Peer and parental influence in the development of cognitive skills and predispostion to risky behaviour

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Ana Balsa (Universidad de Montevideo)

Néstor Gandelman (Universidad ORT Uruguay)

Flavia Roldán (Universidad ORT Uruguay)

Abstract [*]

This paper analyzes the strategic interactions between peers and parents in the development of adolescent's cognitive skills and non-cognitive skills, as proxied by the predisposition to use substances. We estimate a technology of skill formation that identifies peer effects on the basis of quasi-random assignment of students across classes, time varying data, and the use of instrumental variables. We find that both peer and parental socialization efforts have a positive influence over adolescents' academic skills, and that these effects are complementary: as peers get better academically, parents invest more. We do not find, however, linear-in-means peer or parental effects on the predisposition to use substances.

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1. Introduction

The acquisition of strong cognitive, socio-emotional, and health related capabilities is at the basis of successful economic and social trajectories over the lifetime (Heckman, 2007; Heckman and Kautz, 2012). Childhood and adolescence are critical periods for the development of these skills (Chapko, 2015; Cunha and Heckman, 2008). During childhood, family and school play key roles in the formation of these capabilities, providing care, stimulation, nutrition, and a proper environment. In adolescence, the nature of social exchanges and interactions with the group of peers acquires a more relevant role. The shifting of the relative importance of parents versus peers during the course of adolescence has been well documented in the psychology literature (Harris, 2011; Windle, 2000; Wood, Vinson, and Sher, 2001; Trucco et al 2011). Still, a substantial body of research suggests that in early and even in late adolescence parental socialization remains critical in the determination of adolescents' conducts and attitudes (Reifman et al, 1998; Windle, 2000; Wood et al 2004; Barnes et al 2006; Hoffmann and Dufur, 2008; Trucco et al 2011). Moreover, parental efforts may depend endogenously on peers' preferences, beliefs, and behaviors (Bisin and Verdier 2001, 2010). For example, the level of effort parents place on the transmission of cultural traits, such as religious beliefs or gender attitudes has been shown to be complementary to peers' religious and gender attitudes (Olivetti et al 2013; Patachini and Zenou 2011; Patacchini and Zenou, 2016). This implies that the multiplicative effect of peers' socialization could be stronger or milder depending on the type of parental-peer strategic interaction.

To what extent are adolescents' preferences, skills and attitudes shaped by those of their group of peers and what is the relative incidence of parents? Are peers' and parents' socialization efforts strategic complements or substitutes? In this paper we

empirically assess the impact of peers vs. parents in the formation of latent cognitive and non-cognitive skills in adolescence, as captured by risky behaviors, and investigate the returns to parental investment under different scenarios of peer socialization efforts.

We run an empirical model of skill formation in the spirit of Cunha and Heckman (2006) that allows for peer effects, in addition to parental investment. Using principal component analysis, we construct two latent indicators of cognitive skills and of risky behaviors. The first one measures cognitive ability on the basis of a set of academic test results. The other one measures the latent predisposition to use substances based on nine assessments of use of alcohol, tobacco, and marijuana. Substance use has been systematically associated with non-cognitive skills and traits such as the levels of socio-emotional regulation and conscientiousness, risk tolerance, and self-control (Heckman, et al., 2006, Wills et al. 2006, Gunnarsson et al 2008, Belcher et al 2014, Jones et al 2015).[1]

In terms of the peer effects estimation, our analysis takes advantage of the exogenous assignment of students across classes within grades in a sample of private secondary schools in Uruguay. The considered schools do not have tracking policies and seek balance of students across classes. As in Lundborg (2006) and Ammermueller and Pischke (2009), we exploit random variation across small classes in the fraction of students with specific cognitive and non-cognitive capabilities. We address simultaneity of influences by using panel data, and use instrumental variables to address common shocks and measurement error.

[1] Introverts are less likely to be sensitive to competing rewards, and thus more likely to be pulled in by the effect of a drug. Individuals with negative emotionality respond poorly to stressors and are more likely to suffer from anxiety and depressed moods, which have been associated with the use of substances. Also, individuals with low constraint (low self-control and high impulsivity) are less likely to stop a behavior once started.

We find statistically significant linear-in-means peer and parental effects in cognitive skills, but not in non-cognitive skills as proxied by latent substance use. Our findings differ in this respect from results in some previous studies that show larger effects in social than in academic outcomes. In our analysis, a one standard deviation increase in peers' average academic competencies enhances individual academic performance by 0.2 standard deviation. Parental effort, on the other hand, increases academic skills by 0.06 standard deviation. Even more interesting, we find that parental and peers'efforts are strategic complements when it comes to the development of academic skills. This implies that, as peers get better academically, parents are more likely to exert effort.

While the psychology literature has presented evidence on the role of parents in mitigating or reinforcing peer influence, to our knowledge this is one of a few papers to show strategic complementarities between parental and peer efforts in adolescent cognitive skills formation, accounting at the same time for the challenges in the estimation of peer influence, i.e. selection, reflection, common shocks, and endogenous versus contextual effects. Our results are in line with the findings in Bisin and Verdier 2001, 2010), Olivetti et al (2013), Patacchini and Zenou (2011), and Patacchini and Zenou (2016), and may explain the perpetuation of equilibria with low levels of human capital formation.

The remainder of the paper is organized as follows. Section 2 describes the background literature; the paper's significance, data and methodology are described in Section 3; in Section 4 we present and analyze the results; and we conclude in Section 5.

2. Background and Significance

The seminal work of Heckman and colleagues set the foundations of a profusive body of research analyzing the critical periods for the development of cognitive and non-cognitive skills throughout the life-cycle (Heckman 2007; Cunha and Heckman, 2008). Cognitive skills are the mental skills that are used in the process of acquiring knowledge and solving problems, including reasoning, memory, visual-spatial skills, and attention. The concept of noncognitive skills refers to attitudes, strategies and behaviors that are not cognitive but have been positively associated with successful academic and labor market trajectories. These include competencies such as socio-emotional regulation, self-control, conscientiousness, locus of control, and the ability to work and interact with others. Conceptually, some of these can be placed within the individual's endowment (e.g. personality traits[2]), while others belong to the preference set (risk aversion, time preferences, altruism, social norms, values and self-image).[3] While much has been written on the effects of cognitive skills on economic and non-economic outcomes (Murnane et al., 1995; Hanushek and Woessman, 2008; Burks et al. 2009; Hanushek and Woessmann, 2012), only recently have noncognitive traits been recognized a role in economics. Research shows that noncognitive abilities have a strong influence on earnings, employment, labor force experience, college attendance, teenage pregnancy, participation in risky activities, compliance with health protocols,

[2] The most common categorization for personality traits is that in Goldberg's (1990) Big Five Factors of Personality model, which considers the following personality dimensions: openness to experience, conscientiousness, extroversion, assertiveness, and emotional stability (vs. neuroticism).

[3] Almlund et al. (2011) introduce non-cognitive skills in an economic model by allowing choices to depend on personality traits. These authors consider that individuals make choices and take actions on the basis of a system of preferences and endowments. As usual, preferences include features such as risk aversion and time discounting. Endowments, on the other hand, go beyond traditional economic resources and include cognitive skills as well as personality traits. Other authors have studied the processes behind the formation of heterogeneous values, norms, social distinctions, and self-image, which also account for some of the constructs considered in the literature as non-cognitive skills (i.e. motivation, self-efficacy, growth mindsets). For example, Akerlof and Kranton (2000, 2005) incorporate social identity to an economic model and Bisin and Verdier (2010) study the process behind the transmission of culture from parents to children (vertical socialization) and between peers (horizontal socialization).

and participation in crime (Bowles and Gintis, 1976; Bowles et al., 2001; Groves, 2005; Heckman et al., 2006; Borghans et al., 2008a; Borghans et al. 2008b; Heckman and Kautz, 2012).

Much of the literature following Heckman and colleagues' work has thus focused on the effects of investments during the first years of the life cycle, and in particular on those of early schooling and parental investment. The evidence suggests that a healthy family environment (Huttenlocher et al., 1991; Bianchi and Robinson 1997; Brody & Ge 2001; Wills and Dishion 2004; Anda et al., 2006; Rutter, 2006; Huttenlocher et al., 2010; Chapko, 2015;) and the quality and quantity of schooling (Cunha et al., 2006; Heckman et al., 2006; Blau and Currie 2006; Currie and Almond, 2011) can contribute substantially to shape cognitive, noncognitive, and health-related outcomes over the lifetime.

During adolescence, peers acquire a critical role in the socialization process, competing with parental influences in the formation of skills and competencies (Windle, 2000; Wood, Vinson, and Sher, 2001; Harris, 2011; Trucco et al 2011). Sacerdote (2011) defines peer influence as "nearly any externality in which peers' backgrounds, current behavior, or outcomes affect an individual's outcome." Peer influence attains special policy significance when the externality works through peers' current behaviors, as it implies that the individual-level effects of a particular policy will be multiplied by the influential processes that take place between peers. The study of peer effects has received profuse attention in the area of education (Hoxby, 2000; Sacerdote, 2001; Zimmerman, 2003; Angrist and Lang, 2004; Ammermueller and Pischke, 2009; Bifulco et al. 2011; Fletcher 2012; Imberman et al., 2012; Sojourner, 2012; Jackson 2013; Abdulkadiroglu et al., 2014; Billings et al. 2014). In a review of this literature, Sacerdote (2011, 2014) reports that half the studies estimating linear-in-means models

(models in which the average outcome of peers affects an individual's outcome) show modest to large peer effects, but half do not show statistically significant effects. The former are mostly studies that use cohort variation in primary and secondary schools, while the latter come from roommate assignment studies in higher education. Peer effects have also been reported in studies assessing nonlinear effects. For example, Hoxby and Weingarth, 2005, find that high achieving students (but not low achieving ones) benefit significantly from the presence of other high achievers.

There is a large body of literature on peer influence in social outcomes, such as drinking, drug use, and criminal behavior (Gavira and Raphael, 2001; Powell et al., 2005; Duncan et al., 2005; Kremer and Levy, 2008; Lundborg, 2006; Clark and Lohéac, 2007; Trogdon et al., 2008). The evidence tends to suggest larger peer effects when the outcome is social than when it is academic (Sacerdote 2014). In addition, peer effects in social outcomes appear to be stronger in reciprocated friendships than in non-reciprocated pairs (Card and Giuliano 2013). Finally, there is an incipient literature on the transmission of influences in economic parameters and attitudes (Zimmerman et al., 2004; Boisjoly et al., 2006; Ahern et al., 2014; Balsa et al., 2015).

Despite the stronger influence of peers during the adolescent years, parents still play a critical role in shaping their offsprings' skills, preferences, and behavior. Parental socialization at this stage provides youths with the necessary skills to interact in a successful way with others and to assume adult roles (Marshall and Chassin, 2000). Parental effort has been positively associated with the education attained by children (Brooks, 2003; Pattachini and Zenou, 2011; Dufur et al., 2013) and with socio-emotional outcomes (Griffiths et al. 2011 find that family members play a critical role in supporting help-seeking among people with depression). The influence that parents exert on their children has been broadly conceptualized in terms of parents' behaviors,

values, and attitudes. Parental behaviors such as supervising, monitoring, and rule setting are intended to direct the child's behavior towards patterns acceptable to the parent (Barnes et al., 2006). Parental values and attitudes are an indirect means of social modeling (Wood et al., 2001) and may be transmitted tacitly through the setting of limits or by the expression of values.

Parental socialization efforts have been shown to provide a buffering effect against peers in adolescent alcohol use initiation, delinquency and substance misuse (Wood et al., 2004; Barnes et al., 2006; Hoffmann and Dufur, 2008; Chuang et al., 2009; Trucco et al., 2011) and to contribute to identity development: adolescents whose identity is strongly influenced by their parents may be less susceptible to pressure from peers. On the other hand, parental efforts may be endogenous to peer attributes or influences. Bisin and Verdier (2000, 2001) argue that the transmission of traits such as preferences, beliefs, and norms, is the outcome of socialization efforts inside and outside the family. The relative intensity of the socialization effort exerted by parents depends on the degree of complementarity or substitutability between family and peer efforts, and on the level of heterogeneity between family and peer traits. Pattachini and Zenou (2011) find that the better the quality of the neighborhood, the higher the parents' involvement in children's education, indicating cultural complementarity. Focusing on religion, the same authors (Patacchini and Zenou 2016) analyze the interaction between vertical (parental) and horizontal (peers) transmission of the strength of religion. They find that peers and parents exert a complementary influence on the individual: for religious parents, the higher is the fraction of religious peers of the child, the more efforts parents put into transmitting their religiosity, while for non-religious parents, the lower is the fraction of religious peers of the child, the less the parents go to a religious service with their child. In the same line, Olivetti et al. (2013) explore a new mechanism

of gender identity formation. They model the utility function of teenagers, and assume that an adult woman's work decisions are influenced not only by her own mother's choices but also by her friends' mothers' choices when she was a teenager, and by the interaction between the two. By using the longitudinal structure of the AddHealth data set, they find that vertical (mother) and horizontal (friends' mothers) channels positively affect woman's working hours in adulthood. Nonetheless, the own mother's effect is larger the more distant she is (regarding working hours) from the friends' mothers.

3. Data and Methodology

3.1. Data

3.1.1. Data source

The data were originally collected to assess the impact of a web-based substance use preventive program. A randomized controlled trial was conducted to evaluate an Internet and SMS-based intervention that provided adolescents with information about the risks and consequences of substance use. The intervention was somehow effective at improving information but ineffective at changing risky behaviors. In this paper we use detailed data gathered before and after the intervention but we do not exploit the trial per se. [4]

Our data includes students who were in their third and fourth year of secondary school in ten private schools in Montevideo. The majority were between 14 and 16 years old. Compared to the average Uruguayan adolescent, students who attend private secondary schools are of higher socio-economic status. The academic year in Uruguay goes from March to December. All students in the selected grades and school were asked to complete two surveys, one in July 2009 and the other in November 2009. The

[4] The research proyect underwent review by an Ethics committee at Universidad ORT Uruguay in July 2009. See Balsa, Gandelman and Porzecanski (2010) for a description of the project and Balsa, Gandelman and Lame (2014) for an analysis of participation in the program.

surveys collected a variety of information on socio-demographics, academic performance, and substance use, among other measures. The surveys were self-administered at school and took around an hour to complete. 1,044 students corresponding to 47 classes responded to the first survey. During the second survey, around 206 interviews had to be conducted on the phone with a scaled down questionnaire due to scheduling problems and 48 students refused to participate. Because our identification strategy relies on comparing classes within schools and grades, we dropped two schools that had only one class per grade.

To assess whether the actual assignment to classes proxies random assignment, we constructed, for several relevant student characteristics, a Pearson chi square test of the difference in the variable mean across classes within grades. As in Ammermueller and Pischke (2009), under the assumption that schools are independent, we can sum up these chi square statistics across schools and construct a balancing test for each characteristic in the sample. Table 1 reports these statistics for age, gender, mother's education, single mother family, intact family, number of siblings, an asset index as an indicator of wealth, and father and mother's working status. For most variables, we find that assignment of students to classes does not depend on these characteristics. At a 5% statistical significance level there are only differences across classes in the number of siblings, and only for 4th graders.

3.1.2. Students' skills

We use principal component techniques to measure latent cognitive and non-cognitive skills at baseline and follow up. This allows us to consider latent tendencies in attitudes and behaviors avoiding the problem of measurement error and family-wise statistical errors. Our proxy for cognitive skills is the first component of a group of

academic test results. In Uruguay, all secondary schools have to comply with a common curriculum mandated by the national public education authority. This implies that all students take the same courses covering a similar content, and are administered subject-specific tests every month or two. Students were asked to report the grade they obtained in the last test they took in Mathematics, History, Literature, and Biology. Grades range from 1 to 12. The minimum passing grade is 6. The average grade is 7.3 with a standard deviation of 1.79 (see Table 2). The principal component analysis of all academic variables at baseline throws a first component that ranges between -4.8 and 3.9 with a mean of 0.07 and a standard deviation of 1.47. The eigenvalue for the first component is 2.3, and the proportion of the variance explained by it is 57%. All four variables have similar loadings on this first factor, which range from 0.49 to 0.53 (see Appendix 1).

We approximate non-cognitive skills using a measure of the predisposition to use substances, constructed as the first principal component of the following set of variables: a dummy variable indicating any use of alcohol in the past 3 months, a dummy for any use of alcohol in the past 30 days, frequency of alcohol use in the past 3 months and past 30 days, a dummy for any alcohol intoxication in the past 30 days, frequency of intoxication in the past 30 days, a dumy for any use and frequency of use of tobacco in the past 30 days, and a dummy for any use of marijuana in the past 3 months. In our data, sixty eight percent of students report consuming alcohol in the past 3 months and 55.5% in the past 30 days.[5] The prevalence of drinking to intoxication is 19.2%, smoking prevalence is 18.1%, and 11.3% of students report consuming marijuana (see Table 2). The first component for the variables at baseline has an eigenvalue of 4.3 and explains 47.8% of the total variance. Factor loadings are all positive and range from 0.27 in the case of marijuana use to 0.38 for frequency of alcohol use in the past 30 days (see Appendix 1).

Due to non-responses in the 2nd wave and to a shorter telephone interview, that explored mostly substance use behavior, our final sample has 785 observations when dealing with substance use, and 555 when the outcome is academic skills.

3.1.3. Parental investment

Our index of parental investment is a weighted average of seven dummy indicators of parental involvement with the child. These are students' reports of whether the parents, or at least one of them, knows where the child is after school hours or during weekends; is concerned about how the child performs academically at school; shares at least one meal a day with the child; is attentive to the time the child arrives home during

[5] We report substance use descriptive statistics for those students with non-missing values in these variables at baseline and follow-up, and non-missing values in all control variables (N=785).

weekends; is a confident for the child; can keep a peaceful conversation with the child even when disagreeing; and is familiar with the child's best friends. Table 2 shows that 67.4% of parents know the child whereabouts, 66.8% are concerned about his/her academic performance, 61.7% share at least a meal with the child, 86.1% are attentive to the time the child arrives home, 14.6% are among the first persons with whom the child shares a problem, 68.5% are able to keep peaceful conversations when disagreeing, and 43.9% are familiar with their child's best friends.[6] The index ranges from 0 to 1, gives higher weight to scarcer parental competences, and has a mean of 0.48 and a standard deviation of 0.21 (see Table 2).[7]

3.1.4. Other control variables

Table 2 shows descriptive statistics for other variables used as controls or instruments in the estimation. Individual level variables include student's age, gender, mother's education, family structure (single parent family and number of people in the household), whether the student repeated a grade in the past, the average GPA in the past year, and the age of initiation of alcohol use. We also construct a wealth index on the basis of the availability of durable goods in the household. The index gives higher weight to scarcer goods.[8] The age of the students in the sample ranges from 13.5 to 17.8, with an average of 15.3. Fifty-four percent of students are female, mothers'

[6] We report descriptive statistics for the parental index and for the other control variables for the sample of students with non-missing observations in all control variables (including the parental index) and non-missing values for the substance use outccomes at baseline and follow up.

[7] Formally, let P_{ij} be a dummy variable taking the value 1 if the parent of child i shows involvement with the child in dimension j. Let μ_j be the sample average of P_{ij} for dimension j. The parental investment index (PI) is defined as: $PI_i = \sum_j \omega_j P_{ij}$ where the weight is $\omega_j = 1-\mu_j \Big/ \sum_z (1-\mu_z)$. The index ranges from 0 for parents who show no involvement at all with the child (or who show involvement only in those dimensions for which every other parent is also involved) to 1 for parents who show involvement with the child in all assessed dimensions.

[8] The asset index is constructed in the same way as the parental investment index. If D_{ij} is a dummy variable taking the value 1 if the household of student i owns asset j, and λ_j is the sample average of D_{ij} for asset j, the wealth asset index is defined as: $Wealth_i = \sum_j \eta_j D_{ij}$ where the weight $\eta_j = (1-\lambda_j)/\sum_z (1-\lambda_z)$. The index ranges from 0 for a household with no assets (or who owns assets that everybody else owns) to 1 for a household who owns every single available asset.

average education is 14.8 years, 21% of students live in a single-mother household, and the average household size is 4.2. Only 1.4% of students report having been retained in a previous grade, the age of initiation of alcohol use is in average 13.7 and the average passing GPA for the previous year is 8.1. The wealth index ranges from 0 to 1 with a mean of 0.48 and a standard deviation of 0.26. In terms of class level characteristics, we consider the average age in the classroom, the fraction of classmates that are female, class size, classmates' mothers' years of education, and the fraction of classmates living in single-mother households. In a robustness analysis we take into account whether there are alcohol problems, use of drugs, or smoking in the family.

3.2. Methodology

3.2.1. Technology of skill formation

We depart from a technology of skill formation similar to that in Cunha and Heckman (2007). We assume there are two types of skills: cognitive and non-cognitive, denoted respectively by θ_{it}^{C} and θ_{it}^{N}, where *i* indexes the individual and *t* denotes time. As in Cunha and Heckman (2008) skills in period t+1 depend linearly on the individual's skills in period t and on parental investments in that period (θ_{it}^{I}). We assume, in addition, that the accumulation of skills in t+1 depends on peers' skills at t (θ_{-it}^{k}) and that parental investment interacts with peer average skills in the determination of skills. Equation (1) illustrates the technology:

$$\theta_{it+1}^{k} = \gamma_0^k + \gamma_1^k \theta_{it}^{C} + \gamma_2^k \theta_{it}^{N} + \gamma_3^k \theta_{-it}^{k} + \gamma_4^k \theta_{it}^{I} + \gamma_5^k \theta_{-it}^{k} \theta_{it}^{I} + \eta_t^k \qquad (1)$$

with $k = \{C, N\}$

The parameters γ_3^k and γ_4^k capture, respectively, peers' influence and parental influence on skill formation.[9] The parameter γ_5^k reflects the complementarity or substitutability between parental effort and peers' efforts.

3.2.2. *Identification of peer effects*

The empirical identification of peer effects faces two critical challenges. First, peer influence is hard to disentangle from self-selection, a phenomenon also known in the literature as correlated effects (Manski, 1993). Peer associations in economic attitudes and behaviors can be explained by selective group formation - that is, the tendency of those with similar preferences, information, and behavior patterns to get together. In the school setting, the selection (or correlated effects) problem stems from the fact that parents choose schools for their children based on their preferences for location, quality, costs, school values, and other school features. Due to this sorting, it is natural to find that students share more characteristics (e.g. religion) within schools than between schools.

A second problem with the identification of social spillovers is the difficulty in isolating the effect of peers' attitudes on the individual from the influence of the individual on his/her peers, known as Manski's reflection problem. A traditional solution in the literature has been to use instrumental variable techniques (Gaviria and Raphael, 2001; Powell et al., 2005; Lundborg, 2006; Clark and Lohéac., 2007; Trogdon, 2008; Fletcher 2012), where individual-level variables determined ex-ante (such as peers' average family characteristics) instrument for students' current behavior. There are two problems with these instruments. First, they are unable to distinguish contextual from endogenous peer effects. Second, from an empirical point of view, they are usually weak (Angrist, 2014).

[9] An alternative specification for Equation (1) considers θ^{C}_{-it} as well as θ^{N}_{-it} as determinants of θ^{k}_{it+1}..

To avoid confounding peer influence with selection, in this paper we follow Lundborg (2006) and Ammermueller and Pischke (2009) and focus on random variations in attitudes and behaviors across classes within the same grade and school.[10] We exploit the fact that parents of students in our sample are not able to choose the class in which their children will be placed within their age cohort.

The assignment of students across classes in Uruguay is majorly a decision of the school authorities, who seek to balance student characteristics across the different groups. Groups are reorganized every year or every couple of years, depending on the school. While the assignment process is not completely random, it relies on avoiding sorting of equals within classes.[11] Furthermore, once assigned to a class, students are not mixed up with students in other classes (they have different teachers in different courses but the same student-colleagues in each of these courses during the whole year). Also, none of the participating schools have tracking rules in the assignment of students. This configuration ensures more frequent and intense interaction among students within a class than between classes. As in Ammermueller and Pischke (2009), the variation in our peer variable most likely reflects the small differences in composition when multiple groups are formed out of a small population (the absence of the law of large numbers).

We avoid the reflection problem by dissociating student i's and his/her peers' outcomes over time: concretely, we identify endogenous effects by studying how peers' capabilities in period t affect a student's capabilities in period t+1, conditional on the student's capabilities in period t. Our approach allows us also to explore the separate role of contextual effects (i.e. the effects of peers' characteristics on i's behavior) by

[10] Hoxby (2002) uses a similar strategy but across cohorts rather than across classes.

[11] We interviewed principals at each school to understand the nature of students' assignment to classes. While in some schools students are consulted regarding their friendship preferences, the guiding principle for class assignment is randomization with some intervention aimed at avoiding the reinforcement of negative influences, both behavioral and academic, within classes.

controlling for aggregate peer characteristics in our regressions (e.g. education of peers' parents and peers' family structure). Note that by dissociating behavior over time and controlling for own behavior at baseline, our estimates of peer effects are unlikely to be affected by common shocks.

For simplicity, we work with a linear in means model of peer effects, where the peer measure for student i in a particular class c, is given by the average value of the variable of interest (e.g. grades) in that class c, excluding student *i.*

Note that, because we surveyed almost all students in the selected grades and schools (except for those absent), measurement error is less of a concern in our peer measures (Bifulco et al., 2011).

3.2.3. Empirical model

Using each of the latent measures of skills as outcomes of interest, we estimate the following equation:

$$Y^k_{igct+1} = \alpha^k_0 + \alpha^k_1 Y^k_{igct} + \alpha^k_2 \bar{Y}^k_{-igct} + \alpha^k_3 PI_{igct} + \alpha^k_4 \bar{Y}^k_{-igct} PI_{igct} + \alpha^k_5 X_{icgt} + \alpha^k_6 \bar{X}_{-icgt} + \alpha_g + \eta^k_{gct} + \varepsilon_{igct,} \qquad (2)$$

Equation (2) conditions skill *k* of student *i* in school-grade *g*, class *c* and time *t+1* (Y^k_{igct+1}) on the student's skills at *t* (Y^k_{igct}), classmates' average skills at *t* ($\bar{Y}^k_{-igct}$), parental investment at t (PI_{igct}), and other individual-level (X_{igct}) and group-level background measures at t ($\bar{X}_{-igct}$). α_g is a vector of school-grade fixed effects. This term allows us to compare students belonging to the same school-grade across exogenously assigned classes that have different peer composition. The error term includes a component that is common to class *c* at school and grade *g*, η_{gct} , and an

idiosyncratic individual term ε_{gct}. To accommodate inference to intra-classroom common shocks, we cluster standard errors at the school-grade and class level.

One limitation of the previous methodology is that the estimation may be inconsistent if skills at t+1 are associated with persistent unobservables that affect also students' and peers' behavior at t. For example, having a good teacher may be associated with good overall performance at time t and at time t+1. The association between peers' outcomes at t and the individual outcomes at t+1 may capture the common influence of this good teacher if such effect is omitted from the regression. To overcome this problem we instrument peer latent academic skills at t with the average GPA of peers in the previous year, and peer average latent propensity to use substances at t with peers'average age of initiation of alcohol use. These instruments are unlikely to be associated with common shocks, as they were generated in the past, when the students had a different group of peers and different teachers. The use of instrumental variables may address also attenuation biases due to measurement error in the peer group variable.

4. Results

4.1. *Core results*

Table 3 reports the OLS and IV estimations for the academic and substance use outcomes of interest. Each column depicts a regression of a cognitive or non-cognitive latent skill at follow-up (November 2009) on the same skill at baseline (July 2009), the average of peers' skills at baseline, an index of parental investment, individual-level adjustors (age, gender, mother's education, single mother household) and average peer characteristics at the classroom level (average age, percentile female, average mother's education, and average family structure) at baseline. Each regression adjusts in addition,

for school-grade fixed effects. To simplify interpretation and comparison, the student's outcome at t, the peers' mean, and the parental investment measure, as well as the outcomes at follow up, are all standardized with mean 0 and standard deviation equal to 1.

The first two columns report results for latent academic skills and the next two show results for the latent predisposition to use substances. All outcomes at follow up are positively and significantly associated with the same outcome at baseline. The persistence is as high as 0.82 in the case of academic skills and as low as 0.73 when it comes to substance use. In terms of academic skills, the OLS regression (Column 1) shows a positive but non significant coefficient on the measure of peer group average academic skills. On the other hand, the coefficient on parental investment is positive and statistically significant at the 5% level. A one standard deviation increase in parental investment at t increases academic skills at t+1 by 0.06 standard deviations. When instrumenting for peer group average skills at t (Column 2), the coefficient on this variable increases to 0.173 standard deviations and gains statistical significance. In addition, the interaction between peer group average academic skills and parental investment becomes significant and positive (0.083), suggesting a complementarity between parental efforts and peers'efforts in the determination of academic skills. The F-values for the instrumental variables in the first stages are 21.22 for peers' average past-year's GPA and 24.33 for the interaction between peers' past year GPA and parental investment. First stage results are presented in the Appendix.

The OLS results for substance use (Column 3) show a statistically significant coefficient on the peer group average of 0.12 standard deviations. While the sign on parental investment is negative as expected, it is small and statistically non-significant. After instrumenting peer group latent substance use with peers'average age of onset of

alcohol use, the coefficient on peer group average skills decreases in magnitude and loses statistical significant (Column 4). This loss of substantive and statistical significance suggests that the association between own and peers' substance use that remain after controlling for selection may be due to common shocks rather than to peer influence. F-statistics in the first stage are 21.7 for peers' average age of initiation of alcohol use and 1.42 for the interaction between this variable and parental investment. While the latter instrument is weak, the former is sufficiently strong to identify the main effect.[12]

It is worth asking whether the peer effect we found for academic skills is endogenous or contextual. While we are not completely able to isolate the effect of group average academic skills from all other contextual determinants, we control for a set of group average characteristics that we consider to be key contextual explanators, i.e the average age of peers, the fraction of classmates that are female, the average education of classmates' mothers, and the fraction of classmates living in single-mother households. None of these variables explains academic skills when considered individually or jointly (see p-values in last row of Table 3). We conclude similarly when assessing the influence of contextual effects in the latent predisposition to use substances.

4.2. Robustness of the IV estimates

Columns (1) to (5) in Table 4 explore the robustness of the academic skills IV results to changes in the set of control variables. The first column runs a regression

[12] When instrumenting for peer substance use, we observe that the group of compliers with the instrument (those changing behavior as the instrument changes), is located around the median of the latent substance use distribution. If influential peers are more likely to be located in the extremes (as preliminary OLS evidence appears to suggest), we may be missing the relevant effect. We are unable, however, to find suitable instruments for those in the extremes of the distribution.

with a more parsimonious set of controls than those in Table 3 (only age, gender, household education, and family structure, in addition to school-grade fixed effects). The second is the core IV regression in Column (2) of Table 3, which adds to the former peer group's contextual variables (peers'average age, fraction female in the classroom, average households'years of education, and fraction of classmates in single mother households). The third one adds other controls at the individual level, i.e. household size, household's wealth, and whether the student repeated a grade in the past. Column (4) adds other latent individual skills at baseline, such as latent predisposition to use substances and the age of initiation of alcohol use. Finally, the last column considers also parental substance use measures (problems with alcohol, problems with illegal drugs, and tobacco consumption). The coefficient on peers' academic skills at baseline continues to be positive and statistically significant across all specification, ranging from 0.153 to 0.173 standard deviations. The effect of parental investment is also robust to the inclusion of different sets of control variables, with values ranging from 0.056 to 0.074. And the same happens with the interaction between peer group average academic skills and parental significance: it remains positive and statistically significant at 10%, around the 0.08 point estimate. The last column in Table 4 reports Bayesian information criterion (BIC) statistics for the each regression. The BIC statistic is minimized (shows a better fit) in the most parsimonious regression, that in Column (1), which adjusts only for basic individual demographics. We preferred to show results in Column (2) as the core model, because this specification included also peer contextual effects, and including these is important conceptually to understand the nature of our findings.

Results for the substance use analysis (Table 5) are also in line with the core IV estimation. The peer endogenous effect remains non-significant across all specifications. The same occurs with the parental investment measure, except when

including parental problems with substance use as controls (Column 5); in such case the coefficient on parental investment becomes larger (-0.049) and attains statistical significance at 10%. Note that this last specification shows the best fit to the data according to the BIC criterion in the last row.

To complement our analysis, in Table 6 we regress parental investment at t on peer group average academic skills, on peer group average latent propensity to use substances, and on other individual level and peer group level demographics, as well as on school-grade fixed effects. We instrument for peers' average latent academic skills and for peers' average latent propensity to use substances using peers' average past year's GPA and peers' average age of initiation of alcohol use. F-statistics for the instruments in the first stages are, respectively, 28.1 and 19.2. We find that a one standard deviation increase in peers' average academic skills increases parental investment by 0.18 standard deviation. Parental investment is also increasing in maternal education, decreasing in single-mother households, and decreasing in peers' household education.

4.3.Heterogeneity

Next, we explore heterogeneous peer and parental influence in cognitive skills by gender, social network centrality, high achieving academic status, and household education at baseline. Note that due to low statistical power, this exercise is suggestive. In Table 7, the first two columns report instrumental variables regressions by gender. The coefficient on peers' average academic achievement decreases to 0 and loses statistical significance for girls, and increases in magnitude to 0.34 standard deviations for boys. On the other hand, the interaction between parental investment and peers' skills appears a bit stronger for girls, although the difference between boys and girls is

not statistically significant. These results suggests that, for girls, the influence of peers on academic skills works mostly through externalities on parental investment.

Columns (3) and (4) report results by the degree of centrality[13] of the student in the classroom's social network at baseline. Students with higher network centrality are more likely to be influenced by peers' average academic skills (the coefficient on the peer group average is a strongly significant 0.317, versus a non-significant 0.08 for students with low centrality). The effect of parental investment is positive for both students in central and non-central social positions, but it is only significant for the latter. The interaction between peer skills and parental investment is estimated imprecisely.

When assessing results by academic achievement level (Columns 5 and 6), we find that the point estimate on peer academic skills is 0.205 (statistically significant at 10%) for high achieving students, versus 0.096 (non-significant) for low achievers. However, the confidence intervals overlap so we are unable to say much about this difference. On the other hand, while we find a strong interaction between peer average skills and parental investment for high achievers (coefficient of 0.148 standard deviations, statistically significant at 5%), for low achievers we find no-significant effects of parental investment on academic achievement, neither directly nor through an interaction with peers' skills. Surprisingly, the sign on the parent-peer-skills interaction for this group becomes negative and large in magnitude, although it is statistically non-significant.

Finally, results by mother's education show strong peer influence for both children of college graduates and children of non-college graduates. However, while

[13] Centrality is a property of a node's position in a network. We consider in-degree centrality of each student, which is measured as the sum of nominations that a student received from peers in his/her cohort.

parental investment has a strong influence on the academic skills of children of lower educated mothers, both directly and through an interaction with peers' skills, it has no effects on the academic skills of children of college graduates. The coefficient on parental investment is 0.098 (statistically significant at 5%) for children of women with no college degree versus 0.06 (non-significant) for children of college graduate mothers. In addition, the peer-parent interaction is 0.136 (statistically significant at 5%) for children of women with no college degree and 0.035 (non-significant) for children of college graduate mothers.

In sum, boys and central individuals appear to be subject to stronger peer influence. For girls, high achievers, and children of mothers without college degrees, most of the effects of parental investment work indirectly through a complementarity with peer skills. On the contrary, parental investment appears to have no effect over low achieving students.

5. Discussion and Conclusions

In this paper we investigate the relative influence of peers versus parents, and their degrees of complementarity or substitution, in the development of cognitive skills and the propensity to use substances during adolescence. We proxy cognitive capabilities with principal components of academic test results, and proxy the latent propensity to use substances with self-reported measures of substance use. Our data come from a sample of adolescents in 9^{th} and 10^{th} grade from ten private high schools in Uruguay. We address selection by exploiting students' quasi-random assignment to classes within grades. We avoid Manski's (1993) reflection problem by conditioning future behavioral choices on the individual's past choices as well as on peers' past choices. And we address biases due to common shocks and measurement error by using

instrumental variables. Our measure of parental investment is an index that captures several parental nurturing and monitoring behaviors, including being attentive to the child's whereabouts and to the child's time of arrival in the evenings, showing concern about child's academic performance, sharing meals with the child, listening to the child's problems, being well acquainted with the child's best friends, and being able to hold peaceful conversations when disagreeing.

We find statistically significant linear-in-means peer effects in latent cognitive ability. A one standard deviation increase in peers' academic skills at baseline increases individual skills by 0.17 standard deviation. This effect compares to a positive but smaller (0.06 standard deviation) direct influence of parental investment, that increases as the academic skills of the peers are stronger. It is quite interesting to note that due to the complementarity between parental investment and peers' skills, parental investment can produce substantive returns when peer group skills are high. We also show a positive association between parental investment and peer academic skills, even after accounting for selection and common shocks. Parental investment increases by 0.18 standard deviations for each standard deviation increase in peer group average academic skills.

We also show that peer effects in academic skills, and their dynamic interaction with parental investment, are heterogeneous across students' characteristics. Boys and students centrally located in their school networks are more likely to be influenced by peers' academic abilities than girls and non-central individuals. For girls, neither peers' skills nor parents' efforts achieve a direct influence on academic skills; it is mostly the complementarity between peers' skills and parental investment that produce an effect.

Unlike our findings with cognitive abilities, we do not encounter major evidence of peer effects in the latent predisposition to use substances. While OLS estimates suggest positive peer effects in latent substance use predisposition, the linear-in-means effect disappears after using IVs to control for common shocks. In a well identified across cohort variation study, Bifulco et al (2011) also find evidence of peer influence in academic trajectories despite no evidence of effects of peers on substance use or health behaviors.

Our results are conceptually in line with Bisin and Verdier (2001), who argue that "cultural transmission is the result of purposeful socialization decisions inside the family ('direct vertical socialization') as well as of indirect socialization processes like social imitation and learning ('oblique and horizontal socialization')." Families take into account the costs and the benefits of their decisions regarding the socialization of their children in specific environments. Parents are more likely to exert higher efforts when the yields to their efforts are enhanced by the environment. The complementarities we encounter between peers' academic skills and parental investment in private schools in Uruguay are similar to those found by Patacchini and Zenou (2011) between neighborhood quality and parents' involvement in education in the UK, and by Patacchini and Zenou (2016) in their analysis of the interplays betwen peer religiosity and parental religious efforts. Our results may help explain why parental effort remains low in environments with low human capital formation. Furthermore, understanding the degree of complementarity between parental effort and the environment across a variety of preferences, attitudes, and behaviors, as well as across individual characteristics may contribute to elucidate the multiplying effect of policy and the triggers that need to be pulled.

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Table 1: Pearson $\chi 2$ tests for independence of students' characteristics across classes within school-grades.

Students' characteristics	3rd grade	4th grade	Full sample
Age	27.395	38.148	65.543
Female	8.610	5.927	14.537
Mother´s education	34.875	74.390	109.274
Single mother family	21.761*	17.004	38.765*
Intact family structure	18.298	19.392	37.690
Number of siblings	49,692	82.586**	132.278**
Asset index	8,318	19,566	27,884
Mother works	14.028	19.85	33.878
Father works	10.378	13.849	24.227

*** Significant at 1% level; ** significant at 5% level; * significant at 10% level.

Table 2: Descriptive Statistics

	N	Mean	Std. dev.	Min	Max
	(1)	(2)	(3)	(4)	(5)
Latent and Measurement Variables					
PC1 Academic Performance	555	0.112	1.405	-3.225	3.925
Math test result	555	7.013	2.897	1	12
History test result	555	7.294	1.945	3	12
Biology test result	555	7.721	2.232	1	12
Literature test result	555	7.708	1.915	1	12
Average test results	555	7.434	1.650	3.500	11.750
PC1 Substance Use	785	0.007	2.005	-1.926	11.358
Used alcohol past 30 days	785	0.555	0.497	0	1
Used alcohol past 3 months	785	0.680	0.467	0	1
Frequency of alcohol use past 30 days	785	1.896	2.643	0	26
Frequency of alcohol use past 3 months	785	5.078	8.523	0	78
Drunk to intoxication past 30 days	785	0.192	0.394	0	1
Frequency drunk to intoxication past 30 days	785	0.355	0.952	0	10
Used tobacco past 30 days	785	0.181	0.385	0	1
Frequency of cigarette use past 30 days	785	1.906	6.108	0	30
Used marijuana past 3 months	785	0.099	0.299	0	1
Explanatory and control variables					
Parental investment index	785	0.480	0.212	0	1
Parent knows child's whereabouts	785	0.674	0.469	0	1
Parent concerned about child's academic performance	785	0.668	0.471	0	1
Parent and child share at least a meal a day	785	0.617	0.487	0	1
Parent attentive to arrival time	785	0.861	0.346	0	1
Child shares problems with parent	785	0.146	0.354	0	1
Child and parent discuss peacefully	785	0.685	0.465	0	1
Parent knows child's friends well	785	0.439	0.497	0	1
Other controls					
Age	785	15.313	0.608	13.521	17.756
Female	785	0.538	0.499	0	1
Mother’s education (# years)	785	14.812	2.916	3.7	17
Single-mom household	785	0.209	0.407	0	1
Household size	785	4.153	1.063	2.000	10
Repeated a grade	785	0.014	0.118	0	1
Age of initiation of alcohol use	785	13.673	1.557	4	16.271
Average GPA past year	785	8.066	1.620	6	12
Wealth index	785	0.482	0.259	0.036	1
Peers' average age	785	15.339	0.480	14.681	16.063
% of peers female	785	0.515	0.110	0.200	0.800
Peers' avg household education (# years)	785	14.729	1.339	11.630	16.756
% of peers living in single-mom households	785	0.208	0.099	0	0.421
In degree centrality	785	6.289	4.052	0	23

Table 3: Peer and parental influence on academic skills and predisposition to use substances. OLS and IV core estimates.

	Academic skills t+1 OLS (1)	Academic skills t+1 IV (2)	Substance Use t+1 OLS (3)	Substance Use t+1 IV (4)
Individual level skills at t	0.816***	0.821***	0.731***	0.731***
	(0.028)	(0.026)	(0.037)	(0.036)
Peer group average skills at t	0.093	0.173**	0.120***	0.018
	(0.056)	(0.074)	(0.037)	(0.078)
Parental investment	0.059**	0.059**	-0.033	-0.029
	(0.027)	(0.029)	(0.024)	(0.031)
Peer group average x Parental investment	0.039	0.083*	-0.014	0.091
	(0.027)	(0.044)	(0.026)	(0.139)
Age	-0.043	-0.047	0.012	0.034
	(0.071)	(0.067)	(0.068)	(0.067)
Female	-0.036	-0.029	-0.001	0.004
	(0.059)	(0.057)	(0.054)	(0.054)
Mother's years of Education	0.015	0.015	0.009	0.010
	(0.010)	(0.010)	(0.009)	(0.009)
Single mother household	-0.043	-0.039	0.028	0.042
	(0.066)	(0.065)	(0.055)	(0.058)
Classmates' age	-0.231	-0.209	-0.633*	-0.266
	(0.539)	(0.538)	(0.319)	(0.452)
% of classmates female	-0.060	0.046	-0.035	0.256
	(0.332)	(0.352)	(0.351)	(0.374)
Classmates' mothers' yrs of education	-0.028	-0.056	-0.055	-0.038
	(0.060)	(0.062)	(0.049)	(0.059)
% of classmates in single-mother households	-0.055	-0.014	-0.207	0.036
	(0.322)	(0.319)	(0.269)	(0.295)
Constant	4.248	4.376	9.774*	3.471
	(8.727)	(8.688)	(5.557)	(7.603)
School grade fixed effects	yes	yes	yes	yes
N	555	555	785	785
N_clust	40	40	43	43
<u>Instrumental variables F-statistic 1st stage</u>				
Peers' average GPA past year		21.22		
Peers' avg. GPA past year x Parental		24.33		
Peers' average age of initiation of alcohol				21.7
Peers' avg. age of initiation of alcohol use				1.42
Joint significance of contextual peer variables (p-value)	0.947	0.876	0.389	0.900

*** Significant at 1% level; ** significant at 5% level; * significant at 10% level. Coefficients and standard errors in parentheses. Standard errors are clustered at the class level. To simplify interpretation and comparison, the student's outcome at t, the peers' mean, and the parental investment measure, as well as the outcomes at follow up, are all standardized with mean 0 and standard deviation equal to 1. Period t (baseline) corresponds to July 2009 and period t+1 (follow-up) to November 2009. First stage results for columns (2) and (4) are reported in Appendix Table A2.

Table 4: Peer and parental influence on academic skills.
Robustness of the IV estimates to alternative control specifications

	Academic skills at t+1	Academic skills at t+1	Academic skills at t+1	Academic skills at t+1	Academic skills at t+1
	(1)	(2)	(3)	(4)	(5)
Individual level skills at t	0.818***	0.821***	0.821***	0.810***	0.820***
	(0.026)	(0.026)	(0.027)	(0.026)	(0.029)
Peer group average skills at t	0.155**	0.173**	0.169**	0.153**	0.159**
	(0.077)	(0.074)	(0.073)	(0.071)	(0.067)
Parental investment	0.061**	0.059**	0.056**	0.056*	0.074***
	(0.028)	(0.029)	(0.028)	(0.029)	(0.028)
Peer group average x Parental investment	0.084*	0.083*	0.081*	0.079*	0.088**
	(0.043)	(0.044)	(0.042)	(0.041)	(0.041)
Controls					
Age, gender, mother's education, family structure	yes	yes	yes	yes	yes
Peers' average age, gender, mother's education, family structure	no	yes	yes	yes	yes
Household size, wealth index, repeated a grade	no	no	yes	yes	yes
PC substance use, age of initiation of alcohol use	no	no	no	yes	yes
Substance use problems in the family	no	no	no	no	yes
School-grade fixed effects	yes	yes	yes	yes	yes
Constant	0.439	0.003	0.125	0.434	8.582
	(1.006)	(0.961)	(1.003)	(0.971)	(9.340)
N	555	555	555	542	555
BIC	1105.5	1160.6	1179.1	1163.8	1184.5

*** Significant at 1% level; ** significant at 5% level; * significant at 10% level. Coefficients and standard errors in parentheses. Standard errors are clustered at the class level. To simplify interpretation and comparison, the student's outcome at t, the peers' mean, and the parental investment measure, as well as the outcomes at follow up, are all standardized with mean 0 and standard deviation equal to 1. Period t (baseline) corresponds to July 2009 and period t+1 (follow-up) to November 2009.

Table 5: Peer and parental influence on substance use.
Robustness of the IV estimates to alternative control specifications.

	Substance use at t+1 (1)	Substance use at t+1 (2)	Substance use at t+1 (3)	Substance use at t+1 (4)	Substance use at t+1 (5)
Individual level skills at t	0.730***	0.731***	0.726***	0.730***	0.731***
	(0.036)	(0.036)	(0.035)	(0.039)	(0.039)
Peer group average skills at t	0.020	0.018	0.022	0.017	0.002
	(0.060)	(0.078)	(0.078)	(0.092)	(0.098)
Parental investment	-0.029	-0.029	-0.030	-0.037	-0.049*
	(0.031)	(0.031)	(0.030)	(0.028)	(0.025)
Peer group average x Parental investment	0.089	0.091	0.092	0.018	0.015
	(0.136)	(0.139)	(0.141)	(0.140)	(0.124)
Controls					
Age, gender, mother's education, family structure	yes	yes	yes	yes	yes
Peers' average age, gender, mother's education, family structure	no	yes	yes	yes	yes
Household size, wealth index, repeated a grade	no	no	yes	yes	yes
PC academic skills at t	no	no	no	yes	yes
Substance use problems in the family	no	no	no	no	yes
School-grade fixed effects	yes	yes	yes	yes	yes
Constant	-0.922	3.471	3.651	4.612	2.830
	(0.980)	(7.603)	(7.488)	(7.923)	(8.058)
N	785	785	785	785	785
BIC	1608.3	1635.1	1652.6	1565.9	1408.1

*** Significant at 1% level; ** significant at 5% level; * significant at 10% level. Coefficients and standard errors in parentheses. Standard errors are clustered at the class level. To simplify interpretation and comparison, the student's outcome at t, the peers' mean, and the parental investment measure, as well as the outcomes at follow up, are all standardized with mean 0 and standard deviation equal to 1. Period t (baseline) corresponds to July 2009 and period t+1 (follow-up) to November 2009.

Table 6: Parental investment and peer group latent skills. IV regression.

	Parental investment at t
Peer group average academic skills at t	0.179*
	(0.098)
Peer group average propensity to use substances at t	-0.013
	(0.113)
Age	-0.040
	(0.086)
Female	0.006
	(0.079)
Mother's years of Education	0.036***
	(0.013)
Single mother household	-0.266***
	(0.094)
Classmates' age	0.500
	(0.614)
% of classmates female	0.804
	(0.560)
Classmates' mothers' yrs of education	-0.137**
	(0.070)
% of classmates in single-mother households	0.077
	(0.374)
School-grade fixed effects	yes
Constant	-5.623
	(10.609)
Instrumental variables F-statistic 1st stage	
Peers' average GPA past year	28.07
Peers' average age of initiation of alcohol use	19.17
N	785

*** Significant at 1% level; ** significant at 5% level; * significant at 10% level. Coefficients and standard errors in parentheses. Standard errors are clustered at the class level. Both of the peers' average skills and the parental investment measure are standardized with mean 0 and standard deviation equal to 1. We instrument for peers' average latent academic skills and for peers' average latent propensity to use substances using peers' average past year's GPA and peers' average age of initiation of alcohol use.

Table 7: Heterogenous effects of peers, parents and their strategic interactions. IV regression.

	By gender		By network centrality		By academic achievement		By mother's education	
	Female	Male	Low centrality	High centrality	Low achiever	High achiever	Mother is not college-graduat	Mother is college-graduate
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Individual level skills at t	0.795***	0.843***	0.822***	0.837***	0.651***	0.819***	0.826***	0.840***
	(0.036)	(0.042)	(0.042)	(0.035)	(0.090)	(0.038)	(0.035)	(0.035)
Peer group average skills at t	-0.000	0.343***	0.081	0.317***	0.096	0.205*	0.186***	0.235***
	(0.065)	(0.119)	(0.080)	(0.110)	(0.093)	(0.115)	(0.068)	(0.086)
Parental investment	0.034	0.053	0.075**	0.044	0.004	0.057	0.098**	0.006
	(0.039)	(0.046)	(0.032)	(0.050)	(0.050)	(0.039)	(0.038)	(0.045)
Peer group average x Parental investment	0.113*	0.085	0.036	0.112	-0.110	0.148**	0.136**	0.035
	(0.068)	(0.082)	(0.060)	(0.089)	(0.089)	(0.062)	(0.068)	(0.065)
Age	0.082	-0.234*	-0.183*	0.070	-0.059	-0.019	-0.070	-0.016
	(0.098)	(0.129)	(0.100)	(0.107)	(0.077)	(0.101)	(0.101)	(0.095)
Female			-0.151**	0.025	-0.011	-0.023	-0.101	-0.003
			(0.073)	(0.081)	(0.116)	(0.056)	(0.070)	(0.087)
Mother's years of Education	0.026**	0.007	0.001	0.024	-0.007	0.026**	0.002	
	(0.012)	(0.014)	(0.009)	(0.016)	(0.011)	(0.012)	(0.017)	
Single mother household	-0.031	0.009	-0.105	-0.023	-0.147	0.001	0.043	-0.075
	(0.075)	(0.112)	(0.096)	(0.074)	(0.093)	(0.084)	(0.086)	(0.091)
Classmates' age	-0.202	-0.489	0.170	-0.525	0.524	-0.729	-0.986*	0.671
	(0.439)	(0.876)	(0.620)	(0.662)	(0.733)	(0.657)	(0.579)	(0.561)
% of classmates female	-0.355	0.089	-0.589	0.704	0.225	0.110	-0.647*	0.574
	(0.410)	(0.529)	(0.461)	(0.733)	(0.559)	(0.405)	(0.367)	(0.565)
Classmates' mothers' yrs of education	0.069	-0.147*	-0.015	-0.105	0.078	-0.079	-0.107	0.020
	(0.076)	(0.076)	(0.074)	(0.092)	(0.141)	(0.074)	(0.076)	(0.077)
% of classmates in single-mother households	0.347	-0.267	-0.562	0.421	-0.990*	0.277	0.257	-0.158
	(0.448)	(0.397)	(0.532)	(0.553)	(0.526)	(0.426)	(0.334)	(0.470)
Constant	0.198	13.350	0.667	7.979	-7.773	11.617	17.394*	-9.973
	(7.376)	(14.251)	(9.928)	(10.785)	(12.307)	(10.765)	(9.567)	(9.042)
School-grade fixed effects	yes	yes	yes	yes	yes	yes	yes	yes
N	284	271	263	292	213	342	254	301

Appendix 1

Table A1: Principal Component Analysis

Panel A. Academic performance

Eigenvalues

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	2.280	1.604	0.570	0.570
Comp2	0.676	0.110	0.169	0.739
Comp3	0.567	0.090	0.142	0.881
Comp4	0.476	.	0.119	1.000

Eigenvectors

Variable	Comp1	Unexplained
Math test result	0.489	0.456
History test result	0.526	0.370
Biology test result	0.495	0.442
Literature test result	0.490	0.453

Panel B. Substance Use

Eigenvalues

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	4.299	2.981	0.478	0.478
Comp2	1.318	0.323	0.147	0.624
Comp3	0.996	0.211	0.111	0.735
Comp4	0.785	0.133	0.087	0.822
Comp5	0.652	0.333	0.073	0.895
Comp6	0.319	0.050	0.035	0.930
Comp7	0.269	0.060	0.030	0.960
Comp8	0.208	0.055	0.023	0.983
Comp9	0.154		0.017	1.000

Eigenvector

Variable	Comp1	Unexplained
Used alcohol past 30 days	0.364	0.432
Used alcohol past 3 months	0.315	0.574
Frequency of alcohol use 30 days	0.380	0.380
Frequency of alcohol use 3 months	0.350	0.473
Drunk to intoxication past 30 days	0.354	0.460
Used tobacco 30 days	0.331	0.529
Frequency of cigarett use 30 days	0.291	0.637
Used illegal drugs past 3 months	0.271	0.685

Appendix 2

Table A2: First stage regressions, instrumental variable estimation

	Academic skills t+1	Substance use t+1
	(1)	(2)
Instrumental variable #	1.336***	-1.123***
	(0.186)	(0.177)
Individual level skills at t	-0.103***	-0.021
	(0.019)	(0.028)
Parental investment	0.018*	-0.003
	(0.010)	(0.013)
Mother's years of Education	0.000	0.008
	(0.006)	(0.006)
Age	0.010	0.138***
	(0.048)	(0.050)
Female	-0.098**	0.036
	(0.042)	(0.049)
Single mother household	0.006	0.003
	(0.041)	(0.035)
Wealth index	-0.008	-0.009
	(0.009)	(0.012)
Repeated a grade	0.058	-0.068
	(0.061)	(0.069)
Household size	-0.146	-0.261*
	(0.152)	(0.153)
Age of initiation of alcohol use	0.013	-0.029**
	(0.008)	(0.011)
Past year GPA	0.021	0.006
	(0.018)	(0.005)
Classmates' age	-0.037	2.851***
	(0.939)	(0.964)
% of classmates female	-2.185**	0.872
	(0.839)	(1.039)
Class size	-0.063***	-0.025
	(0.021)	(0.019)
Classmates' mothers' yrs of education	0.062	0.161
	(0.107)	(0.103)
% of classmates in single-mother households	0.632	0.739
	(0.792)	(0.712)
School-grade fixed effects	yes	yes
Constant	-9.568	-31.763*
	(15.370)	(16.527)
N	555	785
N_clust	40	43
R^2	0.884	0.847