dense networks are more robust (Borgatti et al. 2006).

Distributions

There are deviations from normal distributions in the original measures of dependent and independent variables. The recoding to natural logarithms has turned the dependent variable and tenure into approximately normal distributions, whereas the human capital variable of GESTO is closer but still deviating from a normal distribution. The network measure is used as is with no transformations. Table 1 displays the distributions. Tables 2-4 display the correlations between the variables for each sample.

Insert Table 1 and Tables 2-4 about here

We tested all independent variables for nonlinearity against the dependent variable and found that the measure of Social Capital, Degree centrality, is curvilinear in all the samples, the best fit for GESTO and ALPHA is a 3rd degree Polynomial, which also fits BETA. See figures 1-3.

Insert Figures 1-3 about here

These results suggest that in all samples a little social capital is better than nothing, but you need to get beyond a a certain level of social capital before it has significant effects on productivity. Based on these preliminary results we add second and third degree terms to the regressions that test the hypotheses.

Regression analyses

The hypotheses are stated as linear relationships with an interaction term, we also add second and third degree polynomials to test for non-linear effects of social capital:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_3*X_4 + b_6X_4^2 + b_7X_4^3 + e$$

where X_1 = Gender, X_2 = lnTenure, X_3 = Human capital, X_4 = Social Capital

All variables are entered simultaneously, since we can not justify sequential testing with this kind of data and model.[3] In the models with the direct effects the interpretations of the regression coefficients is straight forward, b_i showing the relative increase (decrease) in Y given a change of one unit of each independent variable. However, introducing an interaction term changes the interpretation of the direct effects into conditional relationships for the value of X_3 or X_4 when the other regressor is set at 0, the coefficients are no longer tests of main effects (Jaccard and Turrisi 2003). This raises another problem, since no actor is an isolate, this value does not exist for social capital, therefore, we have to recode the variables to have a more meaningful interpretation of the coefficients. We use mean centering for both variables, which is a recoding of the variables by subtracting their mean, so that the mean value is 0. This does not affect statistical tests of significance nor correlations. The coefficients b_i (i = 3, 4) are affected but not b_5, which is the

3. Sequential Tests show the reduction in residual sum of squares (SS) as each effect is entered into the fit. A desirable property is that they are independent and sum to the regression SS. An undesirable property is that they depend on the order of terms in the model. Each effect is adjusted only for the preceding effects in the model. Therefore, it is only appropriate for 1) balanced analysis of variance models specified in proper sequence, 2) purely nested models specified in the proper sequence, and 3) polynomial regression models specified in the proper sequence. Only the last of these conditions is satisfied in our model.

most important test value according to our hypotheses. The coefficients of X_3 and X_4 reflect simple effects, a change in Y when the other variable is set at its mean (Jaccard and Turrisi 2003).

We use Ordinary Least Squares estimates with an emphasis on effect screening. The parameter estimates are highly dependent on the scale of the factor. Since we are interested in the effect size of each variable, we also examine the estimates in a scale-invariant fashion. This means converting from an arbitrary scale to a relative one so that the sizes of the estimates relate to the size of the effect on the response. There are many approaches to doing this. We use orthogonally transformed estimates, which also corrects for other problems with most social science data. Most social science data do not fit regression models well. Among serious issues that make estimates unreliable are correlations among estimates and autocorrelations with the error term (Berry 1993). Since social network data consist of references within dyads, the error terms will be autocorrelated, which enhances the probability of Type I errors. One method to correct this problem is using QAP-regressions (Krackhardt 1987), which will take care of producing correct significance tests. Another method is using Effect Screening based on orthogonal estimates of regression coefficients that correct for scaling and for correlations among the estimates and error terms. It also takes away heteroscedasticity (unequal variances of the error terms). The features of Effect Screening are derived by noticing three things: 1) The process of fitting can be thought of as converting one set of realizations of random values (the response values) into another set of realizations of random values (the parameter estimates). If the design is balanced with an equal number of levels per factor, these estimates are independent and identically distributed, just as the responses are. 2) When fitting a design with many effects and only a few observations, we expect that only a few effects have sizable impact and the rest of them are inactive (they are estimating

zeroes). This is the assumption of effect sparsity. 3) Given points 1 and 2 above, effect screening is a way to determine which effects are inactive with random values around zero and which ones should be considered active (Sall et al. 2004).

Inferences about effect size assume that the estimates are uncorrelated and have equal variances. We use a procedure (SAS-JMP) that finds the correlation of the estimates and then if the estimates are correlated, applies a normalizing transformation to make them uncorrelated and have equal variances. The new estimates gives a different picture than the first parameter estimates of the least squares regression. The column labeled "Orthogonally Coded" shows the new estimates of each parameter in the regressions with t-test statistics. The transformation to make the estimates uncorrelated is the same as that used to calculate sequential sums of squares. The estimates measure the additional contribution of the variable after all previous variables have been entered into the model.

The problem with small samples is generally one of internal and external validity, and getting statistically significant estimates. Since the number of observations is low, we test if the equations have enough degrees of freedom, or if there are variables with observations that replicate each other, we use a test for lack of fit (goodness of fit). None of the regression equations had any problems with degrees of freedom. In addition to the t-tests for significance of the regression parameters, we also did Power analyses. This is based on three parameters: 1) LSV is the lowest significant value of the regression coefficient, 2) LSN is the lowest number of subjects to achieve significance given the current distributions, and 3) Adjusted Power, which is the probability of

achieving a significance level of alpha ≤ 0.05 given the current distributions. In most regressions the parameters are either significant, or closer to no effect.

The issue of external validity depends on representativeness of respondents. We use three samples to test the same model, these samples are taken from three different firms, in three cities and two countries. The remaining question is whether the results can be generalized outside of these settings. This is a question that requires empirical research, however, the theory would suggest that these models are applicable in other settings where human and social capital determine performance, in contrast to having organizational routines determine output, we would expect similar results.

RESULTS

GESTO

We present four regression models testing the hypotheses for each of the three samples. One model shows all variables except the second and third degree terms of Social Capital. The next two models (Model 2 & 3) introduce first the second degree, and then the third degree term. Table 5 shows the results for GESTO. The two polynomials are significant, the second degree term has Adjusted Power 0.92[4] despite inflated estimates of effect sizes and significance tests because

4. The adjusted power is a function of a noncentrality estimate that has been adjusted to remove positive bias in the original estimate (Wright and O'Brien 1988). The Power test can be interpreted as the probability of obtaining a significant alpha value ($p \leq 0.05$) in a similar sample.

of unequal variances and autocorrelations. Model 4 shows the results of orthogonally coded variables with estimates standardized to have equal variances and orthogonalized to be uncorrelated. Using Orthogonally coded variables shows clearly that there are problems with the OLS regressions. These show explained variance and model F tests, however, the regression parameters and the significance tests are not true population estimates, and because of correlations of estimates R^2 is also suppressed in all equations. To analyze true effects we turn to the orthogonally coded parameters, which can be compared directly with each other for effect sizes (within each equation). In model 4 all variables except Tenure are significantly related to productivity. The strongest effect comes from Social capital (all three terms), then Human capital, closely followed by the interaction between Human and Social capital. Thus, we have support for Hypotheses 1, 3 and 4. It looks as if the effects of tenure are absorbed by the measure of Human capital, which yields clear effects.

Social capital, measured as the number of contacts ranges from 7 to 46. Figure 1 shows how the third degree polynomial regression predicts productivity. Between 7 and 15 contacts we see a sharp rise in productivity, after 15 contacts increasing number of contacts do not contribute to higher productivity until around 30 contacts at which point we see a sharp increase.

Insert Table 5 about here

If we combine complex knowledge or knowledge from different domains, so that the effect of social capital depends on human capital to take advantage of advice, we expect to find positive interaction effects between these two variables. We can explain the support for an interaction ef-

fect by the nature and use of social capital in this organization. The direct additive effects of social and human capital means that both will have an effect independent of the size of each other. People with less human capital, can take the same advantage of social capital as people with more human capital. The interaction effect means that more human capital is needed to take full advantage of social capital. In addition to the direct effects there is an additional leverage of having more human capital to the use of social capital. This is the case in GESTO. This organization emphasizes communications between individuals and groups, and the changing composition of groups doing a wide variety of tasks requires more human capital to take advantage of social capital.

We find that women are less productive than men, gender is the fourth strongest effect in the equation, however, the differences in effects are not large. There may be several explanations for this finding. One might be work hours. Men may put in longer hours than women, who may have family obligations outside the workplace. Another explanation may be that women deal more with customers, and are less involved in direct project work. We also find that women have fewer skills and use fewer contacts than men although the differences are not statistically significant, this is an effect of low numbers. Men and women have exactly the same tenure at GESTO.

ALPHA

The next data set is from ALPHA. We have lower explained variance in this sample, however, the main results point in the same direction as the GESTO data. See Table 6.

Insert Table 6 about here

In this sample we see effects from Social capital only, supporting Hypotheses 3. The combined effect sizes (Model 4) from the first and third degree terms show that Social capital has a strong influence on productivity. Since the third degree term is large, we have a curvilinear relationship with a sharp rise for the first 20 contacts (the minimum observation is 5 contacts and maximum is 47) and then the effects of social capital does not add to productivity, if anything it goes down beyond 20-25 contacts. This looks like there are too many contacts to handle. However, a turning point occurs around 35 contacts, where more contacts increases the utility of social capital. However, there are only 7 respondents that use more than 35 contacts, and among these there is one outlier that influences the regression disproportionally. Therefore, the main conclusion is that beyond 25 contacts social capital seems to be counterproductive in this organization, only very few can handle more contacts efficiently.

We do not find any effects of human capital neither measured as the highest academic degree, nor as a result of tenure, and there is no interaction effect with social capital. The differences in contributions are too small to have any effect, since 80% of the sample has the Master level or M. Phil. degree, the number having lower or higher degrees is too small to make a difference. The variance is higher within the two smaller groups than the larger educational group. Power tests showed that we need 925 observations to distinguish the two highest degree levels, which makes it safe to conclude that there are no effects of degree level. Finally, higher degrees may not matter for the type of work this organization does. Work types may be distributed according to who can do what, and higher skill levels may not generate higher income, so that the fit be-

tween competence and contributions is not visible. Less demanding work in terms of competence requirements may pay as well as or more than tasks that require higher academic degrees. A good example is how well consulting is paid compared to academic research.

The final finding is that males are more productive than females. This is also a puzzling finding, and there is no simple explanation. We may have some females not putting in as many hours as the males, which we actually find. Men list annually on average 1224 hours vs. 1070 for females, however, the difference is not statistically significant. Because the number of hours vary a lot, we have used contribution per work hour as a dependent variable. Next, we checked the number of projects, here there is a significant difference between the genders, men worked on 22 projects compared to 16 for females. This may indicate that men work on different types of projects than females, and that these more short term projects yields a higher contribution per hour. These two findings may indicate a different work effort from men, who are engaged in more profitable projects, explaining the gender difference. We also note that there is a significant difference in the number of contacts men (26) and women (15) use for project advice. The women are also younger than the men having fewer years since they got their degree, 10 years vs. 15, and men have worked with ALPHA an average of more than 8 years compared to a little more than 4 years for women. All these factors may explain the gender difference.

BETA

BETA is the last organization in our samples, Table 7 shows the regression results, and Figure 3 the bivariate fit between productivity measured as an index of combined research publications and number of contacts (degree centrality) used during project work.

Insert Table 7 about here

This sample (see Model 4) also supports the Social capital hypothesis (H3), but finds little support for any of the human capital hypotheses (H1 and H2) nor for interaction effects, H4. The strongest effects of social capital is the direct linear effect (3.93) followed by the second degree term (1.99). The third degree term (1.65) is significant at the 10% level, two-tailed test. The number of contacts varies between 3 and 33. Following the second degree polynomial it looks as if there is little effect of social capital up to about 10 contacts after which the effect is strong. The third degree polynomial indicates that there is an increase in productivity up to about 10-15 contacts, after which the effect disappears, at 20-25 contacts there is an increase in effect levels, however, there are only four researchers using more than 20 contacts, see Figure 3.

The low level of support for the human capital hypotheses can be explained by the low number of observation (n = 23). There are some indications of effects of human capital, primarily from having a higher degree (1.55), but also from interaction between social and human capital (0.96). Power tests show that the interaction effect would have been significant with a sample size of 40, but the direct effect of having a higher degree needs 189 observations with the same distributions as this sample to become significant. Tenure has the lowest effect (-0.13). However, the orthogo-

nally coded effects of tenure and the interaction of social and human capitals have lower effects than the direct effect of a higher degree. The orthogonally coded parameter of the direct effect of having a Ph.D. has significance level p = 0.096 (two tailed).

An interesting finding here is that women are more productive than men. The effect size (1.47, p = 0.114) is almost as large as the effect of human capital (1.55 for Ph. D. vs. Master). There are no statistically significant differences between men and women on human and social capital variables. However, the women tend to use more social capital than men, they have fewer years tenure and years since their degrees than men, but the fraction having a Ph. D. is the same. The effect size is too large to attribute it to randomness even though randomness cannot be excluded, since it may be a property of the sample. A possible explanation could be that BETA has offered courses in writing papers for academic publishing, these courses also emphasized how to review papers and give each other comments. A larger fraction of women than men participated in these courses. This shows that investing in training may have positive payoffs, contrary to what Lee et al. (2005) found. Another possible explanation is a labor market selection issue. Several researchers use BETA as a starting point of their academic careers. They have no teaching obligations, and can concentrate 100% on doing research. The best of these researchers are frequently hired into faculty positions in nearby universities.

DISCUSSION AND CONCLUSION

Our study of employees' work performance and cooperation in three project based firms finds that social capital has the most important contribution to productivity. The results for human cap-

ital are mixed. In one setting we could easily see both direct and interaction effects of human capital. In the two other settings, this was not the case. One reason may be that in GESTO there are larger differences in human capital between the respondents than in the other two samples. These differences apply not only to level of expertise, but also to the type of skill and how many areas each individual covers. In the other organizations all of the employees have their education within the social sciences, with a majority of them in economics. Thus, measures of human capital in these firms are related to the level of expertise, which seems not to play a significant role given the type of work they do, or given the types of assignments they get. The productive potential of human capital lies in the knowledge and experience people use to solve problems and get work done. However, problem solving most of the time depends on interacting with other people, and this is why social capital plays a central role.

Social capital influences productivity because most work requires specialized knowledge, and social capital plays a role in several realms. The employees in all three organizations initiate most of the work themselves, except some work that other firms and institutions ask them to do. They set up their own project teams, and a knowledgeable social network is crucial. The project teams are often small, and in ALPHA and BETA, people sometimes do projects on their own. However, in addition to skills, people working on projects, alone or as members in a project group, must be able to cooperate and get advice from others to be productive. Social capital can help finding project members that cooperate in an efficient manner. While setting up projects, people need advice, and the same is required during project work. These advice relations help establish and solve problems of projects without having to include everyone that can contribute to a project in the group. These people may be busy in other projects, but their contribution can be

crucial for several projects at the same time. This is how people are able to use social capital to mobilize complementary resources and augment their own and the team's knowledge. This is important in all project work, and it can include people from other organizations as well (Greve and Salaff 2001; Von Hippel 1988). Much information is contained by people and does not exist in archives. Social capital makes it possible to get access to a wider array of information sources than formal archives and databases can provide. Social capital expands the basis for getting and using information to solve problems, discover opportunities, and avoiding errors that other people have done earlier. The learning component of social capital is important (Brown and Duguid 1991; Brown and Duguid 1998), and since most knowledge is distributed among the members of a social system, people need to interact to take advantage of this knowledge.

Studies that show how human capital is related to productivity without measuring and testing the effects of social capital will, in most cases, exhibit significant correlations of human capital and tenure to productivity. How much is due to the unmeasured effects of social capital? Age, tenure, or education mask the accumulation of social capital. Work that requires specialization of tasks, cooperation, coordination of specialists, and spontaneous self-organizing can best be accomplished using informal relations, or social capital. In this study tenure does not have any significant relation to productivity in any of the firms. We observe direct positive, but low correlations in two samples except BETA, however, these effects are absorbed by human and social capital. Since social capital plays a significant role in all three samples, the effects of tenure is probably absorbed by this variable. Over time people acquire contacts and learn how to best take advantage of these, so that tenure effects can be attributed to social capital effects.

There is a major difference between productivity of men and women in GESTO and ALPHA. Women have much lower productivity than men. Differences in human and social capital cannot explain this difference. In these organizations, as well as in others where we may observe such differences, it would be necessary to conduct more in-depth field studies to find the causes, whether these are external or internal to the organization. One possibility is that men select more profitable projects, and leave the less earning ones to women. Also, it is possible that women work in fields with less value in terms of project income. There is an opposite tendency in BETA, where women are slightly more productive than men, they are younger (as in ALPHA), but apart from that there are no significant differences between the genders. There may be an effect of training offered by BETA that attracted more women than men.

Organization structures are in place to coordinate specialized functions. However, since organization structures cannot be planned for all contingencies, spontaneous coordination through the use of social capital becomes crucial. Many organizations emphasize work in teams and changing project groups. Hiring or mobilizing expertise that can be productive requires people to interact, share knowledge, and provide complementary knowledge. These informal communications are much more efficient than formal structures in finding suitable partners to solve problems or execute tasks. Such structures are also flexible and can quickly be focused on new tasks, which a hierarchical, bureaucratic structure cannot accomplish.

GESTO has an unusual work organization. The average GESTO employee has almost nine different skills. Employees put together their own teams when they initiate projects. Nevertheless, we may find this feature in many project based organizations, such as consulting, engineering,

design, research institutes, and R&D firms. ALPHA and BETA are organized as research institutes. The members' income depend to a large extent (more so in ALPHA than BETA) on what projects they are able to finance. We cannot generalize these findings to organizations dominated by routine tasks. If standard operating procedures cover the work processes, and several people do the same job, social capital is less crucial for help or advice to complete a job, each individual is less distinguishable in several respects (Burt 1997). Also, the differences in human capital tend to disappear if work is done by applying standard operating procedures, which is a substitute for human competence. These results can be generalized to organizations whose activities require the coordination of experts that informally organize and use each others competencies to solve problems, which is project and problem-solving work. Therefore, we suggest that these findings are applicable to other organizations that depend on highly skilled employees and use of social capital to get work done. This occurs in some organizations all the time, and some time in most organizations.

One strength of our study is that we obtained measures on the variables from two independent sources. Demographic data, productivity, and human capital from the databases of the firms, and social network data from questionnaires to GESTO and personal interviews in the other organizations. This enhances internal validity, since the measures are not influenced by each other. One possible weakness of the study may be the measure of productivity in GESTO, the other organizations have more direct measures. However, this is how GESTO measures productivity, and this is the basis of their employees' remuneration. Common factors in all these firms are that there are longer and shorter projects, but time to complete a project does not necessarily indicate a more difficult or larger project. Lower productivity or more part-time work load on some

projects may extend the time it takes to complete any one project. Over time people participate in several projects, and they are also members in more than one team at the same time. This should cancel some of the errors that crude measure introduces. For all samples the high levels of explained variances indicate that our measures are reasonably good. However, all organizations are relatively small, and follow-up studies should be done in other and preferably also larger firms.

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Table 1: Distributions

Variables: GESTO / ALPHA / BETA	GESTO Mean (Std. dev.) n= 51	ALPHA Mean (Std. dev.) n = 50	BETA Mean (Std. dev.) n = 23
#Projects (adjusted for time employed)/ Hourly contribution NOK / Publication index	10.67 (12.21)	911.30 (213.04)	5.63 (6.39)
ln-Human capital (normalized) / Highest Degree / Highest Degree	2.84 (1.24)	B.Sc: 10% Master: 80% Ph.D. 10%	Master: 52.2% Ph. D. 47.8%
Social capital: Degree centrality (all organizations)	31.22 (11.27)	22.32 (11.71)	13.30 (8.54)
lnTenure (days) / lnTenure (days) / Tenure (Years employed at BETA)	6.25 (1.17)	7.51 (0.85)	12.35 (7.06)
Gender: Pct. Female	35.3	32.0	26.1

Table 2: GESTO Correlations

	ln#Projects	Gender	lnTenure	Human capital	Degree centrality
ln#Projects	1.00				
Gender (Female)	-0.32	1.00			
lnTenure	0.04	0.05	1.00		
Human capital	0.38	-0.24	0.66	1.00	
Degree centrality	0.52	-0.21	0.43	0.73	1.00

Table 3: ALPHA Correlations

	Hourly contribution	Gender (Female)	Human capital	lnTenure	Degree project advice
Hourly contribution	1.00				
Gender (Female)	-0.33	1.00			
Human capital	-0.07	0.19	1.00		
lnTenure (days)	0.21	-0.30	-0.11	1.00	
Degree centrality	0.45	-0.42	-0.09	0.50	1.00

Table 4: BETA Correlations

	Publications	Gender (Female)	Ph. D.	Tenure	Degree general advice
Publications	1.00				
Gender (Female)	0.23	1.00			
Ph. D.	0.20	0.03	1.00		
Tenure (Years)	-0.09	-0.30	-0.64	1.00	
Degree centrality	0.66	-0.03	0.19	0.02	1.00

Table 5: GESTO Regression on relative number of projects

	Model 1	Model 2	Model 3	Orthogonally coded
Intercept	-1.65 (9.36)	-13.71 (10.13)	0.28 (10.84)	14.79***
Gender (F)	-2.85 (1.74)	-3.17 (1.65)	-2.80 (1.55)	-4.33**
lnTenure	-3.63* (1.69	-2.93 (1.62)	-2.03 (1.56)	0.68
Human capital	5.20* (2.61)	3.48 (2.57)	3.54 (2.40)	5.18***
Social capital (Degree centrality)	0.63** (0.20)	0.93*** (0.16)	0.24 (0.16)	4.37**
Human capital*Social capital	0.38** (0.13)	0.12 (0.16)	0.25 (0.16)	4.46**
Social capital^2		0.05* (0.02)	0.08*** (0.02)	3.57*
Social capital^3			0.004* (0.001)	3.60*
F value	7.15***	7.67***	8.53***	
R^2	0.46	0.53	0.60	
Adjusted R^2	0.40	0.46	0.53	
n	48	48	48	

† $p \leq 0.10$

* $p \leq 0.05$

** $p \leq 0.01$

*** $p \leq 0.001$

Table 6: ALPHA Regressions on Hourly contributions

	Model 1	Model 2	Model 3	Orthogonally coded
Intercept	928.68** (339.33)	935.16** (197.60)	1236.58** (353.39)	911.30***
Gender (Male)	38.81 (35.87)	38.43 (36.06)	38.35 (34.61)	70.18*
lnTenure days	-6.34 (45.95)	-7.32 (43.92)	-13.91 (41.85)	24.08
Human capital (M.Sc[2]-Ph.D.[1])	-25.27 (95.81)	-26.65 (97.33)	-42.32 (92.76)	-4.63
Human capital (B.Sc.[3]-M.Sc.[2])	43.37 (118.59)	38.83 (123.32)	36.67 (117.22)	5.84
Social capital, Project advice	1.57 (7.36)	1.90 (7.72)	-7.42 (8.37)	68.29*
Human capital(2-1)*Social capital	6.27 (7.69)	6.37 (7.81)	5.97 (7.42)	23.63
Human capital(3-2)*Social capital	1.86 (12.16)	0.92 (13.63)	-8.49 (13.58)	4.33
Social capital^2		-0.04 (0.24)	-0.68† (0.36)	-4.57
Social capital^3			0.05* (0.02)	63.16*
F Value	1.92†	1.64	2.22*	
R^2	0.24	0.24	0.33	
Adjusted R^2	0.12	0.10	0.18	
n	50	50	50	

† $p \leq 0.10$

* $p \leq 0.05$

** $p \leq 0.01$

*** $p \leq 0.001$

Table 7: BETA Regressions on productivity

	Model 1	Model 2	Model 3	Orthogonally coded
Intercept	-0.10 (2.90)	0.85 (2.68	8.35† (4.69)	5.63***
Gender (Male)	-1.58 (1.31)	-1.12 (1.21)	-0.21 (1.22)	-1.47
Tenure at BETA	-0.02 (0.22)	-0.02 (0.20)	-0.09 (0.19)	-0.13
Human capital (Master degree)	-0.34 (1.46)	-0.63 (1.34)	-0.86 (1.25)	-1.55†
Social capital (degree cntr. general advice)	0.49** (0.13)	0.27 (0.16)	-0.20 (0.29)	3.93***
Social capital * Human capital	-0.12 0.13	-0.14 (0.12)	-0.18 (0.11)	-0.96
Social capital^2		0.03* (0.01)	-0.02 (0.03)	1.99*
Social capital^3			0.004† (0.002)	1.65†
F value	3.93*	4.69**	5.17**	
R^2	0.54	0.64	0.71	
R^2 Adjusted	0.40	0.50	0.57	
n	23	23	23	

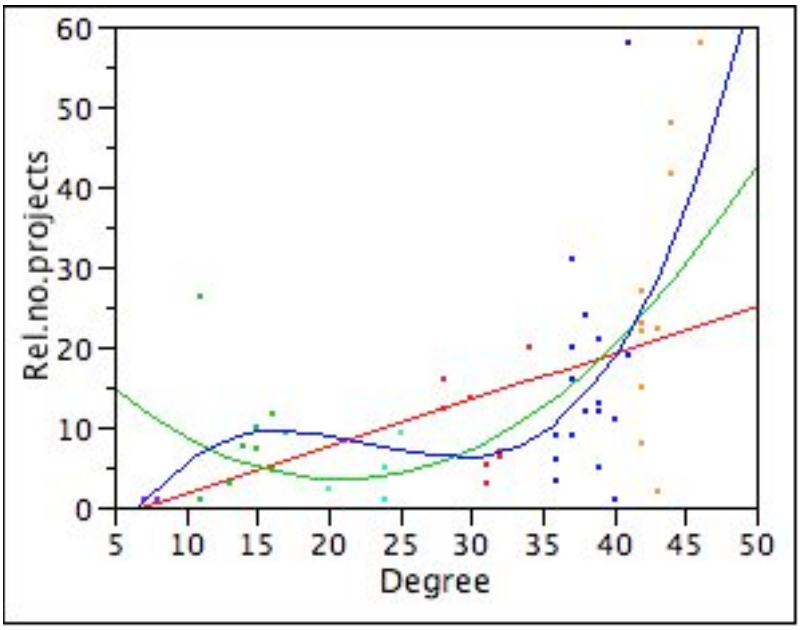
† $p \leq 0.10$

* $p \leq 0.05$

** $p \leq 0.01$

*** $p \leq 0.001$

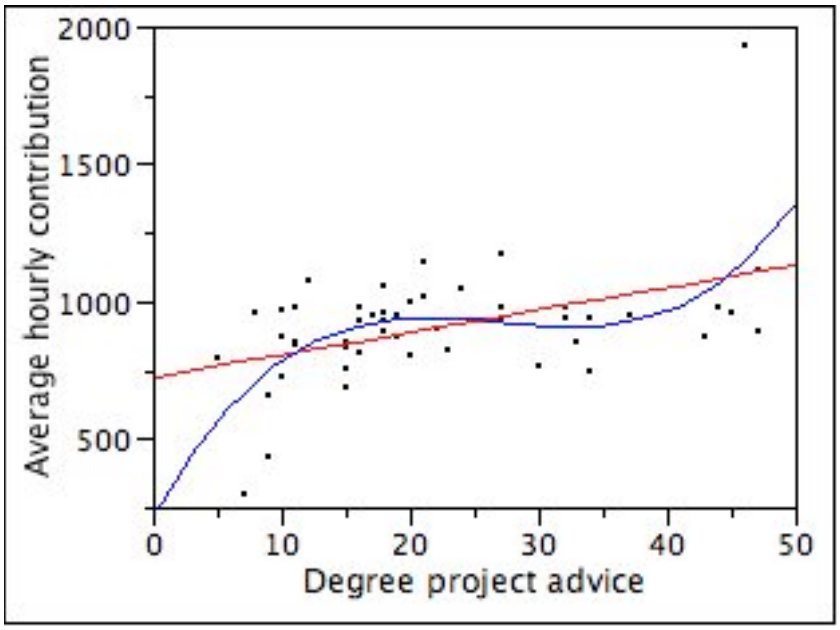
Figure 1: GESTO: Bivariate Fit of Productivity and Social capital



Adjusted no. of projects = -3.80 + 0.34 Degree + 0.09 (Degree-31.2157)^2 + 0.004 (Degree-31.2157)^3

R^2 = 0.44, Adjusted R2 = 0,40, F = 11.91, $p < 0.001$

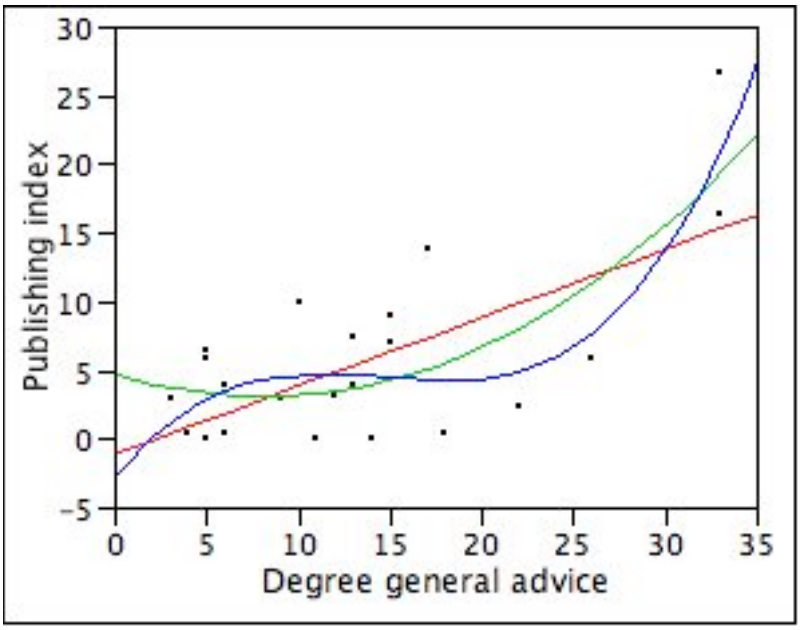
Figure 2: ALPHA: Bivariate Fit of Productivity and Social capital



Hourly contribution = 974.76 - 1.43 Degree project advice - 0.58 (Degree project advice-22.32)^2 + 0.04 (Degree project advice-22.32)^3

R^2 = 0.29, Adjusted R^2 = 0.24, F = 6.19, p = 0.001

Figure 3: BETA: Bivariate Fit of Productivity and Social capital



Publications = 5.82 - 0.09 Degree general advice - 0.01 (Degree general advice-13.3043)^2 + 0.003 (Degree general advice-13.3043)^3

$R^2 = 0.55$, Adjusted $R^2 = 0.51$, $F = 12.47$, $p < 0.001$