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ABSTRACT

What makes you popular at school? And what are the labor market returns to popularity? We investigate these questions using an objective measure of popularity derived from sociometric theory: the number of friendship nominations received from schoolmates, interpreted as a measure of early accumulation of personal social capital. We develop an econometric model of friendship formation and labor market outcomes allowing for partial observation of networks, and provide new evidence on the impact of early family environment on popularity. We estimate that moving from the 20th to 80th percentile of the high-school popularity distribution yields a 10% wage premium nearly 40 years later.

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1 Introduction

Intelligence has long been emphasized as a major determinant of success in life (Herrnstein and Murray [1994]), but there is mounting evidence of the importance of other social skills for a range of social, economic and health outcomes (Bowles *et al.* [2001], Heckman *et al.* [2006], Conti *et al.* [2010]). There is also evidence that successful early childhood interventions work primarily through the development of non-cognitive skills (Heckman *et al.* [2012]). Measurement of these skills is difficult, and still under development (Almlund et al. [2011]). One strand of research uses scales based on self-reports and reports by parents and teachers, which are relatively easy to gather but have potential shortcomings. It has been found that parents' and teachers' ratings can differ systematically from each other and those of the children themselves and professional psychiatric assessors (Pepler and Craig [1998], Fergusson and Horwood [1987], Rosenthal and Jacobsen [1968], Johnston et al [2011]). Another strand uses measures of participation in high school social activities to proxy for social skills (Barron *et al.* [2000], Glaeser *et al.* [2002], Postlewaite and Silverman [2005], Kuhn and Weinberger [2005]).

In contrast with the previous literature we import methods from social network analysis, see, for example, Burt [1976], Borgatti and Everett [1992], Coleman [1961], Wasserman and Faust [1994]. The basic idea is to derive from observed school friendship networks sociometric measures of individuals' relational attributes and to analyse their determinants and their association with adult outcomes.[1] Hence, our proxy for social skills is based on information about interpersonal relationships that is more reliable than self-reports. We use detailed information on high school friendship relations collected from respondents to the Wisconsin Longitudinal Study (WLS), who were asked to report the names of up to three best friends from their senior class in high school. Friendship nominations are by nature

[1]Researchers in this tradition have found that sociometric proxies of social skills are correlated with prosocial qualities and the absence of antisocial behavior. In addition, there are significant differences in the characteristics associated with sociometric measures of social skills, either self-perceived or reported by peers (Parkhurst and Hopmeyer [1998]).

directed and this leads to an important conceptual distinction. If Paul nominates John as his friend, he reveals his affection towards John. In receiving a claim of friendship, John is socially approved by Paul. We can then distinguish students on the basis of the number of friendship nominations they give, which we term the *out-degree* of friendship, and the number of friendship nominations they receive, termed the *in-degree*. We are not the first to use network data to analyze the effect of social connections on individual behavior (see Bramoullé and Fortin [2009] for a recent review). Most existing work, however, focuses on short-run outcomes (Calvó-Armengol *et al.* [2009]), does not analyze the determinants of social connections (an exception is Bandiera *et al.* [2009]), or does not attempt to estimate jointly network formation and individual behavior.[2]

The precise definition of a reference group is one of the strengths of our approach. Contrary to many papers in the literature on social interactions, which use a broad definition of reference group, the use of network data allows us to identify individuals within pre-specified group boundaries.[3] It is also worth emphasizing that the focus on the senior class strengthens the power of our measures of adolescent social standing. Adolescents have been exposed to interactions in different contexts, from mathematics courses to athletics and extracurricular activities. This implies that the pool of individuals who can be nominated is much larger than in cases where the boundaries are restricted to a particular course.

We also make a methodological contribution. A major obstacle to research on social networks is that it is rarely possible to observe the whole network together with individuals' long term economic outcomes. The WLS samples only one in three of the students in each class, which means that many students do not receive as many nominations as they would if every member of the class were polled. For each sampled individual we observe the out-degree fully (subject to the censoring limit of three nominations) but have partial observability of the in-degree, since nominations are only recorded from schoolmates who

[2]The only two examples closer to our work are Weinberg [2006] and Mihaly [2009]. However, we adopt a more structural modeling approach.

[3]See Conley and Topa [2003] on the effect that different definitions of reference group have on estimating local spillovers.

happen to be included in the WLS sample. Thus, the observed in-degree differs from the true in-degree by a non-classical measurement error, which has a complicated distribution with non-zero mean and correlation with the true in-degree. For this reason, instrumental variable methods do not give consistent estimates and are not appropriate here. Instead, we develop a pseudo-likelihood-based approach to dealing with this problem which takes account of the sampled nature of the network data. The basic idea is to estimate simultaneously the outcome of interest together with the friendship formation process. The latter is modeled as the probability that a student would be nominated by a randomly-selected member of his class (in-degree probability), and the probability that a randomly-selected class member would be nominated by him (out-degree probability). More generally, we show how to analyze data from partially sampled social networks with a censored number of possible links. Given the difficulties of sampling complete networks, we expect our method to have wide applicability and to be used to investigate the effect of adolescent social standing on other outcomes, such as health and risk behavior.

We now give an overview of the main results. We consider three groups of determinants of friendship nominations. The first refers to the child's early family environment. In line with earlier research on the effects of early family life on long-term cognitive and behavioral outcomes (Repetti *et al.* [2002]), our results show a positive association between a warm early family environment and the number of friendship nominations given and received. The second group of determinants are the proportions of classmates who share similar characteristics with the respondent. There is a lot of evidence documenting a tendency for various types of individuals to associate with others who are similar to themselves, a phenomenon that Lazarsfeld and Merton [1954] termed *homophily*. Homophily has since been documented across characteristics such as age, race, gender, religion and occupations (Fong and Isajiw [2000], Moody [2001], McPherson *et al.* [2001]). Type-sensitive preferences and matching bias are the two main mechanisms used to explain these patterns (Currarini *et al.* [2008]). We use indicators of common nationality, family background and friends' characteristics

to capture preference-based homophily, and find a strong positive association between the degree of group homogeneity and in-degree and out-degree of friendships. The last set of determinants capture the respondent's relative position among schoolmates: we find that relatively older and smarter students are more popular, while relative family income status plays only a minor role.

We then analyze the effects of in-degree and out-degree of friendship on adult economic success as measured by the wage. While the out-degree has no effect, we find a positive effect of the in-degree. For a median individual, an increase in the stock of social skills sufficient to move up by one decile is equivalent on average to one additional friendship nomination in high school. This increase in social skills is associated with a 2% wage advantage 35 years later, which is roughly 40% of the return accruing to one more year of education. This holds after accounting for a wide range of observable attributes – family background, school quality, cognitive ability, human capital, and adult personality traits and social capital – and for unobserved residual heterogeneity.[4]

Why would the in-degree of friendship in high school matter for subsequent economic attainment? One possible interpretation is that connections established in high school are maintained throughout the life-cycle and produce positive spillovers, such as privileged access to job opportunities. However, controlling for variables which reflect adult social capital and the current job being found through friends does not reduce the magnitude and significance of our estimated association – indeed, the in-degree effect appears to be stronger among those who migrate from Wisconsin to pursue their careers.

A more plausible interpretation is that the number of friendship nominations received is a reflection of the popularity of a student among his schoolmates, which is a measure of his skill in building positive personal and social relationships and adjusting to the demands of a social situation. During secondary school the individual's initial reference points

[4]Note that the strength of the popularity effect relative to the return to education is partly due to the low rate of return found in WLS data when measures of ability, family background, etc., are included in the wage equation.

of "generation-superiors" such as parents, class teacher from elementary school and other significant adults are gradually superseded by new reference groups. In this new reference system students come to occupy differentiated positions as an immediate consequence of their own interpersonal behavior (which may have been shaped by their childhood experience) and of what others consider appropriate conduct.[5] Large parts of an individual's role performance when adult, as an employee in a team of co-workers for example, will also be in association with status-equals or near-equals. By that time, an individual needs to have acquired and developed the appropriate social skills: understand the "rules of the game" – how to gain acceptance and social support from colleagues, whom to trust and when to reciprocate. Thus, social interactions within the group of classmates provide the bridge to the adult world as they train individual personalities to be socially adequate for the successful performance of their adult roles. Consistent with this view, we interpret our measure of popularity as a measure of the stock of social skills of a particular individual, rather than a measure of an innate personality trait. It is the productive skill itself that is rewarded in the labor market, rather than friendships *per se*. We return to this issue of interpretation in section 3.2 below.[6] The remainder of the paper is organized as follows. We describe the data and the econometric methodology in section 2 and we present the results in section 3. We conclude in section 4 discussing possible policy implications of our findings.

[5]In a study of Illinois high schools, Coleman [1961] finds that students identify themselves as belonging to social categories such as nerds, geeks, leading crowd and others. Students tend to differentiate themselves along two major dimensions: 'cognitive achievement' as measured by grades, and 'social approval' as reflected by leadership roles in extracurricular student activities and participation in high school athletics. See Akerlof and Kranton [2002] for a review and economic interpretation of the sociological literature on education.

[6]This view of the school class as an agency of socialization was emphasized by Talcott Parsons [1959] in his seminal work on the school class as a social system.

2 Data and econometric methodology

2.1 Friendship relations among young men in the WLS

The WLS is a random, one-third sample of all seniors in Wisconsin high schools in 1957. Survey data were collected from the original respondents or their parents in 1957, 1964, 1975, 1993 and 2004, and from a selected sibling in 1977, 1994 and 2005. The data provide rich information on socio-economic background, mental ability, educational attainment, family formation, and labor market history.[7] The WLS sample is broadly representative of white, non-Hispanic Americans who have completed at least a high school education. In this paper, to avoid difficulties arising from the lower rate of labor force participation among women of the WLS generation, we restrict our analysis to men. Of the 10,317 WLS respondents, 4,991 are men, and we use information on the 4,330 male respondents to the 1975 questionnaire who provided names of their best friends in 1957. For more detailed information on the WLS see Sewell *et al.* [2001].

Our main variables of interest are adolescent friendship ties and adult earnings. We measure the former from responses to the 1975 Telephone Questionnaire, where respondents were asked to report the names of up to three same-sex best friends from their senior class in high school. Student i is recorded as having a tie with student j if i claims his friendship to j. We do not have information about the strength of the friendship relations, which are therefore dichotomous: either a relation exists or it does not. Relations are also directed: i may claim friendship to j, but the reverse is not necessarily true. These asymmetries allow us to distinguish students on the basis of the number of friendship nominations made, which we term the *out-degree* of friendship, and that received, termed the *in-degree* of friendship.

There is always a possibility of bias in retrospective data, although one could argue that friendships recalled years later are in fact the "real" friendships, while ones perceived

[7] The exact sampling rate is 0.31. Table A1 in the online appendix: http://iserwww.essex.ac.uk/home/spudney/wp-content/uploads/2012/07/Popularity_final_15July2012_APPENDIX1.pdf gives detailed information on the variables we use, the wave at which they were collected and the survey instrument used.

at the time might be transient (we are unaware of any empirical evidence on this point). A particular concern is the possibility of biased recollection in favor of those friends who turn out to be economically successful, which would impart a positive bias to the empirical association between wages and measured popularity. However, note that the relatively long recall period works in our favor here. Recall bias in favor of successful friends can only occur if the respondent knows who is and who is not successful. For this to be so, the respondent must still be in touch, directly or indirectly, 18 years later. Since the probability of being in touch and thus aware of the friend's eventual success is less than 1, the retrospective nature of the data reduces this bias. Two further pieces of evidence suggest that selective recall is not a source of serious bias. First, the distribution of out-degree of friendship is consistent with previous studies, which do not use retrospective information: for example, Ennett and Bauman [2000] give sample proportions nominating one, two and three best friends as 17%, 32% and 41% respectively, which match closely the WLS proportions presented in Table 1 below. Second, the selective recall hypothesis also suggests that there will be a larger estimated popularity effect for people who remained in Wisconsin, and whose success is therefore more visible to old schoolmates, than for those who migrated elsewhere (bear in mind that these measurements pre-date digital communication technology). We report below a test which rejects this hypothesis.

The WLS design imposes several restrictions. First, students are asked to report names of friends within the same school and grade. This raises the boundary specification problem (Laumann *et al.* [1983]). Previous empirical studies suggest that this is not a severe problem in the context of adolescent friendship networks. For example, Ennett and Bauman [2000] consider friendship networks among ninth graders in North Carolina in 1980. Each student was asked to nominate up to three best friends, without restriction to friends from school. In their sample of roughly 1,100 students, 95% of friendship links were within the same school. However, the boundary issue may be important for students in single-sex schools and we return to this in section 3.1 below.

Second, the questionnaire design censors the number of possible friendship nominations at three[8] and, due to random sampling, we only have partial observation of the nominations that would have been received by the sampled students had the sample been exhaustive. While we observe all the ties nominated by sample members towards individuals both inside and outside the sample (the out-degree of friendship), we miss the claims of friendship with sampled members which would have been made by classmates who are not sampled in the WLS. Thus, the observed in-degree differs from the true in-degree by a non-classical measurement error taking non-positive values, with a complicated distribution which is not independent of the true in-degree. Our estimation strategy addresses all these issues.

There are other possible sociometric measures of social status, such as Proximity and Centrality. Such measures go further by taking into account indirect relationships, reflecting the popularity of the people whose friendship is received by the individual. Our use of only the most direct sociometric definition of social status is due to the lack of complete information on the social network and the difficulty of extending sample-based analysis to more complex measures. If the appropriate notion of popularity is better measured by these intensity-sensitive indicators, we would expect our analysis to capture only part of the popularity effect and thus to understate the true effect. However, in most networks that have been studied empirically, there is a high correlation between degree and other more complex measures, so we would not expect bias from this source to be a significant problem. See Borgatti and Everett [1992] and Wasserman and Faust [1994] for discussion of different notions of position and their applicability in several areas of social network analysis.

Table 1 gives summary statistics on the observed partial in-degree, $\tilde{k}_i$, and out-degree, m_i, and reveals substantial variation in both measures. Roughly 11% of respondents give zero nominations, 15% give one, 30% report two and 44% nominate three friends. The average

[8]See Holland and Leinhard [1973] for a discussion of the right-censoring by vertex degree introduced by this fixed-choice design. Note that, although out-degree is censored at 3, our measurement approach allows us to relate the out-degree wage effect to the latent uncensored out-degree. Moreover 56% of respondents give 0, 1 or 2 nominations and some proportion of those making 3 nominations are also uncensored), so there is a fair amount of uncensored variation in the sampled in-degrees.

number of individuals observed per graduating class is close to 170 students, ranging from a minimum of 6 to a maximum of 482. The 661 men who did not respond to the friendship nomination question were excluded from the sample and treated as missing at random. We are able to check this assumption by comparing the measured in-degree for respondents and non-respondents to the friendship questionnaire. For the latter, the proportions receiving $0, 1, 2, 3$ nominations were respectively 0.655, 0.254, 0.077 and 0.009, which are similar to the distribution for respondents shown in Table 1. A formal t-test of the difference in mean nomination rates is insignificant ($P = 0.241$).

Table 1 In-degree and out-degree distributions

No. of nominations	*In-degree*		*Out-degree*	
	n	Sample %	n	Sample %
0	2,598	60.00	483	11.15
1	1,191	27.51	644	14.87
2	398	9.19	1,275	29.45
3	106	2.45	1,928	44.53
4	29	0.67	-	-
5	6	0.14	-	-
6	2	0.05	-	-

2.2 A model of early friendship and adult economic success

The determination of friendship relationships at the individual level depends on the characteristics of both parties, whereas the sampling structure of the WLS does not reveal the characteristics of members of the social network who are not captured by the sampling scheme. Our solution to this partial observability problem is to specify a model which, for each member of our sample, allows inward and outward friendship nominations to depend on the characteristics of the two individuals concerned, but then to marginalize with respect to the characteristics of the other party, so that the estimated form of the model is expressed in terms of observable characteristics of the sample members alone.

The model of friendship envisages an important role for homophily. We can check this assumption to a limited extent from the WLS data, since we observe the characteristics of

any nominated friend who happens to be included in the random sample. We see only mild evidence of homophily with respect to family income, since the correlation between family income of nominators and nominees is 0.15. There is much stronger evidence for IQ, with a correlation of 0.33, and homophily is also evident in indicators of family background: for example, only 8% of nominations by the sons of fathers without a college education are of classmates with college-educated fathers, but that proportion rises to 35% for the sons of college graduates. There is little evidence for homophily in the available measures of personality traits since the nominator-nominee correlations for extroversion, agreeableness, conscientiousness, neuroticism and openness measures are all below 0.1, but those trait measurements are made much later in adulthood and it is likely that the low correlations are largely due to personality changes that may have occurred between high school and mid-life.

Let $\mathcal{N}$ be a school class[9] in our data set with size N, and let $\mathcal{S} \subset \mathcal{N}$ be the sampled group in class $\mathcal{N}$ and assume it has size $n = |\mathcal{S}|$. We make the basic assumption that the actual class is a random sample from a superpopulation of individuals who might potentially have been in that class. A male individual $i \in \mathcal{S}$ is described uniquely by two vectors of observable variables $\mathbf{y}_i, \mathbf{v}_i$ and an unobservable u_i. $\mathbf{y}_i$ contains variables which determine the form his preferences take; $\mathbf{v}_i$ is a vector specifying the personal characteristics that he looks for in a friend and we assume that similarity in terms of $\mathbf{v}$ and u is the basis of friendship choices. The characteristics influencing preferences ($\mathbf{y}_i$) need not coincide with the subject of those preferences ($\mathbf{v}_i$).[10] For any pair of classmates i and j with characteristics $(\mathbf{y}_i, \mathbf{v}_i, u_i)$ and $(\mathbf{y}_j, \mathbf{v}_j, u_j)$, the probability that person i perceives a friendship with person j is:

$$Pr\left(\text{friendship } i \to j | \mathbf{y}_i, \mathbf{v}_i, u_i, \mathbf{y}_j, \mathbf{v}_j, u_j, s\right) = \psi\left(\mathbf{y}_i, \mathbf{v}_j - \mathbf{v}_i, u_i, u_j, s\right) \tag{1}$$

where s is a set of descriptors of the school. The probability that someone chosen at random

[9] Defined here as the whole grade-group, not the size of an individual teaching group.

[10] For example, living in a particular neighborhood ($\mathbf{y}$=location) may predispose one to friendship with a particular ethnic group ($\mathbf{v}$=ethnicity). The distinction between $\mathbf{y}$ and $\mathbf{v}$ is that i's probability of a friendship nomination for j depends on $\mathbf{v}_j$ but not $\mathbf{y}_j$ (note that $\mathbf{y}$ may be empty). Because we marginalize with respect to j's characteristics, we do not have to specify which variables are in $\mathbf{y}$ and which in $\mathbf{v}$.

from the class would be nominated by person i as a friend, conditional only on the school's and person i's characteristics (the out-degree probability) is:

$$\lambda\left(\mathbf{y}_i, \mathbf{v}_i, u_i, s\right) = E_{v_j,u_j}\left\{\psi\left(\mathbf{y}_i, \mathbf{v}_j - \mathbf{v}_i, u_i, u_j, s\right)\right\} \tag{2}$$

and the analogous probability that person i would be nominated as a friend by someone chosen at random from the class (the in-degree probability) is:

$$\pi\left(\mathbf{v}_i, u_i, s\right) = E_{y_j,v_j,u_j}\left\{\psi\left(\mathbf{y}_j, \mathbf{v}_i - \mathbf{v}_j, u_j, u_i, s\right)\right\} \tag{3}$$

Now let $\mathbf{x}_i$ be the observable vector $(\mathbf{y}_i, \mathbf{v}_i, s)$, so the in-degree and out-degree probabilities can be written in general terms as $\pi\left(\mathbf{x}_i, u_i\right)$ and $\lambda\left(\mathbf{x}_i, u_i\right)$.[11] Note that $\lambda\left(\mathbf{x}_i, u_i\right)$ and $\pi\left(\mathbf{x}_i, u_i\right)$ are reduced form constructs which depend not only on i's friendship preferences but also on the structure of the class group and the distribution of others' preferences.

Define k_i as the number of class members who would, if interviewed, nominate student i as a friend, while $\tilde{k}_i$ is the number of such people who appear in the sample. So, $\tilde{k}_i$ is the observed in-degree, k_i is the "true" in-degree of friendship of individual i and, since $k_i \geq \tilde{k}_i$, there is an inherent downward bias in the crude in-degree measure, $\tilde{k}_i$. Although the observed in-degree $\tilde{k}_i$ is an error-prone measure of the true k_i, it is important to realize that the measurement error is non-classical: it has non-zero mean and is not independent of the true k_i. Consequently, IV estimation does not provide consistent estimates in this context.

Let m_i be the number of people that the individual i thinks of as friends. Under the assumption that the actual class group is a random sample from a superpopulation of individuals who might potentially have been in that class, k_i and m_i have binomial $[N-1, \pi(\mathbf{x}_i, u_i)]$ and $[N-1, \lambda(\mathbf{x}_i, u_i)]$ distributions, respectively. Since the sampling of WLS participants is random, $\tilde{k}_i$ has a hypergeometric $[N-1, n-1, k_i]$ distribution conditional on k_i. The joint

[11] The in-degreee probability π is the joint probability of being thought of as a friend and being nominated in response to the survey. It should therefore be interpreted as incorporating the probability of response to the friendship question.

distribution of $(k_i, m_i, \tilde{k}_i)$ is therefore:

$$f(k_i, m_i, \tilde{k}_i|\mathbf{x}_i, u_i) = \binom{N-1}{k_i}\pi(\mathbf{x}_i, u_i)^k[1-\pi(\mathbf{x}_i, u_i)]^{N-1-k}$$

$$\times\binom{N-1}{m}\lambda(\mathbf{x}_i, u_i)^m[1-\lambda(\mathbf{x}_i, u_i)]^{N-1-m}\binom{k_i}{\tilde{k}_i}\binom{N-1-k_i}{n-1-\tilde{k}_i}/\binom{N-1}{n-1} \quad (4)$$

Our aim is to understand the effect of differences in adolescent social standings on subsequent adult economic success, allowing for the possibility of spurious correlation induced by the persistent unobservable factor, u_i. To do this, we assume that the subsequently-observed log earnings variable, w_i, has a conditional Gaussian density, with linear mean function:

$$\mu(\mathbf{z}_i, u_i, m_i, k_i) = \beta_0 + \mathbf{z}_i\boldsymbol{\beta}_1 + \beta_2 u_i + \beta_3 m_i + \beta_4 k_i$$

The conditional wage distribution is then:

$$f(w_i|\mathbf{z}_i, u_i, m_i, k_i) = \sigma^{-1}\phi\left(\frac{w_i - \mu(\mathbf{z}_i, u_i, m_i, k_i)}{\sigma}\right),$$

where $\mathbf{z}_i$ is a set of covariates, σ^2 is the residual variance and $\phi(.)$ is the N(0,1) density. We use a ML approach, based on the following likelihood:

$$P(m_i, \tilde{k}_i, w_i|\mathbf{x}_i, \mathbf{z}_i) = \quad E_u\left[\sum_{k_i=\tilde{k}_i}^{N-1} f(k_i, m_i, \tilde{k}_i|\mathbf{x}_i, u)f(w_i|\mathbf{z}_i, u, m_i, k_i)\right] \quad \text{if } m_i < 3$$

$$E_u\left[\sum_{k_i=\tilde{k}_i}^{N-1}\sum_{m=3}^{N-1} f(k_i, m_i, \tilde{k}_i|\mathbf{x}_i, u)f(w_i|\mathbf{z}_i, u, m_i, k_i)\right] \quad \text{if } m_i \geq 3 \quad (5)$$

where E_u denotes an expectation with respect to a known distribution for the unobserved effect u. We assume a Gaussian density for u. Thus the likelihood function has the form of a single or double summation within an integral and we use Hermite quadrature for the integration step. The expression (5) is the marginal likelihood for a single individual i. A

pseudo-likelihood function for the full sample of I individuals is constructed as:

$$L = \prod_{i=1}^{I} P(m_i, \tilde{k}_i, w_i | \mathbf{x}_i, \mathbf{z}_i).$$

This is not a full likelihood function, since it does not reflect the stochastic dependence between the individuals sampled within the same class and therefore does not generate asymptotically efficient estimates. The sample comes from a set of class groups, generating clusters of realisations of the jointly-dependent variables: $(y_{11}...y_{1n_1}), (y_{21}...y_{2n_2}), ...,$ with independence between clusters but dependence within. The joint distribution of $\boldsymbol{y}_g = (y_{g1}...y_{gn_g})$ is $f_g(\boldsymbol{y}_g; \theta)$ and this has marginals $f_{gi}(y_{gi}; \theta)$ $(i = 1..., n_g)$, where θ is the parameter vector. The pseudo log-likelihood based on the marginals is $L^* = \sum_g \sum_i \ln f_{gi}(y_{gi}; \theta)$, with pseudo-score $\partial L^*/\partial\theta = \sum_g \sum_i \partial \ln f_{gi}(y_{gi}; \theta)/\partial\theta$, which has expectation $E\partial L^*/\partial\theta = \sum_g \sum_i E(\partial \ln f_{gi}(y_{gi}; \theta)/\partial\theta)$. The inner expectation involves a function of y_{gi} only, and therefore requires only the marginal density for its construction. Then we write in the usual way that $E(\partial \ln f_{gi}(y_{gi}; \theta)/\partial\theta = \int \{[\partial f_{gi}(y_{gi}; \theta)/\partial\theta]/f_{gi}(y_{gi}; \theta)\} f_{gi}(y_{gi}; \theta^0) dy_{gi}$. Evaluated at $\theta = \theta^0$, this reduces to $\int [\partial f_{gi}(y_{gi}; \theta^0)/\partial\theta^0] dy_{gi} = \partial\{\int f_{gi}(y_{gi}; \theta^0) dy_{gi}\}/\partial\theta^0 = 0$, under standard regularity conditions, since $f_{gi}(y_{gi}; \theta^0)$ integrates identically to 1. This means that consistency is achieved as the number of clusters goes to infinity, provided a local identification assumption is also satisfied. However, by neglecting the within-cluster dependence, we sacrifice efficiency relative to (intractable) true maximum likelihood. Standard errors and test statistics are derived from the usual 'sandwich' asymptotic approximation to the covariance matrix, which adjusts for within-class clustering of the sample.

In this model, identification comes from two sources. The first is the specific binomial and hypergeometric distributional forms entailed by the sampling structure. Unusually, the distributional form (4) is dictated by the sampling structure and is not an arbitrary approximation. The second source of identifying information is the exclusion from the wage equation of covariates which appear in the friendship part of the model (see the discussion

on homophily and respondent's characteristics relative to class norm in the introduction). This is not formally necessary for identification, since we have *a priori* information on the distributional form of observed in-degree and out-degree. Nevertheless, exclusions sharpen identification and are testable. We return to this in the section below.

3 Results

We present estimates for four specifications of the wage equation, all including the in-degree k and the out-degree m as wage determinants. All variants of the model use the same vector of covariates, $\mathbf{x}$, for the in-degree and out-degree equations, but use different covariates, $\mathbf{z}$, in the wage equation.[12] In the first specification, $\mathbf{z}$ only includes measures of family background, school quality and location; the second introduces additional measures for cognitive ability and human capital, the third includes covariates reflecting adult social capital, marital status and job search methods, and the final specification adds late-measured personality traits. We first discuss the results for the determinants of the in-degree and out-degree of friendship, summarized in Table 2, then the results for wages, which are presented in Table 3. Full parameter estimates are given in the online Appendix Table A2.

3.1 In-degree and out-degree of friendship

Table 2 summarizes the friendship components of the model by means of marginal effects of variations in $\mathbf{x}$ on the expected in-degree and out-degree, averaged over all sampled individuals:

$$M_{in} = n^{-1} \sum_{i=1}^{n} \frac{\partial \left[N\pi(\mathbf{x}_i, u = 0) \right]}{\partial \mathbf{x}_i} \qquad M_{out} = n^{-1} \sum_{i=1}^{n} \frac{\partial \left[N\lambda(\mathbf{x}_i, u = 0) \right]}{\partial \mathbf{x}_i}.$$

[12] We have experimented with different covariates also in the friendship part of the model and the results are not sensitive to such changes.

Table 2 Marginal effects on expected out-degree and in-degree from the full model (3) of friendship structure and wages

Covariate	Out-degree		In-degree	
	Effect	Std.err.	Effect	Std.err.
Respondent's location and size of school				
Rural area	1.437***	(0.109)	1.477***	(0.252)
Small town	1.184***	(0.099)	1.477***	(0.198)
Large town	-0.704***	(0.118)	-0.635***	(0.213)
Graduating class size	0.018***	(0.001)	0.022***	(0.001)
Respondent's childhood family ties				
Mother's affection	0.375***	(0.068)	0.767***	(0.174)
Only child	0.164***	(0.039)	0.136	(0.086)
Aggressive sibling	-0.635***	(0.041)	0.070	(0.101)
Respondent's characteristics relative to class norm				
Deviation from mean IQ	0.163***	(0.070)	0.382***	(0.070)
Deviation from mean year of birth	0.217***	(0.071)	-0.265***	(0.063)
Deviation from mean income	0.029**	(0.012)	0.036	(0.025)
Respondent's school composition: Homophily[1]				
Proportion males in class	0.234**	(0.111)	-4.163***	(0.265)
Parental origin	1.355***	(0.103)	2.470***	(0.476)
Religion	0.681***	(0.121)	0.477	(0.311)
Father high school educated	0.655***	(0.102)	1.463***	(0.500)
Father college educated	-0.491**	(0.187)	-1.055***	(1.021)
Mother high school educated	0.483***	(0.049)	0.577**	(0.263)
Mother college educated	1.282***	(0.100)	0.329	(0.562)
Father managerial/professional	1.304***	(0.199)	2.395***	(0.900)
Mother managerial/professional	2.708***	(0.447)	-0.321	(2.744)
Friends with job plans	0.274	(0.145)	1.255***	(0.347)
Friends with college plans	1.091***	(0.094)	1.598***	(0.232)
Individual effect	1.390***	(0.102)	2.381***	(0.117)

[1] Homophily covariates with respect to a given characteristic are constructed as a dummy for the child himself possessing that characteristic × the proportion of the class also possessing it.
Statistical significance: * = 10%; ** = 5%; *** = 1%

We consider three groups of variables which are potentially important for the formation of friendship ties and therefore for the location of a student in the friendship network. The first group relates to the respondent's childhood family environment, represented by only-child status, the quality of the sibling relationship and the closeness of the mother-child relationship. Overall, the estimates show that a warmer family environment during childhood is associated with a significantly higher degree of adolescent social engagement. The strongest of these effects are the positive impact of a close maternal relationship on the

expected in-degree and out-degree (of 0.8 and 0.4 respectively); and the negative impact (of 0.6) of a poor sibling relationship on the expected out-degree. This underlines the importance of the early family environment for subsequent adolescent social life and acquisition of non-cognitive skills. We also find some evidence that siblings and friends are substitutes, since only-children have a slightly higher out-degree probability, suggesting that they look for external social contacts.

The second group of covariates relates to the characteristics of the respondent and his family relative to the class norm: class-mean deviations of the students' IQ, year of birth and family income. We find a tendency for high-IQ students to nominate more friends and to be popular in turn, suggesting that high ability students might be more attractive as peers and better understand the opportunities arising from social interactions. However, the effect is modest: a 1-standard deviation increase in IQ leads to an increase of around 0.16 in the expected out-degree, and a larger effect of 0.38 in the in-degree. There is significant evidence of a positive effect of relative family income only on expected out-degree: the point estimate suggests that a 1-standard deviation increase in relative income increases expected out-degree by around 1.8, but with a wide 90% confidence interval of ± 1.2. Being relatively young is associated with a small reduction (of about 0.1 for a 6-month age difference) in the expected in-degree and a similar increase in out-degree (see also Dhuey and Lipscomb [2008]).[13]

The final group of variables captures preferences for homophily: that friendship ties tend to be formed among individuals who share similar attributes. We construct a variety of homophily indicators by defining the type of a respondent with respect to his parents' attributes (such as national origin, religion and occupation) and his own attitudes (such as whether he shares schoolmates' aspirations to go to college or to find a job). Each of these variables has the same structure. For individual i in class c: $X_{ic} = \xi_{ic}\left[N_c^{-1}\sum_{j=1}^{N_c}\xi_{jc}\right]$, where

[13]This result is consistent with a model in which all students tend to name slightly older friends. In that case, the younger students might tend to be named by those in a younger class, and the older students might tend to name those in an older class, so that observed in-degree is censored among younger students, and out-degree is censored among older students. We thank an anonymous referee for pointing this out.

X_{ic} is the constructed covariate, ξ_{ic} is a dummy variable recording whether individual i has the characteristic in question and N_c is class size. Most of these variables are positively associated with in-degree and out-degree of friendship and there are some large effects: for example, if a student belongs to a school where half the students share his national origin, his expected in-degree and out-degree are raised by 1.2 and 0.7 respectively. Still large homophily effects include having a managerial/professional father. The influence of the gender composition of the class on the expected in-degree is large: moving from an equally-mixed to a single-sex school reduces the expected in-degree by 4.16. This may be related to the network boundary issue. A student in a male-only class, who has a demand for female social contacts, must necessarily look outside his school class for social contacts, bringing with it some substitution of external friends for school friends. For most of the sample, this gender-mix effect is very small: only 5% of the sampled students are in single-sex classes and, for the remainder, there is little deviation from the median 50-50 mix.

Beside these three groups of covariates, we have also included variables for the location of the respondents and class size (the number of male students in the school grade). The expected number of inward and outward nominations change non-monotonically with the degree of urbanization, with the lowest degree of social interaction observed for large towns and higher levels for city schools and (especially) small towns and rural areas. Holding class size and other factors constant, location in a non-urbanized area produces an expected increase of around 2 friendship nominations relative to a large town, while a city location gives rise to an increase of around 0.6-0.7.

School size has two conflicting effects on social interactions. On one hand, it increases the size of the pool of potential friends; on the other, it reduces the probability that any one member of that pool will be chosen as a friend. The net effect of school size therefore depends on which of these two dominates. It turns out that in our sample the marginal effect of school size on expected in-degree and out-degree of friendship is typically positive, despite its negative coefficient in the in-degree and out-degree probabilities (see Table A2 in

the online appendix). The magnitude of this effect is moderate: for example, at the median class size of 129, an increase of around 40% in class size is required to increase the expected in-degree and out-degree by 1. The finding of a predominantly positive effect of class size is consistent with previous studies of the effect of school size on the nature of school friendship networks (Hallinan and Smith [1989], Allcott *et al.* [2007]). We return to this issue and its relation to educational policy in the conclusion.

In addition to these observable influences on friendship relations, unobserved heterogeneity also matters. A single individual random effect, representing additive unobservable time-invariant individual-specific factors, appears with large and significant coefficients in both the in-degree and out-degree probability functions.[14] The estimates imply that a 1-standard deviation increase in the unobserved factor generates an increase in the expected in-degree and out-degree of 2.4 and 1.4 respectively.

The estimated model implies a much more plausible distribution of in-degree across individuals than the empirical distribution of partially-observed inward nominations. Figure 1 shows the sample average of the individual binomial distributions of in-degree that the model predicts we would observe if we had full observation of all class members, compared with the empirical distribution of in-degree in the partially-observed class networks in the WLS sample. The predicted in-degree distribution is consistent with distributions reported in previous studies of high-school friendship networks with complete information on the relational data (for example, Strauss and Pollack [2003]).

[14]We also estimated a 2-factor variant of the model, but the second factor was never significant.

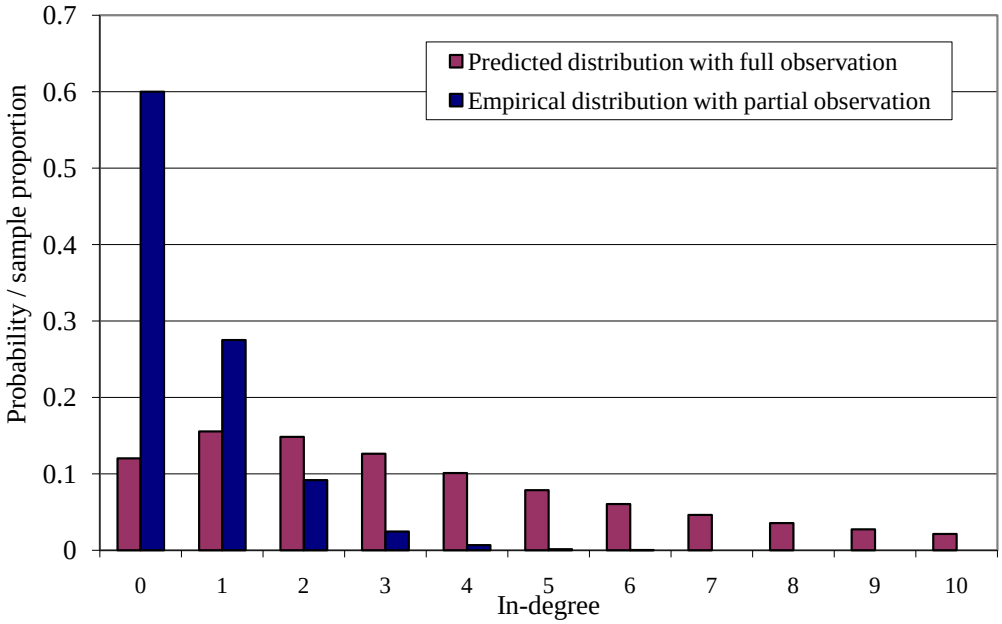

Figure 1: The predicted in-degree distribution and the empirical distribution of in-degree in partially-sampled classes

3.2 The popularity premium

We now look at the association between friendship nominations and adult earnings. We are able to measure wages at a relatively advanced age and thus our estimates capture the cumulative effects of differences in relational skills that have materialized over the entire life course. The core results are reported in columns (1)-(3) of Table 3. Column (4) contains coefficient estimates from the full model extended to include also late measures of personality traits in the wage equation, which are discussed in the next section. We now consider each of the three sets of covariates in the wage model in turn.

Family Background, School Quality and Location. In the first specification, the wage equation only includes measures of family background (parental education), high school quality (proportion of students with friends planning to go to college) and size of the graduating class, location (place of residence both in high school and in 1992), and childhood family ties (as included in the friendship part of the model), in addition to in-degree and out-degree.

The results are reported in Table 3 column 1. All the estimates have the expected sign and they are highly significant. Interestingly, both having a closer maternal relationship and belonging to a bigger class are significant determinants of friendship formation, but have no direct effect on wages. The dominant location effect is the indicator of Wisconsin residence in 1992, which may be in part an outcome indicator, since there is a potential return to mobility. However, excluding the Wisconsin residence variable from the wage equation does not qualitatively alter any of our main findings.[15]

We find that the number of friendships nominated by a student (which measures in part a desire for popularity) has no effect on adult earnings. In contrast, actual popularity as measured by the number of friendship nominations that the student receives from his schoolmates has a sizable effect: the wage premium of additional social skills equivalent to a 1-unit increase in the expected number of friendship nominations at high school is 7%. It is important to note that the unobserved individual effect is never statistically significant in the wage equation, which suggests that the estimated popularity effect is not a statistical artefact generated by common heterogeneity. The nearly two-decade separation between the observation of the friendship relations and the wage is a further argument against the suggestion that the popularity effect is an artefact resulting from endogeneity bias.

Ability and Human Capital. In the second specification, we add proxies for cognitive ability (the Henman-Nelson test of Mental Ability and the grade rank in the high school graduating class) and human capital (years of education) to control for the possibility that our measure of in-degree could act as a proxy of intelligence or achievement.[16] Column 2 in table 3 reports the results of our second specification.[17] We notice that relative age, paternal education and school quality affect wages only indirectly through the process of human capital accumulation. As expected, the addition of these controls reduces the estimated in-degree coefficient. This suggests that the association between school-based social skills and

[15]Results available from the authors on request.

[16]In fact, the positive relationship between social capital and human capital is one of the most robust empirical regularities in the social capital literature (Helliwell and Putnam [1999]).

[17]Note that these estimates are very similar to the ones reported in Zax and Rees [2002].

wages operates in part through schooling itself (Babcock [2008]), although the popularity premium is large (2%) and remains significant at the 5% level.

Marital Status, Job Finding Methods and Adult Social Capital. In our third specification, we add controls for marital status, adult social capital and job finding methods, to account for possible channels through which the effect of in-degree might operate. Joining a social network is one of the most common forms of social capital investment. These networks cover institutions ranging from labor unions, hobby groups and religious associations, and play a role in providing opportunities which may be important for economic success. Empirical work on social capital often uses survey responses about the number of group memberships and the frequency of contacts with friends and family members as proxies for social capital (for example, Glaeser *et al.* [2002]). We follow the literature and include both an index for social participation[18] and two measures of frequency of contacts with friends and relatives. We also include an indicator for whether the job was found through informal contacts, to allow for the role played by network ties in job search.[19]

The results of this third specification are reported in column 3 of Table 3. The introduction of the additional variables does not qualitatively alter the estimated impact of cognitive ability, human capital, school quality and family background. We also confirm existing findings that individuals with higher level of adult social capital and married men have higher wages (see, for the latter, Korenman and Neumark [1991]), and we find a small wage premium for individuals who found their current job via informal channels. Most importantly, once we condition on this richer set of covariates, our conclusions on the wage premium of high school popularity do not change. Shifting somebody from the 20th to the 80th percentile of the predicted in-degree distribution yields a 10% wage premium, a return consistent with estimates reported in previous studies, (Kuhn and Weinberger [2005], Postlewaite and Silverman [2005]). For a median individual, a decile increase in the stock of social skills,

[18]We exclude the subset of organizations with a strong consumption component (see Table A1).

[19]There is an established literature showing that connections transmit information about jobs, offsetting some of the informational asymmetries between the supply and demand side of the labor market (for example Granovetter [1974], Montgomery [1991], Rees [1996] and Topa [2000]).

corresponding to a 1-unit increase in the expected number of friendship nominations in high school, is worth a (statistically significant) 2% higher wage 35 years later. This popularity premium is roughly 40% of the wage premium of an additional year of education.

Table 3 Coefficients in the log-wage equation

Covariate	(1)	(2)	(3)	(4)
Respondent's location and size of school				
In-degree	0.071***	0.021**	0.020**	0.023***
	(0.018)	(0.010)	(0.009)	(0.009)
Out-degree	-0.019	-0.001	0.000	-0.001
	(0.021)	(0.011)	(0.011)	(0.011)
Individual Effect	-0.035	0.003	-0.004	-0.005
	(0.030)	(0.021)	(0.022)	(0.017)
Rural area (1957)	-0.077**	-0.051	-0.057	-0.060***
	(0.035)	(0.034)	(0.032)	(0.019)
Small Town (1957)	-0.118***	-0.095***	-0.103***	-0.102***
	(0.029)	(0.029)	(0.029)	(0.019)
Large Town (1957)	0.070***	0.033	0.039	0.046**
	(0.026)	(0.029)	(0.034)	(0.021)
Resident in Wisconsin (1992)	-0.289***	-0.192***	-0.180***	-0.177***
	(0.020)	(0.017)	(0.021)	(0.020)
Graduating Class size	0.008	0.012	0.011	0.011
	(0.012)	(0.011)	(0.011)	(0.009)
Respondent's childhood family ties				
Mother's affection	0.012	0.029	0.027	0.020
	(0.017)	(0.019)	(0.018)	(0.015)
Only child	0.096***	0.068**	0.065**	0.067***
	(0.018)	(0.031)	(0.028)	(0.019)
Aggressive sibling	-0.113***	-0.109***	-0.086**	-0.102**
	(0.018)	(0.039)	(0.035)	(0.040)
Male sibling	0.044***	0.043***	0.033**	0.032***
	(0.016)	(0.013)	(0.014)	(0.010)
Respondent's characteristics relative to class norm				
Deviation from mean year of birth	0.088***	0.010	0.010	0.012
	(0.020)	(0.018)	(0.017)	(0.009)
Family background and school quality				
College-educated father	0.085***	0.023	0.039	0.031
	(0.029)	(0.027)	(0.040)	(0.020)
College-educated mother	0.153***	0.110***	0.088**	0.078***
	(0.032)	(0.028)	(0.041)	(0.021)
Proportion of friends with college plans	0.193***	0.046	0.037	0.032
	(0.033)	(0.047)	(0.051)	(0.040)

Table 3 (continued) Coefficients in the log-wage equation

Covariate	(1)	(2)	(3)	(4)
Ability and human capital				
IQ	-	0.088***	0.087***	0.084***
		(0.011)	(0.011)	(0.012)
Grade rank	-	0.098	0.060	0.065*
		(0.097)	(0.071)	(0.038)
Years of schooling	-	4.951***	4.612***	4.484***
		(0.469)	(0.356)	(0.425)
Marital status and adult social capital				
Married	-	-	0.174***	0.177***
			(0.031)	(0.011)
Social participation	-	-	0.323***	0.318***
			(0.068)	(0.078)
No. of outings with friends	-	-	0.722***	0.740***
			(0.048)	(0.082)
No. of outings with relatives	-	-	-0.654***	-0.620***
			(0.054)	(0.094)
Job found through network	-	-	0.016*	0.015*
			(0.009)	(0.009)
Personality traits				
Extraversion	-	-	-	0.001
				(0.012)
Agreeableness	-	-	-	-0.031**
				(0.015)
Conscientiousness	-	-	-	-0.009
				(0.015)
Neuroticism	-	-	-	-0.003
				(0.008)
Openness	-	-	-	0.036**
				(0.014)

Standard errors in parentheses. Statistical significance: * = 10%; ** = 5%; *** = 1%.

We make two final remarks about these estimates. First, the unobserved individual effect appearing in the in-degree and out-degree equations remains statistically insignificant in the wage equation, implying that in-degree and out-degree, if fully observed, could be treated as exogenous conditional on our set of covariates.[20] However, the wage equation cannot be estimated in isolation, since the non-classical measurement error in $\tilde{k}$ resulting from

[20]This is also reassuring, given the retrospective nature of our friendship data. As the friendship information is collected almost twenty years before the wage, this weakens the possibility that the observed positive association between the two might arise from spurious correlation in unobservables.

partial observation of the friendship network must still be dealt with. Standard arguments suggesting attenuation bias in OLS and consistency of IV estimators of the wage equation are invalid here, since the measurement error is correlated with the true variable and has non-zero mean. In fact, OLS gives a significant estimated popularity premium of 0.048, while 2SLS or LIML give 0.16 and 0.33 respectively (neither significant at the 5% level).[21]

The second remark concerns the validity of our exclusion restrictions. Apart from having *ex-ante* theoretical and empirical plausibility, they are also tested *ex-post* and not rejected. A generalized model with unrestricted wage equation yielded a log-likelihood of -11396.180, with an insignificant likelihood ratio statistic of 8.44 with 14 degrees of freedom ($P = 0.86$), comparing this unrestricted model with the most general form of the restricted model.[22]

3.3 Popularity – personal capital or personality trait?

Our interpretation of the in-degree is that it is a measure of early investment in a form of personal social capital or non-cognitive skill, rather than an indicator of innate personality traits. The WLS sample allows us to explore this further, since the 1992/3 interview contained the "big 5" instrument designed to measure the individual's degree of extraversion, agreeableness, conscientiousness, neuroticism and openness. We have reservations about these measures, since they are observed contemporaneously with the wage and are therefore possibly subject to spurious correlation. While there is some debate about the malleability of personality traits (Almlund et al 2011), it would be inappropriate to include late adult measures of personality in the in-degree and out-degree equations which represent friendship relations during the transition to adulthood, so we include these measures only in the wage equation. This changes the estimates very little (see column 4 of Table 3). In particular, the in-degree coefficient in the wage equation rises from 0.20 to 0.23 and remains statistically significant, consistent with our view that the in-degree captures a productive skill quite dis-

[21]The OLS and IV results are available upon request to the authors.

[22]It should of course be borne in mind that, like tests of overidentifying restrictions in other contexts, this procedure is dependent on the particular specification we use and the asymptotic approximation to its null distribution may not always be a good guide to its finite sample properties.

tinct from the personality traits measured by the big five. Like Mueller and Plug (2006), we find that, in the labor market, openness commands a positive return, while the negative impact of the agreeableness measure suggests that a willingness to be challenging has some market value.

We finally return to the issue of recall bias in the friendship nominations which underlie our popularity measure. If there is a tendency for recall to be biased towards friends who turn out to be successful in the labor market, this bias will be strongest among the group who remain in Wisconsin and are presumably more likely to be able to observe the success of their friends 18 years later. As a consequence, we would expect to see a larger estimated popularity effect (caused by recall bias) among those who remain in Wisconsin than those who live elsewhere in 1992. This can be tested by including an interaction between the Wisconsin residence dummy and the latent popularity measure. The hypothesis of biased recall then implies that this interaction parameter should be positive. Estimation of the extended model in fact suggests the reverse: a significantly larger estimated parameter for non-Wisconsin residents (0.033, $P = 0.002$) than for Wisconsin residents (0.011, $P = 0.079$), with a P-value of 0.022 for the difference. Given the strong negative correlation (-0.74) between these two estimates, it is unwise to read too much into the relatively high popularity premium for non-Wisconsin residents, but it suggests that geographical mobility may be one of the routes by which people with good social skills developed in adolescence achieve success.

4 Conclusions

This paper contributes to the emerging literature on the relevance of social skills for achieving economic success in life. We overcome some of the difficulties encountered in the literature on the meaning and measurement of these skills by focusing on popularity, objectively measured as the number of friendship nominations received from high-school classmates. This measure of social skills is based on information about interpersonal relationships, is more reliable than

self-reported proxies and is distinct from measures of personality traits. We exploit the non-reciprocal nature of friendship relations and are able to show that the popularity premium is substantial: an increase in the stock of popularity, measured by an additional friendship nomination received in high-school, is associated with about 2% higher wages 35 years later. In contrast, there is no evidence of a wage premium associated with the number of friendship nominations the individual makes.

As a by-product of our estimation strategy, we also provide novel evidence on the determinants of popularity. Of particular interest is the role played by early family environment, school composition and school size on adolescent social engagement. While current research focuses on the effect of class size on cognitive achievement (Angrist and Lavy [1999], Hoxby [2000]), our results suggest that a deeper understanding of the effect of school size and composition on the development of social skills is needed. Policies that focus on promoting integration in schools and on developing social competencies may be a fruitful way of promoting success in life.

Finally, we also provide a methodological contribution. We show how to analyze data from partially-sampled social networks with a censored number of possible links. Given the difficulty of observing complete networks, we expect our method to have wide applicability. While we focus on earnings here, the analysis can be extended to investigate the effect of adolescent social standing on other outcomes, such as health and risk behavior.

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