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Jörg Claussen Oliver Falck Thorsten Grohsjean

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Fakultät für Betriebswirtschaft

Ludwig-Maximilians-Universität München

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Jörg Claussen[†], Oliver Falck[*], Thorsten Grohsjean‡

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[†]Ifo Institute for Economic Research at the University of Munich, Poschingerstr. 5, 81679 Munich (Germany), Phone: +49 89 9224 1253, Email: claussen@ifo.de.

[*]Ifo Institute for Economic Research at the University of Munich, Poschingerstr. 5, 81679 Munich (Germany), Phone: +49 89 9224 1370, Email: falck@ifo.de, and CESifo. (corresponding author)

‡Imperial College London, South Kensington Campus, London SW7 2AZ (UK), Phone: +44 20 7594 8567, Email: t.grohsjean@imperial.ac.uk.

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Abstract

We analyze the economic effects of a developer's connectedness in the electronic game industry. Knowledge spillovers between developers are likely to be of special relevance in this knowledge-intensive and regionally concentrated industry. We calculate social network measures for a developer's connectedness to other developers at multiple points in time. In a regression in which we exploit within-career variation in social network measures, we find that the number of direct ties a developer has to other developers has a strong effect on both a game's revenues and critics' scores. The quality of indirect ties makes no additional contribution to the game's success.

Keywords: social network analysis, electronic game industry, knowledge spillovers

JEL Classification: L14, L86, D83

1. Introduction

The importance of knowledge spillovers has been emphasized in both the regional context (Jacobs 1969) and in the growth context (Lucas 1988, 2009). Knowledge spillovers result when people at no cost interact and learn from each other.[1] When describing an actor's social interactions, Granovetter (1973, 1983) distinguishes between individuals' strong ties and weak ties. In a close network in which actors are directly connected by strong ties, everyone knows everyone else and knowledge is quickly shared. Some shared past experience or face-to-face contact is necessary to establish close networks, which are based on trust between individuals.[2] By contrast, a wide network that indirectly but weakly connects actors in a network to outside actors offers new opportunities for knowledge inflow; further, "whatever is to be diffused can reach a larger number of people, and traverse greater social distance" (Granovetter 1983, p. 1366). Despite the plausibility of these arguments, it is difficult to empirically identify the economic effects of social interaction since individuals might select into networks on the basis of unobserved characteristics that themselves affect economic outcomes, leading to the possibility that the economic effect of these unobserved characteristics are erroneously attributed to social interactions.[3]

Using measures from social network analysis, we study the economic effects of a developer's connectedness in the electronic game industry.[4] Typically, an electronic game is created by a team of developers.[5] The electronic game industry is an ideal microcosm in which to study the economic effects of a developer's connectedness because it is a highly knowledge-intensive and regionally concentrated industry. Thus, knowledge spillovers via developer networks are likely to be very relevant. We use the "degree centrality" measure to count a developer's direct connections to other developers. A direct connection is defined as forming when two or more parties have worked on a project jointly, i.e., have gained common experience. Degree centrality thus measures how many strong ties a developer has. The "closeness centrality" measure is the inverse of the average number of intermediate actors necessary to connect a developer to any other developer.[6] Given the number of direct ties, closeness centrality thus measures how easy it is for a developer to make

[1]Durlauf (2004) offers a comprehensive survey of the theoretical and empirical literature on group behavior. For a recent survey that focuses on peer effects in schools, see Sacerdote (2011).
[2]The importance of trust is especially emphasized in the literature on social capital (Coleman 1990; Putnam 2000). Sobel (2002) and Durlauf (2002) provide critical literature reviews.
[3]Furthermore, close networks in which actors are directly connected by strong ties are often localized, e.g., within a neighborhood or firm. Members of a network then also share the same environment and it is difficult to disentangle contextual effects of the environment from network effects. For a general discussion on the empirical identification of endogenous social effects, see Manski (1993, 2000).
[4]For a review of social network analysis, see Freeman (2006).
[5]Commercial and academic research, also, is typically done by teams (cf. Fershtman and Gandal (2011) for open-source projects and Goyal, van der Leij, and Moraga-Gonzales (2006) for co-authorships in academia).
[6]For example, let's assume that developer A wants information about a previous project from developer D. A does not know D personally. However, C knows D personally, B knows C personally, and A knows B personally. In this situation, unadjusted closeness centrality is 1/2.

contact with any other developer in the network with whom he or she has no common experience. In other words, conditional on the number of direct ties a developer has, closeness centrality measures the quality of a developer's indirect ties.

We compiled our unique dataset on the electronic game industry from two sources. We use MobyGames, a comprehensive electronic game documentation project, as a source of information about the members of game development teams. These data allow us to calculate both the degree centrality measure and the closeness centrality measure for a developer at any point in time since 1972 at which he or she was involved in a project. We can thus trace the evolution of a developer's network along his or her career. We link these social network measures with revenue information from the NPD database, which includes information for every electronic game commercially released in the United States between 1995 and 2007. Along with revenue, we also use critics' scores from MobyGames as an alternative indicator of a game's success.

To identify a causal effect of a developer's connectedness on a game's success, the analysis needs to address a developer's endogenous choice of the project and firm at which she or he works. Given the special features of our data, we can address this issue by including developer, developing firm, and publishing firm fixed effects. The developer fixed effects control for time-invariant unobserved developer characteristics that are correlated with both the developer's connectedness and his or her contribution to a game's success. Of course, some developing firms and publishing firms are more prestigious than others and the best developers might select into prestigious firms' projects. To address this issue, we only compare projects within the same developing and publishing firm by including developing and publishing firm fixed effects. One problem not addressed by the fixed effects framework is the reciprocal nature of social interaction; that is, the social networks of developers working in the same project team are jointly determined. This might introduce a problem when using a developer's contemporaneous social network measures in a regression in which the outcome variable is team success. We solve this problem by controlling for co-developers' social network measures and by lagging our social network measures. However, lagging social network measures ignores the additional value of the developer's contemporaneous connectedness, which may result in an underestimate of social interaction.

Based on more than 150,000 observations, we find a significantly positive effect of a developer's (lagged) degree centrality measure on a game's success. The result is robust to the inclusion of several control variables, including the game genre, release year and month, team size, developer tenure, and co-developers' social network measures. We also find evidence of heterogeneity of this effect between lead and non-lead developers. By contrast, the developer's closeness centrality measure contributes no additional explanatory power. These results suggest that direct ties foster sharing of knowledge and thus strongly contribute to a game's success, whereas the quality of indirect ties has no significant influence on success.

Our paper is closely related to Fershtman and Gandal (2011; hereafter FG) who study the social network of open-source projects. The open-source model typically implies that source codes are made freely available to all interested parties. Using cross-sectional data, FG construct networks on two levels: the open-source software project level, in order to identify learning effects from working on or studying a particular project, and the developer level, in order to identify learning from interacting with other developers. The latter is the focus of our paper. FG find spillovers to be an important determinant of project success at the project level. However, in contrast to our findings, none of the centrality measures are positively associated with project success at the developer level. These differences between our findings and theirs may be due to the fact that the open-source model allows "anonymous" learning from studying the freely available program codes and thus no personal interaction between developers is necessary for the exchange of knowledge. In the electronic game industry, which is predominately based on a proprietary closed model, the exchange of knowledge between developers who do not work on the same project team requires some kind of interaction between developers as program codes are not freely available.

The remainder of the paper is organized as follows. Section 2 briefly describes central features of the electronic game industry. In Section 3, we set out our estimation strategy, introduce our data, and report the results. Section 4 concludes.

2. The Electronic Game Industry

The electronic game industry encompasses both video and computer games. Video games are developed for game or handheld consoles; computer games are developed for personal computers. In 2010, the electronic game industry had total sales of US$ 15.6 billion. There are two main players on the software side of the electronic game industry: developing firms, which design, create, and code the game, and publishing firms, which provide financing, packaging, marketing, and manage relationships with retailers and console providers. Developing and publishing firms are highly concentrated geographically, as evidenced by the regional clustering of firms in Montréal, Canada (Cohendet, Grandadam, and Simon 2010). Due to government grants, tax allowances, and its bilingual, multicultural workforce's reputation for creativity, Montréal is one of the most important sites for the electronic game industry, home to more than 40 developing firms.

Comparable to commercial and academic research and other product development projects, games are developed by teams. In the electronic game industry, a development team typically includes four main disciplines: producer, game designer, artist, and programmer (Chandler 2009).

Producers manage and track the game development process and ensure that the game is released on time and within budget. Game designers develop the main story, characters, and levels, and devise the game's rules (Novak 2008). Artists create the concept art and graphics. Their tasks include drawing, modeling, texturing, and animation (Chandler 2009). Programmers write the game's code and develop tools the designers and artists need for their work (Novak 2008). Other parts of the game development process include audio design, game testing, and quality assurance, but these tasks typically are outsourced (Novak 2008). We focus on producers, game designers, artists, and programmers when building our social network measures as these positions interact substantially during game creation.

The composition and size of game development teams has changed dramatically over time. In the early years of the industry, a game development team usually consisted of two people: one who conceived the game idea and one who wrote the code for the game. However, several technological changes, such as the introduction of compact discs as a storage medium in the mid-1990s, allowed developing firms to make games look more realistic and be more immersive.[7] Accomplishing this, however, required the talents of various art and cinematographic specialists. Team sizes increased correspondingly, ranging, on average, from 30 to 80 members (Hight and Novak 2008). These days, the development and maintenance of "massively multiplayer online games," i.e., games that can accommodate hundreds of thousands of individuals playing simultaneously in a virtual world across the Internet, requires even larger teams of up to 400 developers. As a consequence of increasing team size, teams are hierarchically separated into lead and non-lead members, with lead members fulfilling mostly supervisory and managerial functions, and non-lead members mostly involved in implementation.

The organizational structure of most firms in the electronic game industry can best be described as project-based with a high level of autonomy. The producer puts together a team that will temporarily work together to create a single game. During the game development process, which usually lasts from one to three years, exchange between developers is intense. Developers from different disciplines often share open-space offices and meet regularly to discuss problems as the success of a game is heavily dependent on the effort of each discipline involved. In addition, work within the same discipline is often done in tandem. One example of this is pair programming: two programmers sit side-by-side and take turns programming and reviewing throughout the day to ensure that the code is of high quality (Zaferakis, Lichius, and Schneider 2007). When the development project is complete, individual team members are usually assigned to other projects. That is, the team as a whole usually does not stay together for more than one project, although

[7] Immersiveness is the quality of feeling like one is in a realistic virtual environment.

parts of the team might work together several times. In addition, although large developing firms try to retain talented people, employee turnover is very high in the gaming sector (Cadin, Guérin, and Defillippi 2006). The high level of employee turnover also translates into a high number of start-ups. Entry barriers in the gaming industry are fairly low, with the quality of the developer team being the most important resource.

Being part of a large network is important for game developers because exposure to a wide variety of ideas either from own experience in different fields (Parnes and Noller 1972) or from interaction with different people (De Dreu and West 2001) is associated with more creativity and innovation. Interaction with other people is also important in that an original idea will only be successful if it is approved by the relevant community or, in other words, creativity is the result of an individual idea in combination with social context in which it is judged (Csikszentmihályi 1999). The intense past joint experience among developers, combined with the regional concentration of the electronic game industry, presumably provides an ideal environment for the exchange of ideas and knowledge between developers, even after a project is finished and even when developers no longer work for the same firm. Not only can a developer contribute the knowledge and ideas acquired through intense interaction with other developers on a previous project, in such an atmosphere, knowledge and ideas also spill from individual to individual when friends who work for different firms swap ideas during informal after-work interaction (Cohendet, Grandadam, and Simon 2010; Cohendet and Simon 2007; Saxenian 1994), or when colleagues who worked together in the past ask each other's advice about a current problem.

3. The Connectedness of a Developer and Success of a Game

3.1. Identification of Social Network Effects

Developers on the same project team are likely to have similar personal characteristics and they work in similar environments. It is thus impossible to disentangle the impact of a developer's connectedness on a game's success from the effects of unobserved individual characteristics and the environment without sufficiently strong assumptions about the nature of individual behavior and social interactions. To address Manski's (1993) *reflection problem,* we consider developer fixed effects, i.e., we only exploit within-career variation of a developer's connectedness. The developer fixed effects control for all time-invariant individual characteristics that might explain a developer's project choice. Obviously, this decision is not the developer's alone; he or she must still be hired by the developing firm. The attractiveness of a game project is also influenced by the publishing firm, which provides the resources for the game's development. These resources could have a direct impact on the game's success, and will also be somewhat determinative of the size and composition of the project team. In addition to developer fixed effects, we thus also include developing firm and publishing firm fixed effects. The developing firm and publishing firm fixed effects extract firm-specific components that do not vary over time.

One problem not addressed by the fixed effects framework is the reciprocal nature of social interaction that likely introduces simultaneity problems when using contemporaneous social network measures, i.e., the social networks of developers working on the same project team are jointly determined. This might cause a problem in a regression in which team success is regressed on developer-level social network measures. We solve this problem by (1) controlling for co-developers' social network measures and (2) lagging our social network measures. Lagging social network measures ignores the value of the intense exchange between developers during the game development process and focuses only on the value of the direct or indirect exchange of knowledge and ideas between former colleagues. We thus presumably underestimate the value of social interaction in the electronic game industry.

Our estimation equation is:

$$S_{igdpt} = \alpha_i + \alpha_d + \alpha_p + \beta_1 D_{igdpt-1} + \beta_2 C_{igdpt-1} + CV_{igdpt}\gamma + \varepsilon_{igdpt} \qquad (1)$$

S is a measure of success for game g of developing firm d and publishing firm p. Our social network measures are at the level of the individual developer i. Thus, the outcome variable is the same for all developers in a game project. We consider this nested structure of our data by clustering the error term ε_{igdpt} at the game level. α_i are developer fixed effects. Thus, we consider only those developers that were engaged in at least two game projects over time t. α_d are fixed effects for the developing firm; α_p are publishing firm fixed effects. α_t is a full set of dummies for the year a game was launched. These time dummies control for macroeconomic influences or changes in preferences toward electronic games in general. The time dummies also account for technological progress in gaming devices. Other control variables are included in the matrix CV_{igdpt}, including developer tenure, project team size, and co-developers' social network measures, as well as dummies for licensed titles, genre, release month, and platform.

To measure the connectedness of the individual developer, we use two lagged social network measures: the degree centrality measure D and the closeness centrality measure C. Degree centrality is a measure of a developer's direct connections. A direct connection is defined as forming when two (or more) developers jointly work on a game project. It is thus a proxy for strong ties. We calculate degree centrality relative to the size of the network:

$$D_{igdpt} = \frac{direct\ connections\ to\ other\ network\ members}{number\ of\ network\ members - 1} \qquad (2)$$

The closeness centrality measure is the inverse of the average length of paths from one developer to all other developers in the game industry, whereby the developers are again connected by having worked on joint game projects. Closeness centrality is thus a measure of the quality of the ties:

$$C_{igdpt} = \left(\frac{\textit{cumulated path to other network members}}{\textit{number of network members}-1}\right)^{-1} \quad (3)$$

The shorter the average path length from the focal developer to all other developers, the higher the value of the measure. Conditional on the degree centrality measure, β_2 gives us the additional impact of the quality of indirect ties on a game's success. Calculation of the network measures is explained in greater detail in the next section.

3.2. Data from the Electronic Game Industry

Our data are derived from two sources: MobyGames and the NPD database. MobyGames is the largest video game documentation project in the world, with the stated ambition of "meticulously catalog[ing] all relevant information about electronic games."[8] In 2010, the database listed more than 49,000 games, 19,000 of which had full information on genre, platform, release date, and the individuals and firms that developed and published the game. All information is provided by users of the site on a voluntary basis. The data set is highly reliable as MobyGames has a strict set of coding instructions and requires all entries to be peer reviewed before they are published.

We use the MobyGames data from the beginning of the industry in 1972 up to 2007 in calculating our two social network measures, i.e., degree centrality and closeness centrality. The MobyGames data include information on all developers who participated in the development of a game. Based on these data, we create networks in which two developers are directly connected if they have worked together on a project.[9] We construct networks for every year from 1995 on, with the networks becoming larger over time. That is, the 1995 network contains all developers active between 1972 and 1995 and their connections formed from games released between 1972 and 1995. The 1996 network includes all connections initiated until 1996 and so on. We thus calculate cumulative network measures.[10]

The MobyGames data are then combined with revenue data collected by the NPD Group, a consumer market research firm. The NPD Group has systematically tracked retail sales of electronic games and game consoles in the United States and Canada since 1995, covering all distribution

[8] For more details, see http://mobygames.com.
[9] We use the program *Pajek* to calculate the network measures (available at http://pajek.imfm.si).
[10] We thus implicitly give direct ties that formed from having worked on a joint project 10 years ago the same weight as ties formed one year ago, meaning that we ignore the possibility of forgotten or now impossible (e.g., due to death) ties (Holan and Phillips 2004).

channels, including online sales.[11] The latest available revenue data date from December 2008. From NPD, we calculate the commercial success of a game, measured as the natural logarithm of all revenues generated by a game within the first 12 months after its release.[12] We focus on the first 12 months as a typical game makes most of its profits in that period, with revenue usually peaking in the second month. This approach of comparing game revenues within the first 12 months after release instead of comparing revenues in a given year means we are not making the mistake of comparing apples to oranges, i.e., games in different stages since release. After merging NPD data with the MobyGames data, our sample includes all games that were released between January 1995 and December 2007.

We use critics' scores as a measure of *qualitative success*. Game critics are opinion leaders for hardcore gamers, but they also have some influence on casual gamers through specialized magazines and websites. We use the critics' scores that MobyGames has collected from the leading game magazines and websites.[13] Critics' scores range from 0 to 100. However, since critics' scores are subjective and may systematically differ between scorers, we normalize the scores by subtracting the critic's mean score over all games and then dividing by the critic's standard deviation over all games. For a single game, we then derive our variable *critics' score* as the mean of all normalized critics' scores judging the respective game.

We also include the following control variables.[14]

Leading Position. This dummy variable indicates whether a person occupies a leading position on the development team and is thus chiefly involved in management, or whether the person is an ordinary team member and is therefore mainly active in the actual implementation of the game.

Tenure. We measure the person's tenure as the number of years between the year the person was first involved in game development and the year the game under study was introduced. Conditional on tenure, a developer's cumulative network measures increase only when a developer's connectedness increases more than average by joining a new project.

[11]The NPD database is also used by other researchers (e.g., Shankar and Bayus 2003; Venkatraman and Lee 2004; Clements and Ohashi 2005; Stremersch, Tellis, Franses, and Binken 2007).

[12]Revenues are deflated to 1995 US$. Total revenues of the game industry are driven by blockbuster products (McGahan 2004). For example, the best-selling game in 2008, "Wii Sports," made more than US$ 400 million; however, another top-10 game, "New Super Mario Bros," made only about a quarter of that (see Figure A.1). We use the natural logarithm of revenues to account for this skewness in revenue distribution.

[13]We use only those magazines and websites that have rated a minimum of 10 games.

[14]Descriptive statistics and pair-wise correlations for all variables are reported in Tables 1 and 2, respectively. Histograms of our key variables are shown in Figures A.2. through A.7.

Team Size. As more complex games with detailed and realistic graphics require larger teams, the size of the developer team might have a positive influence on game performance. Hence, we control for team size in our regression.

Licensed Game. Since “blockbusters” play such a huge role in the electronic game industry, more and more frequently developing firms are using intellectual property from movies or books (e.g., Harry Potter or Indiana Jones) or from sports leagues and player associations (e.g., NFL or FIFA) in an attempt to appeal to the mass market.[15] To control for external intellectual property, we include a dummy equal to unity if a game is based on external intellectual property.

Release Month. Due to the high seasonality of the electronic game industry, with its demand and supply peaks occurring during the holiday season and during important trade fairs, we include a dummy for the month in which the game is released.

Genre. Like movies and books, electronic games can be classified into genres, such as role-play games or first-person-shooter games. We use the genre classification from the NPD data, which distinguishes between 50 different categories. We control for genre as it can heavily influence market potential and, therefore, the success of a game.

Platform. Since an electronic game is designed for one or multiple platforms, its success will depend on the diffusion of the targeted platform(s). Thus, games developed for more popular platforms have higher market potential, but also face stiffer competition. Hence we include dummies for each of the 23 platforms observed in our sample.

INSERT TABLE 1 HERE

INSERT TABLE 2 HERE

3.3. The Impact of a Developer’s Connectedness on a Game’s Success

Based on the estimation strategy introduced in Section 3.1, Tables 3 and 4 report our estimation results with cluster (game) robust standard errors.[16] Table 3 report results with a game’s commercial success as the outcome measure; Table 4 reports results with critics’ scores as the outcome

[15] Electronic Arts 2005 Annual Report, http://analist.be/reports/electronic_arts-2005.pdf.

[16] Clustering the standard errors at the more conservative developing-firm level only marginally changes the standard errors of the estimated coefficients.

measure. In all specifications, we include fixed effects for the developer, developing firm, publishing firm, and time, as well as a set of controls (cf. Section 3.2).

INSERT TABLE 3 HERE

INSERT TABLE 4 HERE

In Column (3-1) of Table 3 and Column (4-1) of Table 4, social network measures are contemporaneous. There is a significant positive association of degree centrality with both success measures, but closeness centrality contributes no additional explanatory power. Taking the results from Column (4-1) as an example and assuming that we can interpret our results as causal effects, all else equal, a one standard deviation increase in a game developer's direct ties increases the game's revenue in the first year by about 0.02 percentage points. For a top-10 game, which might generate revenues of more than US$ 100 million, this translates into an increase in revenue of more than US$ 20,000 per developer. The development team for a top-10 game often includes as many as 50 members, meaning that if degree centrality of the average team member increases by one standard deviation, revenues will increase by more than US$ 1 million.

In Columns (3-2) and (4-2), social network measures are lagged, but there is still a significant positive coefficient for our degree centrality measure. The coefficient is somewhat smaller compared to the results in Columns (3-1) and (4-1), which is what we expected since this approach ignores the additional value of the developer's contemporaneous connectedness. The coefficient for lagged closeness centrality is not significantly different from zero.

In Columns (3-3), (3-4), (4-3), and (4-4), we also control for average (lagged) degree centrality and average (lagged) closeness centrality of the developer's co-developers. Again, we find a significant positive association of the individual developer's degree centrality measure. The coefficient for closeness centrality remains insignificant.

When looking at the results for our control variables, we find that tenure has no significant influence. Results do not change qualitatively when including higher order polynomials of tenure. Not surprisingly, we see a strongly significant positive influence of team size on both success measures. Interestingly, licensed games generate higher revenues but receive lower critics' scores.

Perhaps this is because licensed content appeals to the mass market, resulting in higher revenue, but critics rate original and creative ideas more highly.

In a next step, we take advantage of our information as to whether a developer is in a leading position and therefore chiefly engaged in management, or whether he or she is mainly active in game implementation. We allow the variable "leading position" to interact with our social network measures so as to be able to identify differences between leading and non-leading developers.

Estimation results with standard errors clustered at the game level are reported in Table 5. The effect of a developer's closeness centrality measure is not significantly different from zero, neither for the group of lead developers, nor for the group of non-lead developers. However, there are interesting differences in the effect of degree centrality between the two groups of developers. When using revenue as the measure of success, leaders' degree centrality has a significantly positive effect on a game's success, whereas non-leaders' degree centrality has no significant effect on the game's success. In contrast, when critics' score is the dependent variable, leaders' degree centrality has no significant effect on a game's success, but non-leaders' degree centrality has a significantly positive effect on the game's success, at least in one specification (Column 5-3). Apparently, the two measures are tapping into different dimensions of success, which is also reflected in the low correlation of 0.375 between the two measures (cf. Table 2). The results suggest that different knowledge is necessary to succeed on each dimension.

INSERT TABLE 5 HERE

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4. Conclusion

In this paper, we investigate the extent to which a developer's connectedness to other developers influences the success of a project in the knowledge-intensive and regionally concentrated electronic game industry. Given the features of the electronic game industry, knowledge spillovers between developers are likely to be of special relevance. Based on a comprehensive dataset covering the electronic game industry since its infancy, we calculate developers' connectedness measures at different points in time. We find that the number of direct ties a developer has (degree centrality), i.e., the number of other developers a developer has worked with on joint game projects, has a strong and economically meaningful impact on the success of a game, measured by revenues and critics' scores. We also find evidence for the heterogeneity of this effect between lead and non-lead developers. By contrast, we find no additional impact from the quality of a developer's indirect ties to other developers (closeness centrality). These results suggest that direct ties are indeed important in the game industry, but that the quality of indirect ties is not. We argue that our results, which are derived from fixed effects regressions with lagged connectedness measures, plausibly can be interpreted as causal effects of a developer's connectedness on a game's success. Our results are arguably applicable to other industries that are predominately based on a proprietary closed model and work in teams.

References

Cadin, Loic; Guérin, Francis and Defillippi, Robert. 2006. "HRM Practices in the Video Game Industry: Industry or Country Contingent?" *European Management Journal*, 24(4), pp. 288–98.

Chandler, Heather M. 2009. *The Game Production Handbook.* Sudbury, MA: Jones and Bartlett Publishers.

Clements, Matthew T. and Ohashi, Hiroshi. 2005. "Indirect Network Effects and the Product Cycle: Video Games in the U.S., 1994–2002." *Journal of Industrial Economics*, 43(4), pp. 515–42.

Cohendet, Patrick; Grandadam, David and Simon, Laurent. 2010. "The Anatomy of the Creative City." *Industry & Innovation,* 17(1), pp. 91–111.

Cohendet, Patrick and Simon, Laurent. 2007. "Playing Across the Playground: Paradoxes of Knowledge Creation in the Videogame Firm." *Journal of Organizational Behavior*, 28(5), pp. 587–605.

Coleman, James S. 1990. *Foundations of Social Theory*. Cambridge, MA: Harvard Univ. Press.

Csikszentmihályi, Mihaly. 1999. "Implications for a Systems Perspective for the Study of Creativity." In: *Handbook of Creativity*, ed. by Robert J. Sternberg. New York: Cambridge University Press, pp. 313–35.

De Dreu, Carsten K. W. and West, Michael A. 2001**"**Minority Dissent and Team Innovation: The Importance of Participation in Decision Making.**"** *Journal of Applied Psychology*, 86(6), pp. 1191–1201.

Durlauf, Steven N. 2002. "On the Empirics of Social Capital." *Economic Journal*, 112(483), F459–79.

Durlauf, Steven N. 2004. "Neighborhood Effects." In: *Handbook of Regional and Urban Economics*, Vol. 4, ed. by J. Vernon Henderson and Jacques-Francois Thisse. Amsterdam: Elsevier Science, pp. 2173–2242.

Fershtman, Chaim and Gandal, Neil. 2011. "R&D Spillovers: The 'Social Network' of Open Source Software." *RAND Journal of Economics*, 42, pp. 70–91.

Freeman, Linton. 2006. *The Development of Social Network Analysis*. Vancouver: Empirical Press.

Goyal, Sanjeev M.; van der Leij, Marco J. and Moraga-Gonzalez, José L. 2006. "Economics: An Emerging Small World." *Journal of Political Economy,* 114(2), pp. 403–12.

Granovetter, Mark S. 1973. "The Strength of Weak Ties." *American Journal of Sociology*,78(6), pp. 1360–80.

Granovetter, Mark S. 1983. "The Strength of Weak Ties: A Network Theory Revisited." *Sociological Theory,* 1, pp. 201–33.

Hight, John and Novak, Jeannie. 2008. *Game Development Essentials: Game Project Management.* Clifton Park, NY: Thomson Delmar Learning.

Holan, Martin de and Phillips, Nelson. 2004. "Remembrance of Things Past? The Dynamics of Organizational Forgetting." *Management Science*, 50(11), pp. 1603–13.

Jacobs, Jane. 1969. *The Economy of Cities*. New York, NY: Vintage.

Lucas, Robert. 1988. "On the Mechanics of Economic Development." *Journal of Monetary Economics*, 22(1), pp. 3–42.

Lucas, Robert. 2009. "Ideas and Growth." *Economica*, 76(301), pp. 1–19.

Manski, Charles F. 1993. "Identification of Endogenous Social Effects: The Reflection Problem." *Review of Economic Studies*, 60(3), pp. 531–42.

Manski, Charles F. 2000. “Economic Analysis of Social Interactions.” *Journal of Economic Perspectives,* 14(3), pp. 115–36.

McGahan, Anita M. 2004. *How Industries Evolve: Principles for Achieving and Sustaining Superior Performance*. Boston, MA: Harvard Business School Press.

Novak, Jeannie. 2008. *Game Development Essentials: An Introduction.* Clifton Park, NY: Thomson Delmar Learning.

Parnes, Sidney J. and Noller, Ruth B. 1972. **“**Applied Creativity: The Creative Studies Project—Part II: Results of the Two-Year Program.” *Journal of Creative Behavior*, 6(3), pp. 164–86.

Putnam, Robert D. 2000. *Bowling Alone: The Collapse and Revival of American Community*. New York, NY: Simon and Schuster.

Sacerdote, Bruce. 2011. “Peer Effects in Education: How Might They Work, How Big Are They and How Much Do We Know Thus Far?” In: *Handbook of the Economics of Education*, ed. by Eric A. Hanushek, Steven Machin, and Ludger Woessmann. Amsterdam: North-Holland (Elsevier), pp. 249–78.

Saxenian, A. 1994. *Regional Advantage: Culture and Competition in Silicon Valley and Route 128*. Cambridge, MA: Harvard University Press.

Shankar, Venkatesh and Bayus, Barry L. 2003. “Network Effects and Competition: An Empirical Analysis of the Home Video Game Industry.” *Strategic Management Journal*, 24(4), pp. 375–84.

Sobel, Joel. 2002. “Can We Trust Social Capital?” *Journal of Economic Literature*, 40(1), pp. 139–54.

Stremersch, Stefan; Tellis, Gerard J.; Franses, Philip H. And Binken, Jeroen L. G. 2007. “Indirect Network Effects in New Product Growth.” *Journal of Marketing,* 71(3), pp. 52–74.

Venkatraman N. and Lee, Chi-Hyon. 2004. “Preferential Linkage and Network Evolution: A Conceptual Model and Empirical Test in the U.S. Video Game Sector.” *Academy of Management Journal*, 47(6), pp. 876–92.

Zaferakis, Andrew; Lichius, Benand and Schneider, Ben. 2007.“A Day in the Life: Three Slices of Life from the Front Lines of Game Development.” *Game Career Guide*, 4, pp. 31–36.

Figures and tables

Table 1: Summary statistics

VARIABLE	N	Mean	SD	Min	Max
ln(Revenue)	151677	14.958	1.701	4.264	19.440
Critics' score	146675	0.007	0.781	-3.831	2.223
Degree centrality D_{igdpt}	148627	0.001	0.002	0.000	0.041
Closeness centralityC_{igdpt}	148627	0.205	0.038	0.052	0.338
Leading position	151677	0.213	0.410	0	1
Tenure	151677	3.871	4.254	0	28
Team size	151677	65.780	53.234	1	297
Licensed game	151677	0.362	0.480	0	1

Table 2: Pair-wise correlations

VARIABLE		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ln(Revenue)	(1)	1.000							
Critics' score	(2)	0.375	1.000						
Degree centrality D_{igdpt}	(3)	-0.009	0.016	1.000					
Closeness centralityC_{igdpt}	(4)	0.022	-0.079	0.212	1.000				
Leading position	(5)	-0.070	-0.049	-0.092	0.003	1.000			
Tenure	(6)	0.040	-0.023	-0.053	0.062	0.236	1.000		
Team size	(7)	0.280	0.150	-0.034	0.254	-0.136	0.015	1.000	
Licensed game	(8)	0.055	-0.210	-0.023	0.056	0.001	0.026	0.086	1.000

Table 3: Baseline regression results with revenue as success measure

	(3-1)	(3-2)	(3-3)	(3-4)
	DEPENDENT VARIABLE: ln(Revenue)			
Degree centrality D_{igdpt}	8.494*	8.029*	7.281**	6.512*
	(4.468)	(4.342)	(3.321)	(3.644)
Closeness centrality C_{igdpt}	-0.137	-0.307	-0.105	-0.223
	(0.201)	(0.217)	(0.155)	(0.174)
Co-worker degree c. $\bar{D}_{-igdpt}$			40.20	56.53
			(60.77)	(45.38)
Co-worker closeness $\bar{C}_{-igdpt}$			-0.548	-3.122
			(3.059)	(2.567)
Tenure	0.0170	0.0612	0.0236	0.0676
	(0.0618)	(0.0886)	(0.0664)	(0.0932)
Team size	0.00447***	0.00396***	0.00446***	0.00394***
	(0.000937)	(0.000990)	(0.000938)	(0.000991)
Licensed game	0.192***	0.172**	0.193***	0.171**
	(0.0720)	(0.0771)	(0.0721)	(0.0774)
Network measures lagged	No	Yes	No	Yes
Observations	151484	94597	151443	94388
Number developers	56944	30993	56937	30956
Within-developer R^2	0.635	0.638	0.635	0.638
Between-developer R^2	0.802	0.742	0.798	0.736
Overall R^2	0.736	0.689	0.734	0.684

Notes: Fixed-effect OLS point estimates with standard errors clustered at the project level in parentheses. As the panels are not nested within the clusters, a degree of freedom adjustment is conducted, producing conservative results for the standard errors. Asterisks denote significance levels (*** p<0.01, ** p<0.05, * p<0.1). All specifications control for fixed effects on the level of the developer, the developing firm, the publishing firm, the release year, the release month, the genre, and the platform, but results are not reported here.

Table 4: Baseline regression results with critics' score as success measure

	(4-1)	(4-2)	(4-3)	(4-4)
	DEPENDENT VARIABLE: Critics' score			
Degree centrality D_{igdpt}	4.043**	3.880*	2.889*	3.175*
	(2.047)	(2.143)	(1.623)	(1.845)
Closeness centralityC_{igdpt}	0.0113	-0.150	0.0170	-0.109
	(0.0998)	(0.110)	(0.0795)	(0.0890)
Co-worker degree c. $\overline{D}_{-igdpt}$			50.71*	20.70
			(29.32)	(21.34)
Co-worker closeness$\overline{C}_{-igdpt}$			0.570	-1.492
			(1.555)	(1.312)
Tenure	-0.0248	0.0198	-0.0254	0.0219
	(0.0300)	(0.0423)	(0.0323)	(0.0444)
Team size	0.00203***	0.00180***	0.00203***	0.00180***
	(0.000502)	(0.000524)	(0.000503)	(0.000526)
Licensed game	-0.276***	-0.265***	-0.274***	-0.264***
	(0.0363)	(0.0389)	(0.0363)	(0.0390)
Network measures lagged	No	Yes	No	Yes
Observations	146522	91897	146481	91703
Number developers	55843	30635	55835	0.722
Within-developer R²	0.542	0.540	0.543	0.541
Between-developer R²	0.708	0.723	0.706	0.722
Overall R²	0.654	0.663	0.654	0.661

Notes: Fixed-effect OLS point estimates with standard errors clustered at the project level in parentheses. As the panels are not nested within the clusters, a degree of freedom adjustment is conducted, producing conservative results for the standard errors. Asterisks denote significance levels (*** p<0.01, ** p<0.05, * p<0.1). All specifications control for fixed effects on the level of the developer, the developing firm, the publishing firm, the release year, the release month, the genre, and the platform, but results are not reported here.

Table 5: Results for interactions of the network measures with leading position

	DEPENDENT VARIABLES			
	(5-1)	(5-2)	(5-3)	(5-4)
	ln(Revenue)		Critics' score	
Degree centrality D_{igdpt}	5.746	4.573	4.058*	2.856
	(4.938)	(3.786)	(2.249)	(1.846)
Closeness centrality C_{igdpt}	-0.116	-0.0885	0.0168	0.0174
	(0.217)	(0.172)	(0.108)	(0.0886)
Leading position	-0.0385	-0.0432	-0.0123	-0.0189
	(0.0758)	(0.0756)	(0.0405)	(0.0405)
Leading position * D_{igdpt}	10.14	9.944	-0.0909	0.0775
	(6.490)	(6.455)	(3.532)	(3.551)
Leading position * C_{igdpt}	-0.0332	-0.0159	-0.0184	0.00451
	(0.301)	(0.300)	(0.161)	(0.161)
Co-worker degree c. $\overline{D}_{-igdpt}$		40.71		50.85*
		(60.75)		(29.32)
Co-worker closeness $\bar{C}_{-igdpt}$		-0.546		0.567
		(3.059)		(1.555)
Tenure	0.0171	0.0237	-0.0248	-0.0253
	(0.0617)	(0.0664)	(0.0300)	(0.0323)
Team size	0.00445***	0.00445***	0.00203***	0.00202***
	(0.000937)	(0.000938)	(0.000502)	(0.000503)
Licensed game	0.192***	0.193***	-0.275***	-0.274***
	(0.0720)	(0.0721)	(0.0363)	(0.0363)
Network measures lagged	No	No	No	No
Observations	151484	151443	146522	146481
Number developers	56944	56937	55843	55835
Within-developer R^2	0.635	0.635	0.542	0.543
Between-developer R^2	0.803	0.800	0.706	0.706
Overall R^2	0.737	0.734	0.653	0.653
Degree centrality $\mathrm{D_{igdpt}}$ +	15.89**	14.52**	3.967	2.933
(Leading position * $\mathrm{D_{igdpt}}$)	(6.213)	(5.694)	(3.310)	(3.124)

Notes: Fixed-effect OLS point estimates with standard errors clustered at the project level in parentheses. As the panels are not nested within the clusters, a degree of freedom adjustment is conducted, producing conservative results for the standard errors. Asterisks denote significance levels (*** p<0.01, ** p<0.05, * p<0.1). The last two lines are not part of the regression results but represent the coefficient of a linear combination together with the respective standard error in parentheses (calculated with Stata command *lincom*). All specifications control for fixed effects on the level of the developer, the developing firm, the publishing firm, the release year, the release month, the genre, and the platform, but results are not reported here.

Appendix

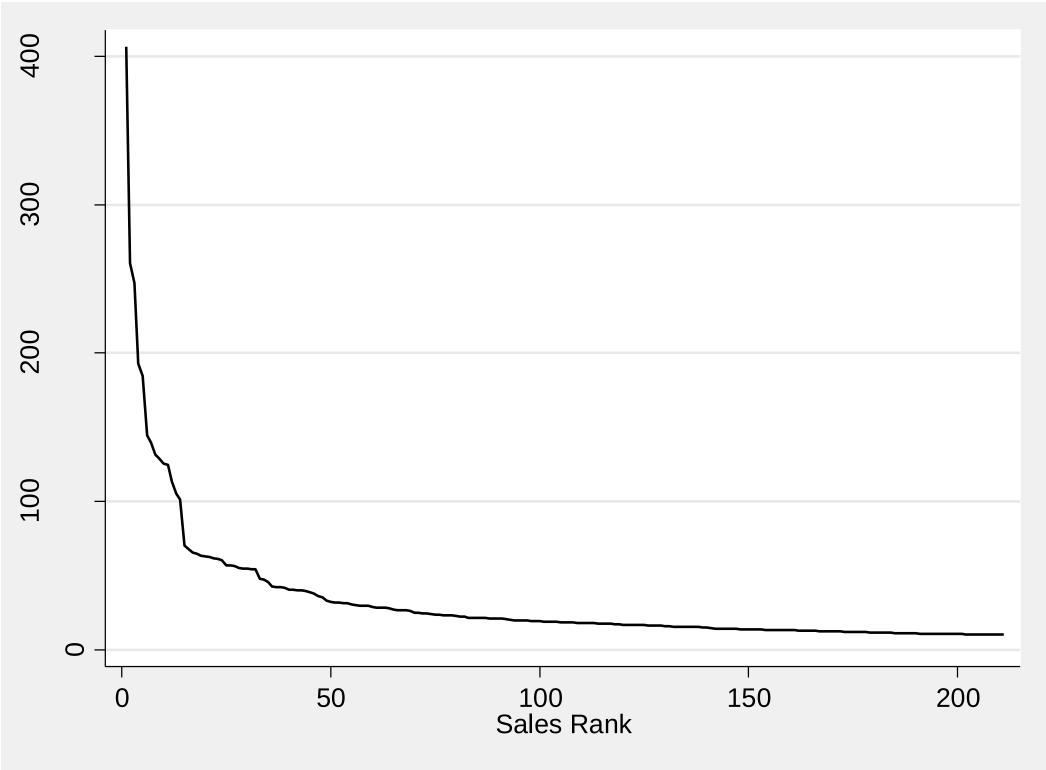

Figure A.1: Revenue and sales rank for all electronic games in the United States in 2008

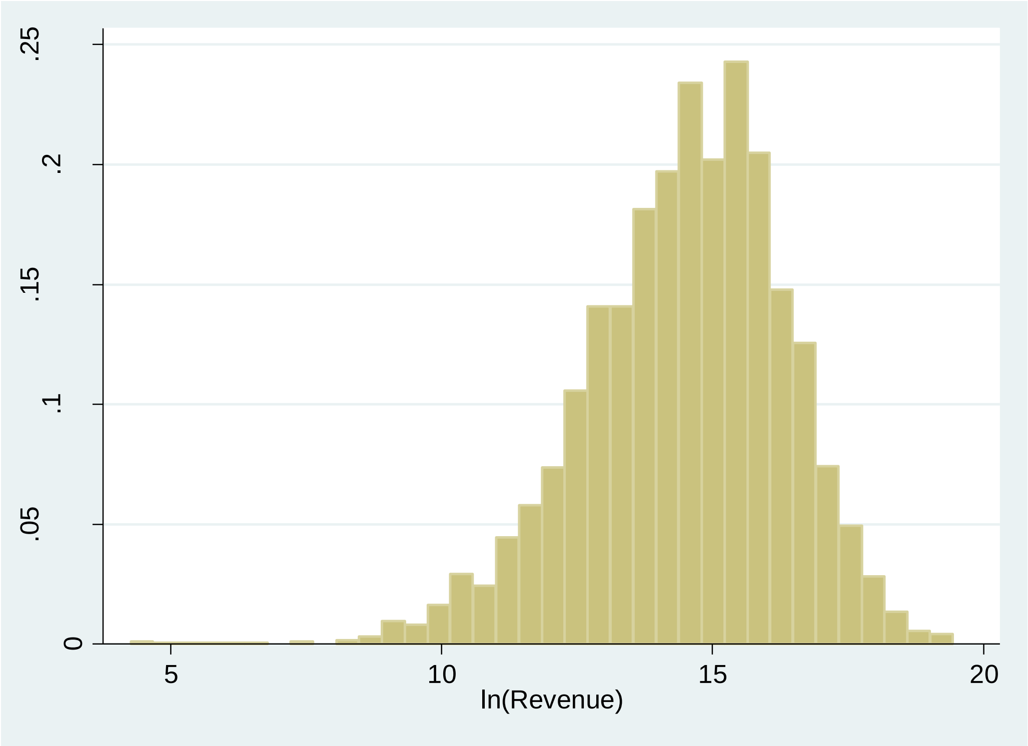

Figure A.2: Histogram for variable ln(Revenue)

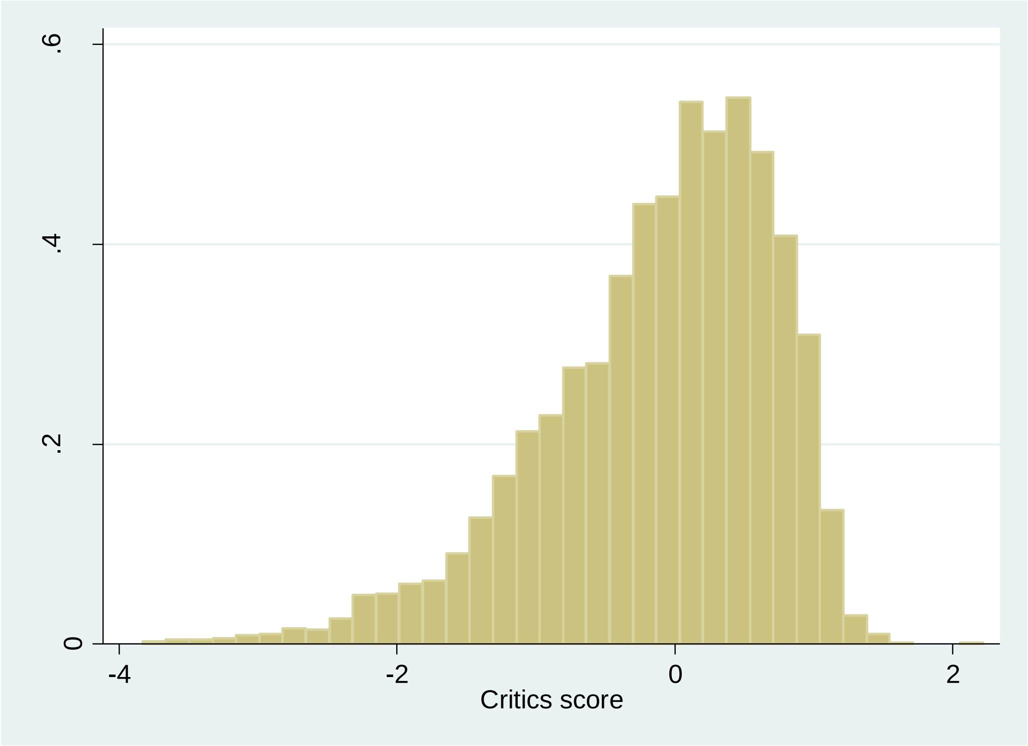

Figure A.3: Histogram for variable critics' score

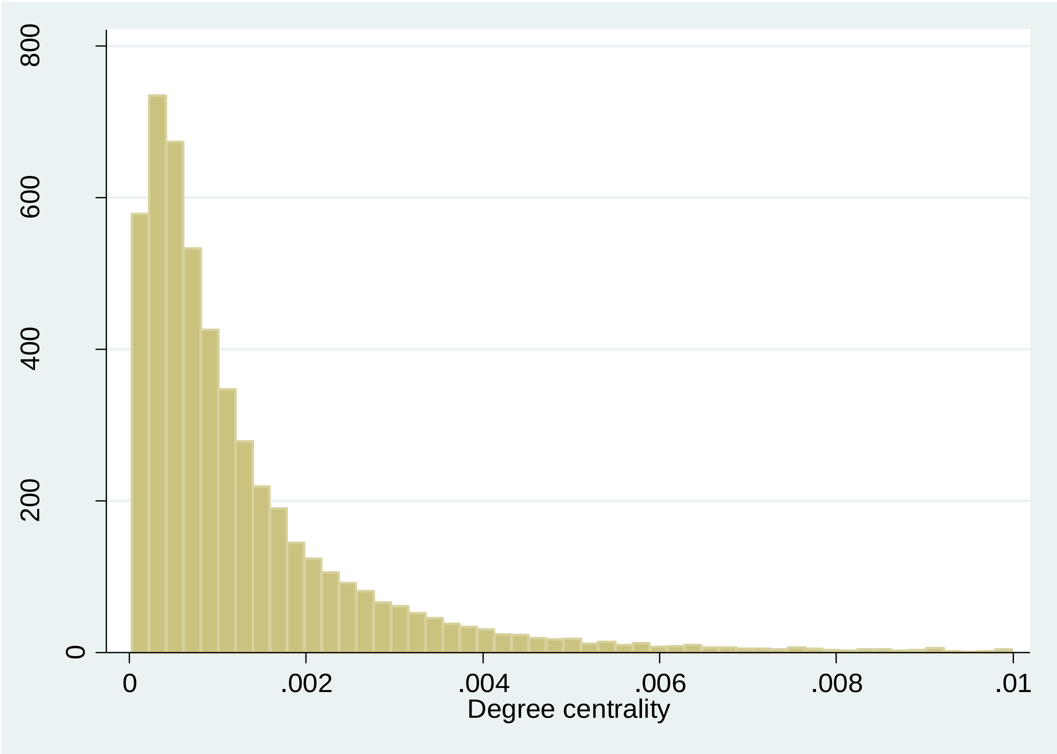

Figure A.4: Histogram for variable degree centrality

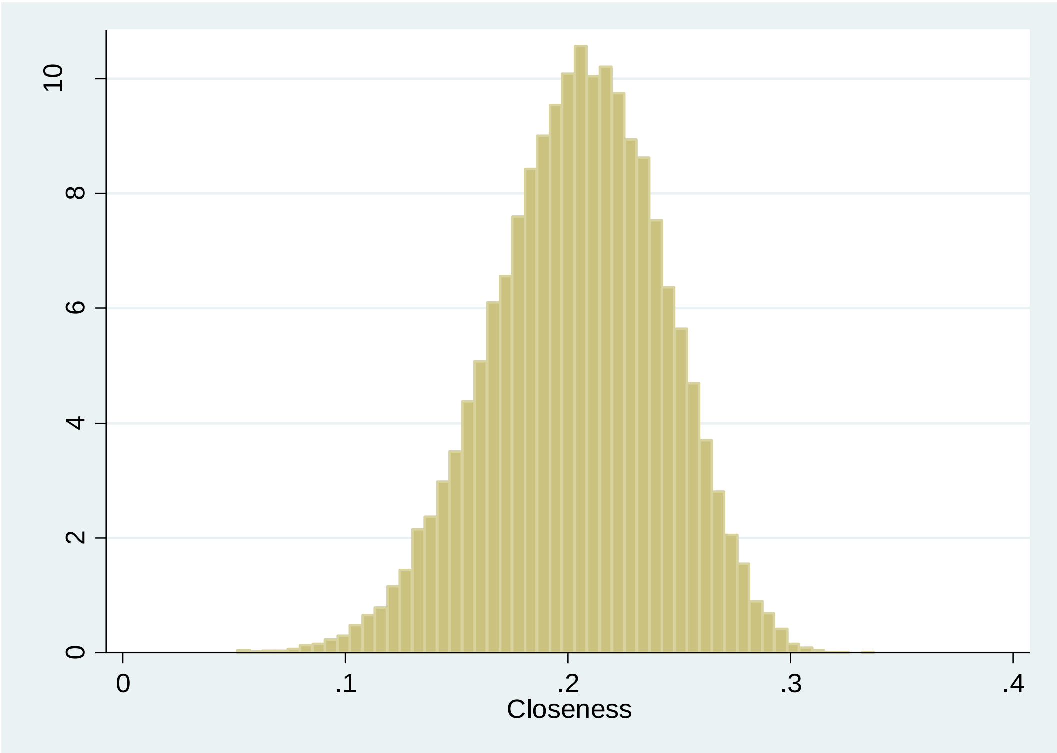

Figure A.5: Histogram for variable closeness

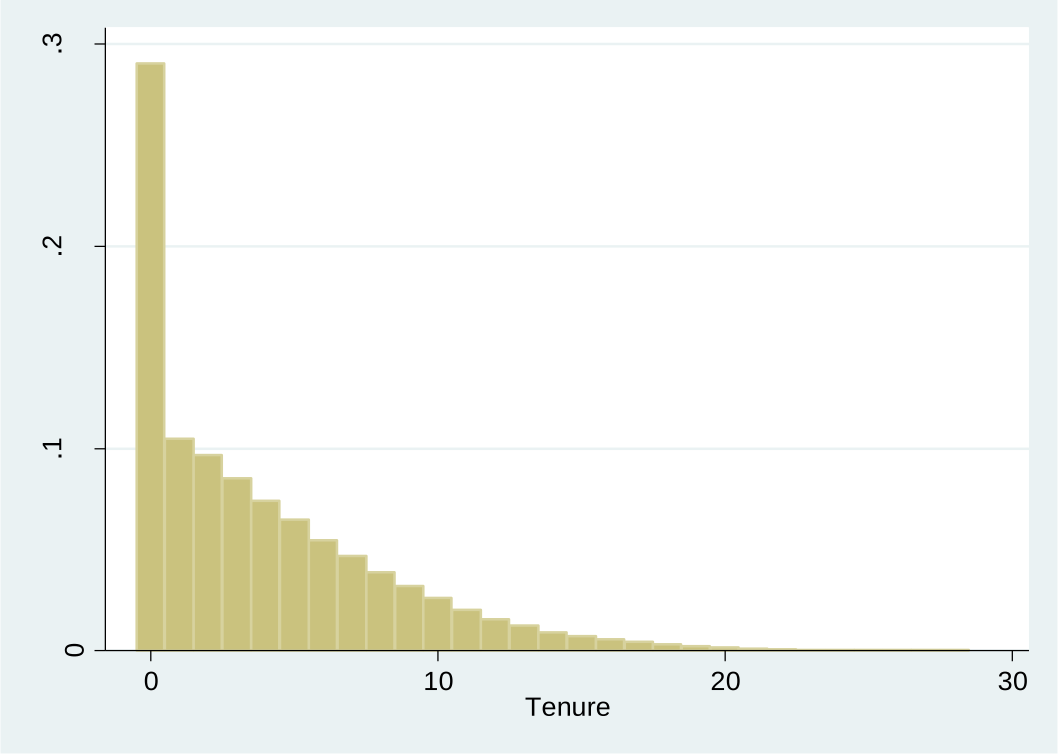

Figure A.6: Histogram for variable tenure

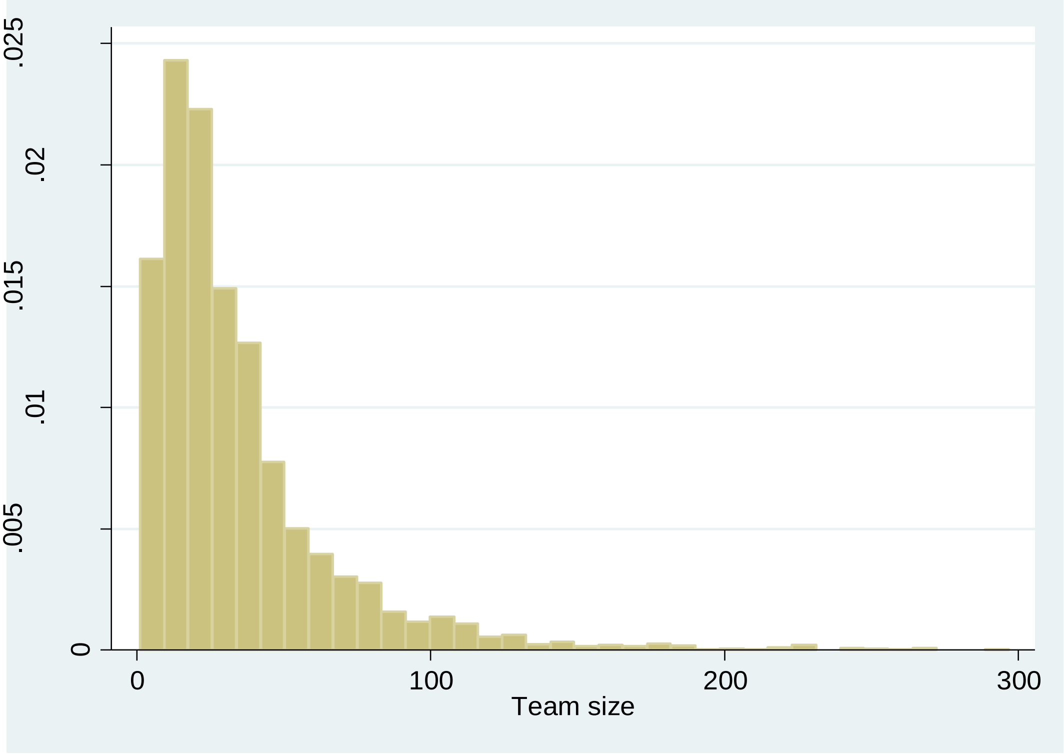

Figure A.7: Histogram for variable team size