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HOME COMPUTER USE AND THE DEVELOPMENT OF HUMAN CAPITAL*

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Abstract

This paper uses a regression discontinuity design to estimate the effect of home computers on child and adolescent outcomes by exploiting a voucher program in Romania. Our main results indicate that home computers have both positive and negative effects on the development of human capital. Children who won a voucher to purchase a computer had significantly lower school grades but show improved computer skills. There is also some evidence that winning a voucher increased cognitive skills, as measured by Raven's Progressive Matrices. We do not find much evidence for an effect on non-cognitive outcomes. Parental rules regarding homework and computer use attenuate the effects of computer ownership, suggesting that parental monitoring and supervision may be important mediating factors.

I. Introduction

The impact of home computer use on the development of children's human capital has been the subject of much debate.1 As with the introduction of television and other media, proponents of increasing access to home computers have touted the educational benefits for children, while opponents have expressed concern about the negative effects of excessive computer use and the risks of exposure to adult content (Wartella and Jennings 2000).2 Many studies have documented a positive correlation between home computer use and various educational outcomes in the United States, including math and reading test scores (Attewell and Battle 1999), school enrollment (Fairlie 2005), and high school graduation (Beltran, Das, and Fairlie 2010).3 Access to a home computer may also foster the development of computer skills and thereby lead to better labor market outcomes.4 On the other hand, home computer use is hypothesized to lead to a lack of physical activity,

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[1]A related literature examines the effect of school computer use on educational outcomes. See Angrist and Lavy (2002), Banerjee et. al. (2007), Barrera-Osorio and Linden (2009), Barrow, Markman and Rouse (2010), Goolsbee and Guryan (2006), and Rouse and Krueger (2004).

[2]Recent evidence on the effect of early exposure to television on test scores suggests that television does not lead to lower cognitive achievement (Gentzkow and Shapiro, 2008). In related studies, Olken (2009) finds that television and radio reduces social participation in Indonesia while Jensen and Oster (2009) show that access to cable TV improves women's status in India.

[3]However, Fuchs and Woessmann (2004) observe that the positive correlation between home computers and student performance on PISA math and reading scores becomes negative after controlling for detailed student, family and school characteristics.

[4]Krueger (1993) estimates a large wage premium among Americans who use a computer at work but DiNardo and Pischke (1997) have cast some doubt about a causal interpretation of these premiums.

increased risk of obesity, decreased social involvement, and more aggressive behavior when playing violent computer games (Subrahmanyam, et. al. 2000 2001). Nevertheless, with some recent exceptions (Fairle and London 2009; Vigdor and Ladd 2010), most of the evidence on the relationship between home computer use and child development outcomes is subject to many confounding factors and therefore unlikely to reflect a true causal effect.[5]

Understanding the risks and benefits of home computer use on children's outcomes is especially important in light of the large disparities in computer ownership both within and between countries. In the United States, less than half of children with family incomes under $25,000 live in a household with a computer, compared to 92 percent of those with family incomes over $100,000 (U.S. Census Bureau 2005). Estimates from the 2003 Programme for International Student Assessment (PISA) show that the vast majority of 15 year old students in developed countries have access to a home computer in contrast to only about half of 15 year old students in emerging Eastern European countries such as Poland, Latvia and Serbia. Among 15 year olds in the bottom SES quartile within these emerging countries, fewer than a quarter have access to a home computer.[6] (OECD 2005) Many government and non-governmental organizations are trying to bridge this "digital divide". For example, the One Laptop per Child (OLPC) program has received substantial publicity in its efforts to develop and distribute cheap laptop computers to children in developing countries.[7] Uruguay recently completed its *Plan Ceibal* by providing a free OLPC laptop to every primary school child, while other countries, such as Peru and Rwanda, have placed orders for and received hundreds of thousands of computers (Psetizki 2009; Stross 2010). However, to our knowledge, there have been no large-scale evaluations of these major efforts to increase computer access for children.

This paper seeks to provide a causal estimate for the effect of access to a home computer on the development of human capital for children and adolescents from disadvantaged households. We analyze a government program administered by the Romanian Ministry of Education which subsidized the purchase of home computers. The program awarded approximately 35,000 vouchers worth 200 Euros (about $300) in 2008 towards the purchase of a personal computer for low-income students enrolled in Romania's public schools. Similar to programs in other countries, the Euro 200 program was intended to increase home computer use among disadvantaged families and promote computer skills for school-aged children. Since the fixed number of vouchers were allocated based on a simple ranking of family income, we employ a regression discontinuity design that allows comparisons across students who are very similar in family income and other respects, but markedly different in their access to a computer at home. Using data that we collected through in-person household interviews, we estimate the impact of winning a program voucher on computer ownership and use, academic achievement, cognitive skills, computer skills, and various non-cognitive outcomes.

Our findings indicate that home computer use has both positive and negative effects on the development of human capital. We find that winning a voucher increased the likelihood of households owning a home computer by over 50 percentage points, making them almost twice as likely to own a computer as compared to households whose income was above the

[5]Fairlie and London (2009) find that home computers have positive effects on educational outcomes based on a randomized control trial of 286 community college students in California. Vigdor and Ladd (2010) use panel data to show that newly purchased home computers lead to negative impacts on student math and reading test scores in North Carolina.

[6]This fraction is substantially lower for less-developed countries such as Thailand, Tunisia, and Turkey, and essentially zero for countries in sub-Saharan Africa and parts of south Asia.

[7]Even in cases where these computers are provided for school use, they are also intended to serve as home computers. The chairman of OPLC, Nicholas Negroponte, explains that "mobility is important, especially with regard to taking the computer home at night...bringing the laptop home engages the family."http://laptop.org/faq.en_US.html

program threshold. As expected, higher rates of computer ownership also led to increased computer use, with children in households who won a voucher using computers about 3 to 4 hours a week more than their counterparts who did not win a voucher. We find strong evidence that children in households who won a voucher had received significantly lower school grades in Math, English and Romanian, with our preferred estimates indicating effect sizes between 1/4 and 1/3 of a standard deviation. We also estimate that children in household who won a voucher had significantly higher scores in a test of computer skills and in self-reported measures of computer fluency, with effect sizes of about 1/4 of a standard deviation. There is also some evidence that winning a voucher increased cognitive skills, as measured by Raven's Progressive Matrices. We do not find much evidence that winning a computer voucher affected non-cognitive outcomes. Although less precise, the same pattern of results holds for a smaller sample of households who received a computer voucher four years earlier, suggesting that our main findings persist over time.

The effect of computer use on academic achievement may not be surprising given the patterns of actual use. Despite efforts by the government to provide educational software, few parents or children report having educational software installed on their computer, and few children report using the computer for homework or other educational purposes. In contrast, most children report playing computer games on a daily basis.8 Furthermore, there is some suggestive evidence that winning a computer voucher reduced the time spent doing homework, watching TV, and reading. These changes in time-allocation may have contributed to lower academic achievement.

Our analysis also sheds some light on the potential role of parents in shaping the impact of home computer use on child and adolescent outcomes.9 Interestingly, we find that the presence of parental rules regarding homework help mitigate some of the negative effects of winning a computer voucher without affecting the gains to computer skills and cognitive skills. However, the presence of rules regarding computer use diminishes the positive impacts on computer skills without improving academic achievement. While these results are only suggestive, given that such rules are not randomly assigned, they may indicate that encouraging homework is more effective than restricting computer use.

The paper is organized as follows: Section II provides background on the Euro 200 program. Section III describes the data collection effort and the resulting data. Section IV explains the empirical strategy which underlies the analysis. Section V presents our main findings. Section VI reports on some further results, and Section VII concludes.

II. The Euro 200 Program

The voucher program, widely known as the Euro 200 program in Romania, was proposed by the Prime Minister's office and adopted by unanimous vote in Parliament in June 2004 as Law 269/2004. According to the law, the official purpose of the program was to establish a mechanism to increase the purchase of computers through financial incentives based on social criteria so as to promote competence in computing knowledge. Over time, the government expanded the resources allocated to the voucher program: 25,051 families received vouchers in 2004, and the number of awards increased to 27,555 in 2005, 28,005 in 2006, 38,379 in 2007, and 35,484 in 2008. The rules of the program specified the minimum specifications for computers purchased using the vouchers. In 2008, computers had to be

[8]Stinebrickner and Stinebrickner (2008) provide evidence indicating that the presence of a video game console lowers academic performance in college.

[9]In a qualitative study of home computer use, Giacquinta et. al. (1993) find that children only engaged in educational computing if parents took an active role in selecting software and spending time with children at the computer.

new and equipped with at least a 2 GHz processor, 1GB RAM memory, 160 GB hard-disk with a keyboard, mouse and monitor, as well as some pre-installed software.

In the early rounds of the program, the 200 Euro (roughly $300) subsidy covered a large fraction of the price of a new computer that met the minimum specifications. For example, in 2005, the voucher covered about 75 percent of the price quoted by Romania's largest computer retailer, who sold almost 40 percent of the program's designated computers (Comunicatii Mobile 2005). However, as the price of computers declined over time, the voucher covered an even higher fraction of the cost. Indeed, by 2007, two of the largest computer retailers were able to offer computers that met the minimum specifications for 200 Euros (Ministry of Education 2007). Thus, not surprisingly, data from the Ministry of Education indicates that 99 percent of the vouchers issued for the regions included in our study resulted in computer purchases.

The program was targeted towards children from low income families.10 To apply for the program, a household was required to have at least one child under the age of 26 enrolled in grades 1 to 12 or attending university. Furthermore, only households with monthly family income per household member of less than 150 RON (around $65) were eligible to apply. The calculation of income included all permanent sources of income for family members in the month prior to the application, with the exception of unemployment benefits, state support for children, merit scholarships and social scholarships. According to Government Decision Nr. 1294/2004 that elaborated on the implementation of the Euro 200 program, parents were required to provide original documents showing the family income of all household members and sign a declaration that they were reporting their true family income (Anexa 1, Art. 3). The application form also included several explicit warnings against reporting false incomes.

In 2008, 52,212 households applied for the program. Following the application deadline, all the applicants were ranked based on their family income per household member. Since the government had limited funds, it restricted the number of vouchers to 35,484, which corresponded to a maximum income of 62.58 RON (about $27). Winners were announced in May and received their vouchers in August of 2008.11 Neither the number of vouchers nor the income threshold was known to the applicants in advance. This feature of the program is extremely important for implementing the regression discontinuity design and we discuss it further in the section describing our empirical strategy.

The Ministry of Education also offered 530 multimedia educational lessons to encourage the use of computers for educational purposes. The lessons included subjects such as math, biology, physics, geography, computer science, history and chemistry for different grades and were developed under the guidelines of the Ministry of Education in accordance with the national teaching curriculum. Computer retailers who participated in the Euro 200 program were encouraged to install these lessons at no charge on the computers of program winners, and these lessons were made available to non-winners as well. However, as revealed by our household survey, relatively few parents and children report having educational software installed on their computer, and still fewer children report using the computer for educational purposes.

[10]Due to the correlation between income and academic acheivement, this also tended to target lower achieving children. Among children who took the national exam at the end of grade 8, those who participated in the Euro 200 program scored about 0.3 standard deviations below the national average.

[11]Vouchers were issued in the name of the child, and were not transferable. While it was possible for families to sell their computer after purchase, we show that most voucher winners actually kept their computers.

III. Data

The data used in this paper come from a 2009 household survey that we conducted with families who applied to the 2008 round of the Euro 200 program. To conduct the survey, we obtained a list of 6,418 families who participated from the regions of Arad, Bistrita-Nasaud, Braila, Cluj, Maramures, Mures and Sibiu.12 This list contained the names of the parent and child who applied to the program, the place of residence and the name of the child's school. It also included information on the income per family member in the month prior to the application deadline, which is the running variable used to implement our regression discontinuity design. With the help of Gallup Romania, we attempted to locate and interview each of these families in person. The survey was conducted in the spring of 2009, between May and June, while most children were still in school.

We succeeded in interviewing 3,354 families for a response rate of 52 percent, which is in line with Gallup's usual rate for this population. While the resulting sample is not completely representative of the program applicant pool or the population of these regions more generally, we found no evidence that response rates differed between households who won vouchers and their counterparts who did not receive vouchers, after controlling flexibly for income. The raw response rate for households who won vouchers was 53 percent as compared to 50 percent among the non-winners. However, this difference is close to zero around the income threshold for receiving a voucher (see Panel A of Appendix Figure I).13

The household survey had three parts. First, we interviewed the family to obtain demographic information about each member of the household and basic household characteristics, including information about computer ownership. Second, we asked the primary caregiver (i.e. a parent in every case) to provide information on child outcomes for each child in the family. Third, we conducted a separate interview with each child present at home on the day of the survey. Both the parent and the child questionnaires included questions about our main variables of interest, such as computer ownership, computer and time-use patterns, academic achievement, and the presence of behavioral problems. In addition, we administered a cognitive skills test, a computer test, and a battery of computer fluency questions to the children present at the time of the survey.

Table I presents summary statistics for the main household variables. The average monthly income per household member reported by households in their Euro 200 application is 47.6 RON (approximately $20). Among our 3,356 applicant families, 64.7 percent received a voucher in the 2008 round of the Euro 200 program and 98.6 percent of the awarded vouchers were cashed according to records by the Ministry of Education. Since the program was targeted to low income families, the sample population is predominantly rural and has comparatively low levels of educational attainment. About 73 percent of all households owned a computer, indicating that about one third of households who did not qualify for a voucher in the 2008 round had a computer in the spring of 2009. Appoximately 65 percent of households had access to computer games, or 87 percent among those owning a computer. In contrast, only 9 percent of households had access to educational software. Access to the Internet was limited to just 14 percent of households. Thus, when interpreting our results, it is important to keep in mind that the voucher program increased computer access without much of an effect on Internet access.

[12]These regions are quite representative of Romania. There were no statistically significant differences between the regions in our study and the rest of the country in terms of area, population, income per capita or program characteristics such as number of applicants and percent winners.

[13]All Appendix Figures, Appendix Tables, and a Data Appendix are contained in an on-line appendix.

Table II presents parental reports on time-use, academic, and behavioral outcomes for about 5,900 children.14 The sample of children is evenly split between boys and girls and with almost all between the ages of 7 and 19. On average, parents reported that children used a computer about 5 hours a week, or over 6 hours a week conditional on having a home computer. For measures of time spent doing homework, watching TV, and reading, we focus on a binary variable indicating daily use: whether children spent more than 1 hour per day engaged in that activity. Academic outcomes consist of average school grades during the 2008–09 academic year in the subjects of Math, Romanian, and English, as well as a school behavior grade. All subjects are graded out of 10. Average grades in Math, Romanian, and English were centered around 7.5, while most students received a 10 in behavior. Response rates are somewhat lower for school grades (especially for English which is not a required subject for all students).15 We also asked parents if their children had exhibited various behavioral problems during the past three months. We created an index for the fraction of the problems that were reported to be "sometimes" or "often" true of the child, as opposed to "not true" for the following behaviors: trouble getting along with teachers, disobedience at home, disobedience at school, hanging around with troublemakers, bullying others, inability to sit still, and whether the child prefers to be alone.16 Finally, we elicited information about children's height and weight to form measures of BMI, as well as information about participation in sports and service activities.

Table III presents summary statistics from approximately 4,600 child interviews on time-use, academic, and behavioral outcomes, as well as cognitive and computer assessments.17 The distributions of child age and gender in the child surveys are very similar to those in the parent surveys. Almost all child respondents are aged 7 to 19, with a large majority between the ages of 9 and 13. Children also reported doing homework and watching TV at similar frequencies to those reported by parents. In addition, we asked children about the daily use of computers for games, homework, and educational activities. Almost 20 percent of children reported that they play games every day. In contrast, less than 2 percent of children reported that they use the computer for homework every day and less than 1 percent reported using educational software every day. Average grades in Math, Romanian, and English are also comparable to those reported by parents. As with the parent reports, there are slightly lower response rates for school grades (especially for English). We examine the degree of correspondence between child and parent reports for different questions in greater detail in a subsequent section.

We also assessed children's skills more directly. We administered an un-timed cognitive test based on Raven's Progressive Matrices, which is standardized with a mean of 0 and standard deviation of 1.18 This test is designed to assess general intelligence by measuring the ability to form perceptual relations and to reason by analogy (Raven 1939, 1956). However, a number of scholars have argued that the test also measures an important spatial component of ability.19 We also administered a computer test and elicited self-reported computer

[14]We allowed the head of household to report on up to 5 children. This sample censoring affects only 29 families who have between 6 and 11 children (based on roster information).

[15]There are slightly more instances of non-response among the oldest and youngest children. However, there is no significant relationship between non-response and winning a voucher (or most other household characteristics).

[16]The questions are based on items used in the National Health Interview Survey and the National Longitudinal Survey of Youth Children's Supplement (NLSY-CS). As in recent MTO evaluations (Katz, Kling, and Leibman 2001), we focus on seven questions that asked about behaviors which the mothers could observe directly, as opposed to generic questions about behavior or questions requiring intuition about how their child was feeling.

[17]We found no evidence that response rates of children differed between households who won vouchers and those who did not receive vouchers, after controlling flexible for income (see Panel B of Appendix Figure I).

[18]This is comprised of two different sets of test questions: one given to children aged 5–12 and another given to children aged 13 and over. The test instrument is based on the one administered to respondents of the Mexican Family Lifestyle Survey (available at http://www.mx.s.cide.edu/).

[19]See Burke (1958), Hunt (1975), Colom et. al. (2004) and Lynn et. al. (2004).

fluency. The computer literacy test contained 12 multiple-choice questions intended to measure basic computer skills. Self-reported computer fluency was obtained by asking children about their knowledge of different tasks related to operating a computer, using applications, as well as email and the internet use. The data appendix contains a full description of the computer test and the computer fluency questions. These questions are based on a computer-email-web (CEW) fluency scale developed by Bunz (2004), and validated with actual abilities performing related tasks in an applied computer-lab session by Bunz et. al. (2007). We report the raw fluency scores ranging from 1 to 4 in the descriptive statistics, but we normalize the scales to a mean of 0 and standard deviation of 1 in the regression analysis. In addition, we asked children to complete a 10 item Rosenberg Self-Esteem Scale for a self-reported measure of non-cognitive skills.20 Finally, we asked children about their health status, whether they experienced problems with pain in the hands, their perception of being overweight or underweight, and the frequency of smoking and consumption of alcohol.

IV. Empirical strategy

We employ a regression discontinuity (RD) design to estimate the effect of providing a computer voucher to low-income students enrolled in Romania's public schools in 2008. Since these computer vouchers were allocated according to a simple income cutoff, we are able to compare outcomes across families with similar income and other characteristics, but very different levels of computer ownership. This corresponds to a RD design and the standard regression model used through the analysis is as follows:

$$outcome_i = \beta' \mathbf{X}_i + \delta winner_i + f(income_i) + \varepsilon_i \quad (1)$$

where $outcome_i$ represents a particular child outcome such as computer use or GPA for child i. $\mathbf{X}_i$ includes a set of control variables: age, ethnicity, gender, and educational attainment of the head of household, as well as child gender and age dummies. In practice, these control variables have very little effect on our estimates of the discontinuity and serve mainly to increase precision. The indicator variable, $winner_i$, is equal to 1 if monthly household income per capita is less than the cut-off of 62.58 RON, and 0 otherwise. The coefficient δ, our main coefficient of interest, indicates the effect of receiving a Euro 200 computer voucher on the relevant outcome. Finally, $f(income_i)$ is a smooth function of income, which is the forcing variable that determines the assignment of a computer voucher.

The central assumption underlying the RD design is that we have correctly specified the function of income, $f(income_i)$. Accordingly, we consider both parametric and non-parametric functions of income and explore the robustness of our findings to a variety of functional form assumptions. For our parametric specifications, we present quadratic splines which allows the slope to vary on each side of the cutoff, but results using linear and cubic splines are shown in an online appendix. For our non-parametric specifications, we follow Hahn, Todd, and van der Klaauw (2001) and Porter (2003) in using local linear regressions to estimate the left and right limits of the discontinuity, where the difference between the two is the estimated treatment effect. We estimate this in one step using a simple rectangular kernel. Although a triangular kernel, by putting more weight on observations closer to the cutoff point, has been shown to be boundary optimal (Chang, Fan, and Marron, 1997), Lee and Lemuiex (2010) argue that a more transparent way of putting more weight on observations close to the cutoff is to re-estimate a model with a rectangular kernel using

[20]The Rosenberg test consists of 10 statements related to overall feelings of self-worth or self-acceptance. The items are answered on a four-point scale which ranges from "strongly agree" (1) to "strongly disagree" (4). Summing the ratings after reverse scoring the positively worded items, scores range from 10 to 40, with higher scores indicating lower self-esteem.

smaller bandwidths. However, as in much of the earlier research, our results are not very sensitive to the choice of kernel (Fan and Gijbels, 1996). A more consequential decision is the choice of bandwidth.

Given the absence of a widely agreed-upon method for the selection of optimal bandwidths in the non-parametric RD context, we follow Ludwig and Miller (2007) and examine our results for a broad range of candidate bandwidths. Our preferred estimates are based on a bandwidth of 30 RON which appears to balance the goal of staying relatively local to the cutoff while providing enough data to yield informative estimates, but results using bandwidths of 60, 15, and 7.5 are presented in an online appendix. In addition, we present two alternative approaches for estimating the optimal bandwidth: (i) a modified cross-validation (CV) procedure, as described by Ludwig and Miller (2005) and Imbens and Lemuiex (2007);21 and (ii) the Imbens-Kalyanarman (IK) optimal bandwidth, as described by Imbens and Kalyanarman (2009).22 The specific bandwidths determined according to these procedures differ for each outcome, but most IK bandwidths range from 5 to 10 whereas most CV bandwidths range from 20 to 40. Finally, we follow Imbens and Lemuiex (2007) and Lee and Lemuiex (2010) by presenting standard robust errors, but cluster by household when running regressions at the child level to allow for within-household correlations.23

Another important assumption for the RD design is that households were not able to manipulate the forcing variable, income, around the program threshold. We have strong reason to believe that this assumption is maintained in our particular setting. As mentioned earlier, parents were warned against any attempt to falsify information on income and were required to provide documentation regarding family income. Furthermore, essentially all household who applied for vouchers in the previous rounds of 2006 and 2007 ended up qualifying to receive a voucher. Therefore, it is plausible that families believed they would receive a voucher even if their income was close to the upper limit for eligibility. Nevertheless, it is possible that some families still attempted to understate their true income in order to raise the likelihood of receiving a voucher. Such cheating would only create a problem for our identification strategy if it varied differently on either side of the income threshold. This could arise only if families had information about the income threshold at the time they applied for the Euro 200 program. In fact, the cut-off of 62.58 RON for receiving a voucher was not known ex-ante; it was determined by the amount of funds available and by the number of households who applied and their corresponding income, none of which were known prior to the start of the program.24 Furthermore, along the lines of McCrary (2007), we show that the frequency density does not vary around the income threshold (see Appendix Figure II).

Note that we restrict most of our analysis to the reduced-form effects of winning a voucher. Given that almost all of the awarded vouchers are actually cashed in to buy computers, this closely corresponds to the effect of *receiving* a free computer. But this does not necessarily represent the effect of having a computer because some households who did not win a

[21]The cross-validiation (CV) procedure is implemented by examining prediction errors for each data point within 10 RON of the income cutoff. Specifically, we generate a loss function of the average boundary prediction error, where the predicted values of datapoints to the left (right) of the cutoff are based on local linear regressions using data only to the left (right) of these points. We create this loss function for bandwidths ranging from 1 to 50 and select the one which minimizes loss. This procedure is implemented separately for each outcome variable.

[22]The IK bandwidth selection procedure is implemented using the Stata ado file named rdob.ado available at http://www.economics.harvard.edu/faculty/imbens/software_imbens.

[23]Using analytic standard errors derived based on the formula provided by Porter (2003) does little to alter our inferences. However, these do not account for the possibility of correlated observations within-household.

[24]Note that, due to the choice of bandwidths, all of our non-parametric specifications omit families who report zero income which might be associated with a higher likelihood of cheating (since it would almost guarantee the receipt of a voucher).

voucher do report having a computer at home. Unfortunately, we do not know exactly when these computers were purchased so there may be variation in the exposure to computers which is not revealed by observed computer ownership at the time of the survey. As a result, instrumenting for computer ownership with receipt of a voucher may not "scale up" our estimates appropriately. Nevertheless, though we focus on the reduced-form effects of the program, we will report "naive" two-stage least squares (2SLS) estimates for a selection of our main outcomes.

V. Main Results

We present our main results by showing 3 non-parametric specifications (local linear regressions using a bandwidth of 30, as well as the Imbens-Kalyanaraman (IK) and cross-validation (CV) optimal bandwidths) and 1 parametric specification (quadratic spline) for each outcome. All our regressions include age, ethnicity, gender, and educational attainment of the head of household, as well as child gender and age dummies. We show results based on both child and parent reports, which serve as an important check on the validity of our measures. Our preferred estimates are based on child reports with a non-parametric bandwidth of 30. Consequently, we also plot graphs based on child reports using local linear regressions with a bandwidth of 30, unless otherwise stated. These show fitted values of residuals from local linear regressions of the main outcomes on our standard set of controls (where income is always normalized to be 0 at the 62.58 RON cutoff).25

V.A. Effect on Computer Ownership and Use

Table IV and Figure I present estimates for the effect of winning a voucher on computer ownership and computer use. Columns 1 and 6 of Table IV indicate that households who won a voucher were over 50 percentage points more likely to own a home computer at the discontinuity, representing at least a 170 percent increase over the rate of computer ownership for non-winners. Panel A of Figure I reveals a sharp discontinuity and confirms that families around the cutoff with very similar incomes experienced a very different likelihood of owning a computer at home. Panel B shows that winning a voucher also increased computer use among children. The corresponding estimates from columns 2 and 7 indicate that children in households who received a voucher spent between 2 and 4 additional hours per week on the computer as compared to children who did not receive a voucher with similar income; our preferred estimates are clustered around 3 hours. The estimates in columns 3 and 8 also confirm that winning a voucher did not lead to significant differences in internet access.

Panels C and D of Figure I display the likelihood that households who won a voucher had a computer that is installed with educational software and games, respectively. The corresponding estimates are again shown in Table IV. While the effect of winning a voucher on having educational software installed is significant in columns 5 and 10, it is substantially smaller than the effect on having games installed in columns 4 and 9. Indeed, almost all households who won a voucher had a home computer installed with games. The absence of educational software is somewhat surprising given that the Ministry of Education made such software freely available to winners of the Euro 200 program. However, this software was not pre-installed and required additional effort for installation by computer vendors and voucher winners.26 The next section examines the types of computer use reported by children in more detail, as well as time use for other activities.

[25]Plotting residuals yields similar graphs to those based on raw values but helps reduce some of the noise. See Lee and Lemuiex (2010) for a discussion of residualized outcomes.

[26]Anecdotal evidence from internet postings regarding the Euro 200 program suggests that children may have wished to avoid the substantial time cost to installing these programs.

V.B. Effect on Time Use

Table V and Figure II present estimates for the effect of winning a voucher on children's computer and time use activities based on binary variables that indicate daily use.[27] Information about specific types of computer use was only recorded in the child survey. Column 1 shows that children who won a voucher were 14 percentage points more likely to use a computer for games on a daily basis. In columns 2 and 3, we observe that winning a voucher did not translate into increased computer use for doing homework or for using educational software. Apart from the fact that computers are not used for strictly educational purposes, time spent in front of a computer also appears to have crowded out other activities. Columns 5 and 7 suggest that the probability of doing at least 1 hour of homework a day is lower for voucher winners, although this finding is not very precisely estimated, nor is it robust across all specifications. Columns 6 and 8 indicate that winning a computer voucher also decreased the time spent watching TV. Finally, parental reports of reading in column 9 indicate that children in households who won a voucher were significantly less likely to read for pleasure on a daily basis. The results from Table V are mirrored in Figure II which suggest that the increase in computer use among winners of the Euro 200 program was mostly spent playing games, and may have been associated with some reductions in the time spent watching TV and doing homework. However, it is important to note that we generally do not find significant effects for *average* measures of time-use for homework and TV use (results for time spent reading are robust to using measures of average hours). This might suggest that the effect on time use is on the margin of daily use. More generally, we believe that our time-use results may be subject to measurement error. Retrospective reports of time-use, as used in this survey, are known to be seriously affected by recall bias and internal inconsistencies (Robinson 1985; Juster and Stanford 1991).[28]

V.C. Effect on Academic Achievement

Table VI and Figure III present estimates for the impact of winning a computer voucher on measures of academic achievement. In particular, we focus on average school grades for the 2008–2009 academic year in Math, Romanian, and English, as well as grades for school behavior. These constitute the main subjects in Romanian schools and serve as important indicators of school performance. Note that the age distribution of respondents to these academic outcomes is very similar to the age distribution in the broader sample.

Columns 1 and 5 of Table VI indicate that children in households who won a voucher had a significantly lower Math GPA than non-winners across most specifications. The coefficients generally range from 0.3 to 0.7 which represents an effect size of 1/5 to 1/2 of a standard deviation, with a preferred estimate of approximately 1/4 of a standard deviation.[29] Panel A of Figure III displays the discontinuity in the non-parametric plots of Math GPA on our normalized measure of income. Columns 2 and 6 also indicate significantly negative effects of winning a voucher on GPA in Romanian language, and the corresponding discontinuity is plotted in panel B of Figure III. The effect size in our preferred estimate is about 1/3 of a standard deviation. Columns 3 and 7 together with panel C show similar results for the effect of winning a voucher on GPA in English language. These magnitudes are similar to the differences in Math and Romanian GPAs between children whose head of household has a secondary education versus a primary education (although they are only half the size of the differential between secondary and primary educated heads for English GPAs). We find no

[27] As explained earlier, we asked children whether they used their computer every day for games, homework, and educational activities. For homework, watching TV, and reading, we measure daily use with a binary variable indicating whether children spent more than 1 hour a week engaged in that activity.

[28] Unfortunately, we lacked sufficient funds to incorporate time-diaries, which yield more reliable measures of time use.

[29] The magnitudes appear to be larger for smaller bandwidths. Plots using these smaller bandwidths appear to be somewhat undersmoothed with a few points near the discontinuity driving the larger results.

significant difference in the effect of winning a voucher on grades received for school behavior, as seen in columns 4 and 8 and panel D. Overall, these results indicate that winning a voucher and receiving a free computer through the Euro 200 program led to lower academic performance in school.30

V.D. Effect on Cognitive and Computer Skills

Table VII and Figure IV present estimates for the effect of winning a computer voucher on a number of different assessments that we administered directly to children. The first is an un-timed cognitive test based on Raven's Progressive Matrices. As explained earlier, this test is designed to assess general intelligence independent of formal schooling so it is likely to differ from the measures of academic achievement described in the previous section. Moreover, insofar as the test requires matching different shapes and patterns to a series of spatial configurations, it may also pick up an important spatial component of cognitive skills. Column 1 of Table VII shows that children in households who received a voucher tended to have significantly higher Raven scores than their counterparts who did not win a voucher, with an effect size of 1/3 of a standard deviation in our preferred specification. However, this result is not robust across all specifications.31 Panel A of Figure IV confirms the discontinuity in cognitive skills.

The magnitude of these effects on cognitive skills appear to be quite large. This may be surprising given that the Raven's test is thought to provide a relatively stable measure of what psychologists term "g", or general intelligence. However, there is other evidence that home computer use at young ages is correlated with cognitive skills (Fiorini, 2010), and a number of psychological experiments have shown that playing computer games increases spatial skills in the short-run (Subrahmanyam and Greenfield, 1994; Okagaki and Frensch, 1994). To the extent that the Raven's test picks up spatial ability, this may explain the sizeable effects. Other interventions, such as the Perry Preschool Project, also led to extremely large initial gains of over 12 points on the Stanford-Binet IQ test, though the effects faded over time (Heckman, et. al. 2006). Furthermore, it is important to note that, as with other measures of IQ, scores on the Raven Progressive Matrices have been rising over time. Flynn (1987) presents data from 14 nations showing IQ gains ranging from 5 to 25 points in a single generation, with some of the largest gains observed for Raven's Progressive Matrices.32 One hypothesis for the observed gains in IQ scores is the increased exposure to new media, including computers (Neisser 1996; Greenfield 1998). While the debate about the sources of rising IQ scores over time is beyond the scope of this paper, our findings may be viewed as providing some tentative support for this hypothesis.

We also administered two assessments to measure children's computer skills. The first was a computer test consisting of 12 multiple choice questions intended to measure computer knowledge. Column 2 of Table VII shows that children in households who received a voucher had significantly higher computer test scores than those who did not win a voucher, with an effect size ranging from 1/5 to 2/5 of a standard deviation in all specifications. The graphical representation of this estimate is shown in Panel B of Figure IV. The second assessment asked children about their fluency with respect to different aspects of computer use. We find that winning a voucher improves the ability to operate a computer (column 3) and the ability to effectively use a number of applications (column 4). While the coefficients

30While many of our residualized measure of academic achievement show a downward slope for winners, the differences in slope on either side of the discontinuity are generally not statistically significant.

31The magnitude and significant of this effect diminishes substantially with bandwidths smaller than 15 (including the IK bandwidth which is approximately 7 for this outcome).

32For example, the scores of 19-year-olds in the Netherlands, for example, went up more than 8 points, or over half a standard deviation between 1972 and 1982.

on these outcomes become insignificant for bandwidths smaller than 15, the magnitudes remain similar in these specification. These findings are confirmed in panel C of Figure IV, which plots an average of these two measures of computer fluency. Given that internet use did not increase much with the Euro 200 program, it is not surprising that we do not find improvements on questions related to web and email fluency reported in columns 5 and 6, or in panel D of Figure IV which plots an average of these two measures of internet fluency.

V.E. Effect on Non-Cognitive Outcomes

We examine the impact of winning a voucher on various non-cognitive outcomes in Table VIII and Figure V. In the child survey, we administered the Rosenberg Self-Esteem Scale and asked children about their health status, whether they experience pain in their hands and fingers, their perception of being overweight, and frequency of smoking and drinking of alcohol. In the parent survey, we asked parents to complete the Behavioral Problem Index (BPI) and provide information about child height and weight for BMI calculations, as well as their engagement in sports and community service activities. For most of these non-cognitive outcomes, we find no significant effects across our various specifications. There are a few significant coefficients that could suggest negative effects of winning a computer voucher on health (i.e. hand pain) and behavioral outcomes (Rosenberg, BPI). However, given the problems associated with multiple inference, we are hesitant to put much weight on these findings.

V.F. Effects of Parental Rules Concerning Computer Use and Homework

We explore whether the effects of winning a computer voucher are mediated through parental involvement and supervision by introducing indicator variables for whether parents have rules regulating computer use and homework activities for each child. Approximately one third of children have parents who imposed rules on computer use and a similar fraction of children have parents who imposed rules on homework activities.[33] Table IX presents estimates from regression equations in which the variable for winning a Euro 200 voucher is interacted seperately with each of these parental rules.[34] Note that these variables are potentially endogenous, so the results of this analysis should be interpreted with care.

Panel A of Table IX displays the interaction of our program effect, $winner_i$, with the presence of rules related to computer use. As might be expected, the interaction is negative and significant in column 1, indicating that computer use is substantially lower for children whose parents imposed rules on computer use. This appears to lead to lower computer skills, as demonstrated by the negative and significant interactions for the computer test and measures of computer fluency in columns 7, 8, and 9. On the other hand, the presence of rules on computer use do not seem to impact daily homework activities, or academic achievement in school. In Panel B, we present analogous results for the interaction of $winner_i$ with the presence of rules related to homework. Again, as might be expected, children whose parents impose rules on homework do more homework (the interaction is positive and significant in column 2). Moreover, this also appears to impact academic outcomes. The presence of rules regarding homework activities attenuates the negative impact of winning a computer voucher on Math, Romanian, and English GPAs with the coefficients on the interaction terms in columns 3, 4, and 5 about half the size of the main effects. Interestingly, having rules regulating homework does not have a negative effect on

[33] Interestingly, the fraction of parents who impose rules on homework activities is similar between winners and non-winners, whether or not we control for income. The fraction of parents with rules regarding computer use is significantly higher for winners.

[34] Specifically we estimate the equation: $outcome_i = \beta' \mathbf{X}_i + \delta winner_i + \tau rules_i + \lambda winner_i * rules_i + f(income_i) + \varepsilon_i$ where $rules_i$ is an indicator for whether the parents have rules about computer use or homework activities.

computer use or the accumulation of computer skills. Neither rules regarding computer use nor homework appear to impact scores on the Raven's Progressive Matrices test.35

We interpret these findings as potentially consistent with the view that parental monitoring through rules can be an important mediating factor. In particular, our results suggest that rules regarding computer use reduce the positive effects of winning a voucher on computer skills without improving academic achievement, while rules regarding homework mitigate some of the negative effects of winning a computer voucher without affecting the gains to computer skills or cognitive skills.

VI. Further Results

To summarize the evidence presented thus far, winning a voucher and receiving a free home computer has both positive and negative effects on child outcomes. While computers certainly improve computer skills, they affect school performance negatively, as measured by the average grades in three important academic subjects. There is also evidence that winning a voucher and receiving a free computer leads to higher scores on a test of cognitive skills. This section reports on further results that build on our main findings. In particular, we examined whether the effects of winning a computer voucher differed by child age and gender and whether the effects persisted over time. We also compare estimates using OLS and 2SLS, and consider a number of different specifications checks. All of the tables containing these results are available in an online appendix.36

VI.A. Heterogeneous Effects

We explored the differential impact of child characteristics by estimating equations in which we interacted child age and gender with the indicator for winning a Euro 200 voucher.37 The results are reported in Appendix Table I. There are substantial differences in the mean levels of our outcomes variables by gender: girls spent less time using computers and did more homework; girls also had higher GPA and cognitive skills scores but lower computer skills. However, we do not find any significant differences in the effect of winning a computer voucher between boys and girls. As with gender, there are substantial differences in the mean levels of our outcome variables by child age. But there is also some evidence that younger children experience the largest gains in computer fluency and in cognitive skills as measured by Raven's Progressive Matrices. The finding that younger children display larger gains in cognitive skills is consistent with work by Cunha and Heckman (2008) showing that cognitive skills are more malleable at early ages.

VI.B. Long Term Effects

The main analysis examined the impact of winning a computer voucher on outcomes approximately one year after families received their free computer. To address whether this program also had longer term impacts on child outcomes, we implemented an identical survey on a sample of children who participated in the 2005 round of the same Euro 200 program.38 From an initial list of 1,554 families who applied to the 2005 round from the

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35Appendix Figures III and IV show results for parents who do and do not impose rules on computer use and homework respectively.

36In the interest of saving space and to improve the precision of our estimates, all of the results in this section are based on linear splines using the full sample and the standard set of controls. We focus on nine of our main outcome variables which include computer use, homework, Math GPA, Romanian GPA, English GPA, Raven's Progressive Matrices test, computer test, computer fluency, and application fluency, all derived from the child survey instrument.

37Specifically, we estimate the equation: $outcome_i = \beta' \mathbf{X}_i + \delta winner_i + \tau child\_chars_i + \lambda winner_i * child\_chars_i + f(income_i) + \varepsilon_i$ where $child\_chars_i$ includes age and gender.

38We previously analyzed the short term effects of the Euro 200 program on this sample of 2005 program participants from Covasna and Valcea as part of a smaller scale pilot study (Malamud and Pop-Eleches 2008). Our findings from that study are broadly consistent with those in the current study.

regions of Covasna and Valcea, we were able to successfully complete 647 household interviews in 2009. Results from this sample are reported in Appendix Table II. We find that households who won a voucher in the 2005 round of the Euro 200 program had significantly higher levels of computer ownership than non-winners, even four years after they received a free computer.39 The long-term effects of receiving a voucher on average grades in Math, Romanian, and English are negative but imprecise. The impact of winning a voucher on cognitive skills as measured by the Raven's Progressive Matrices test is positive but insignificant. Finally, the effect of winning a voucher on computer skills is positive in two out of our three assessments. The lack of power in most of these estimates is not surprising given the small sample and we do not wish to draw any strong conclusions. However, if we re-scale the size of these effects in light of the smaller difference in computer ownership, the magnitude of these estimates suggest long term effects that are similar to the short-term ones. Taken as a whole, these results are consistent with the long term persistence of negative effects on academic achievement and positive effects on cognitive skills and computer skills.

VI.C. 2SLS and OLS Estimates

Thus far, we have focused exclusively on the reduced-form estimates of winning a computer voucher through the Euro 200 program. This does not represent the effect of having access to a home computer because some of the households who did not win a voucher do report having a computer at home. But we could "scale up" our reduced-form estimates by the difference in computer ownership between household who won and did not win a voucher. 40 With an estimated difference in computer ownership of approximately 50 percentage points, this suggests the impact of having access to a home computer is about twice the impact of winning a voucher ($2\,\delta$). A similar scaling would be achieved by estimating 2SLS regressions in which we use our indicator for winning a voucher ($winner_i$) to instrument for computer ownership ($computer_i$). Panel A of Appendix Table III presents these 2SLS estimates of computer ownership on nine of our main outcomes. However, as explained earlier, this approach may not "scale up" our estimates appropriately. Since we do not know exactly when these computers were purchased, there may be variation in the exposure to computer ownership that isn't captured by observed ownership in 2009. For example, households who did not win a voucher but purchased a computer just prior to the time of the survey will have had a much shorter exposure than households who won a voucher and received their computers in the summer of 2008. Nevertheless, our naive 2SLS estimates do provide a useful benchmark and indicate effects of computer ownership that are approximately twice as large as the reduced-form effects of winning a computer voucher.

We also compare our estimates with those that would emerge from a conventional cross-sectional analysis by estimating an OLS regression for children in households that did not receive a computer voucher through the Euro 200 program.41 Approximately 37 percent of the 1,186 households in our sample who did not receive a voucher reported owning a computer at the time of the survey. The OLS estimates for our nine main outcome variables are reported in Panel B of Appendix Table III. As with our reduced-form and 2SLS estimates, owning a computer is associated with higher scores on the computer test as well as greater fluency in operating a computer and using applications. Indeed, the magnitude of

[39]The difference of 17 percentage points between households who did and did not receive a voucher is substantially smaller than the differential in the short-term, but not surprising given that those families who applied for a voucher in 2005 but did not receive one could reapply in subsequent years.

[40]Note that this resembles the standard calculation used in moving from an intention-to-treat (ITT) estimator to a treatment-on-the-treated (TOT) estimator. Such a scaling of the reduced form estimate by the proportion of individuals that actually received the treatment was introduced by Bloom (1984).

[41]Specifically we estimate the equation: $outcome_i = \beta' \mathbf{X}_i + \delta\, computer_i + f(income_i) + \varepsilon_i$ where $computer_i$ is an indicator variable for computer ownership.

the coefficients in these OLS regressions are strikingly similar to those from 2SLS. On the other hand, owning a computer is also associated with higher average grades in Math, Romanian, and English. Insofar as our causal estimates indicate a negative impact of winning a computer voucher on average grades, this suggests that children in households who purchased computers were more likely to have higher academic achievement. Finally, the OLS estimate for the effect of computer ownership on cognitive skills is positive and significant but only two-thirds of the magnitude of the 2SLS estimate.

VI.D. Specification Checks

We conducted a number of specification checks. First, we verified that our estimates are generally robust to using a broader set of parametric and non-parametric specifications. Appendix Tables IV to VIII present local linear regressions with bandwidths of 60, 30, 15, and 7.5 as well as linear, quadratic, and cubic splines for all outcomes. Second, we provide evidence that response rates do not differ around the income threshold of 62.58 RON for receiving a voucher. Panel A of Appendix Figure I shows that there is no difference in overall response rates among households who won and didn't win vouchers; panel B indicates that there is also no difference in the response rates among children in the household around the income threshold. Third, we tested for manipulation of reported income by checking the frequency density along the lines of McCrary (2007). Appendix Figure II plots local linear regressions of the density of children over income from the child survey (in panel A) and the parent survey (in panel B) showing that the density varies continuously over different income levels with no significant discontinuity around the income cutoff. Fourth, we sought to test that all backgound characteristics, other than receipt of a computer voucher through the Euro 200 program, vary continuously around the income cutoff of 62.58 RON. While we cannot verify this assumption for unobserved characteristics, Appendix Figure V and Appendix Table IX confirm that there are no significant discontinuities in all but one (child gender) of our observed household and child characteristics. Fifth, we examined the degree of correspondence between the parent and child reports in their responses to the same survey questions. For questions regarding household characteristics, such as computer ownership, the responses of children and their parents were identical 96 to 98 percent of the time. For questions regarding average grades in Math, Romanian and English, the responses of children and their parents were identical 91 to 92 percent of the time. For questions regarding time-use, the responses of children and their parents were somewhat less likely to match up, being identical only 86 percent of the time. But overall, we find the relatively high level of correspondence between child and parent reports to be a reassuring finding.[42] Finally, we checked that our main results continue to hold when we restrict ourselves to samples where parent and child responses overlap and when averaging between parent and child responses for identical survey questions.

VII. Conclusion

This paper examined the impact of increased access to home computers on the development of human capital among low-income children and adolescents. Using data from several regions in Romania that we collected through in-depth household interviews during 2009, we implemented a regression discontinuity design to estimate the effect of winning a Euro 200 government-funded voucher towards the purchase of a personal computer in 2008. We show that winning a voucher led to substantial increases in computer ownership and computer use. We find that children in households who won a voucher had significantly

[42]We also examined whether the rates of match between parent and child reports varied around the discontinuity. For the most part, there were no significant differences for these outcomes.

lower school grades in Math, English and Romanian, with most estimates clustered around an effect size of 1/3 of a standard deviation. On the other hand, we estimate that children in households who won a voucher had significantly higher scores on a test of computer skills and in self-reported measures of computer fluency. There is also some evidence that winning a voucher increased cognitive skills, as measured by the Raven's Progressive Matrices test. These results indicate that providing home computers to low-income children in Romania lowered academic achievement even while it improved their computer skills and cognitive skills. Given the positive and negative effects of home computer use on the development of human capital, it would be extremely useful to evaluate the net effect of home computer use on labor market outcomes, such as wages. We hope to pursue this question in further work, by following up on these children over time.

Our results also reveal several additional factors which may play an important role in shaping the impact of home computer use on child and adolescent outcomes. We find that despite efforts by the Romanian Ministry of Education to encourage the use of these computers for educational purposes, relatively few children have educational software installed on their computer, and fewer still report using their computer for educational purposes. Instead, computers were mainly used to play games. There is also some suggestive evidence that children who received vouchers spent less time reading and doing homework. These factors may have contributed to the decline in academic achievement. Moreover, we show that parental involvement and supervision can be important mediating factors. The presence of rules regarding homework help mitigate some of the negative effects of winning a computer voucher. In contrast, the presence of rules regarding computer use seem to reduce the positive impacts of winning a voucher on computer skills without improving academic achievement. Since computers represent such a versatile technology, the potential risks and benefits of computer use are highly dependent on the availability of different types of software and the patterns of actual use. In implementing future programs to increase access to home computers, policy makers need to take these behavioral responses by both children and parents into account to maximize the positive effects and minimize the negative effects of home computer use.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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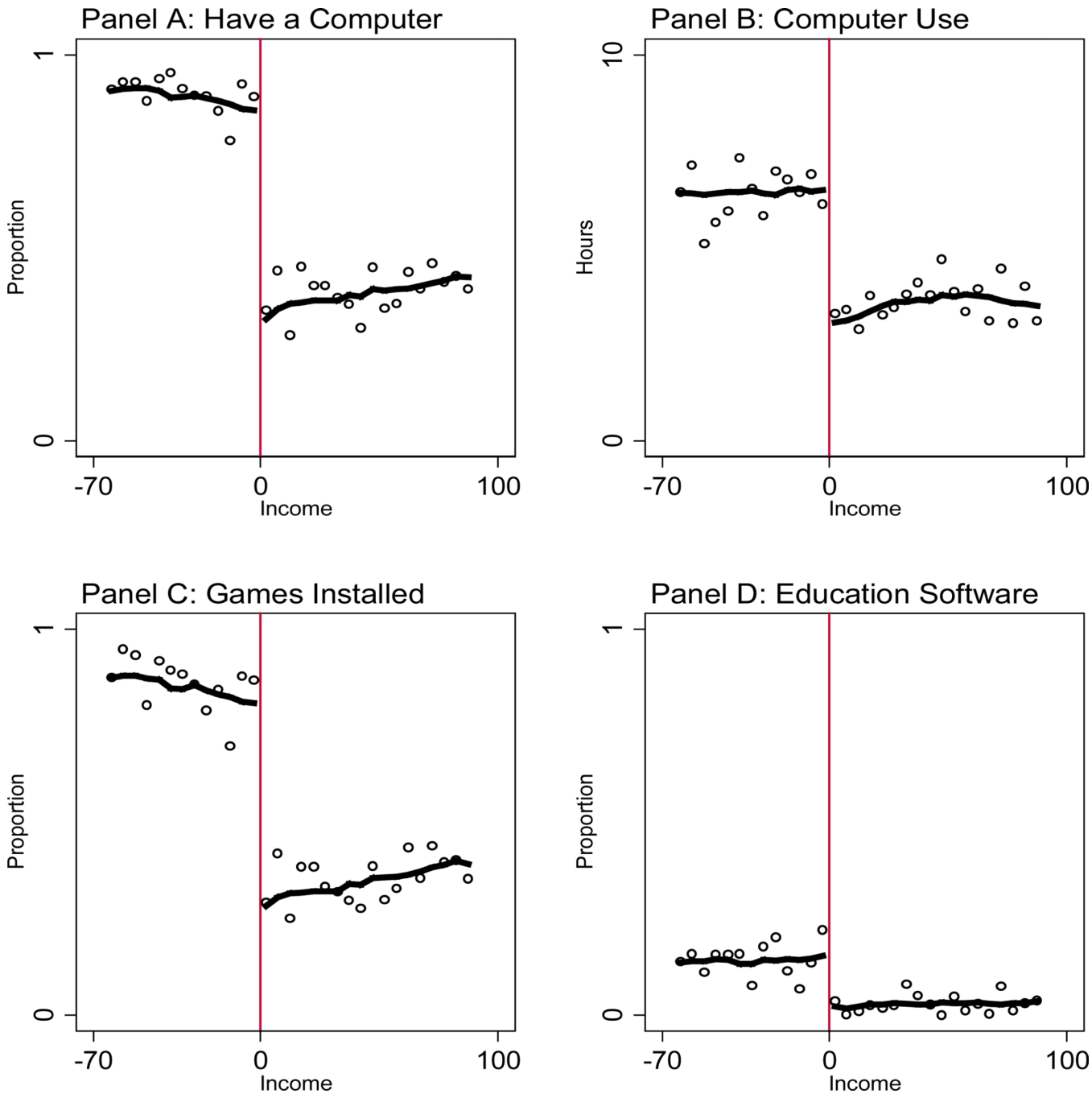

Figure I. Computer Ownership and Use

Notes: The dependent variables are defined in Tables I, II, and III. The open circles plot the residuals from regressions of the dependent variables on our standard set of controls for 5 RON intervals. The solid lines are fitted values of residuals from local linear regressions of the dependent variable using a rectangular kernel with a bandwidth of 30. The income variable is the monthly household income per family member used by the Euro 200 program and is normalized to be 0 at the 62.58 RON cutoff. Source: 2009 Euro 200 Survey.

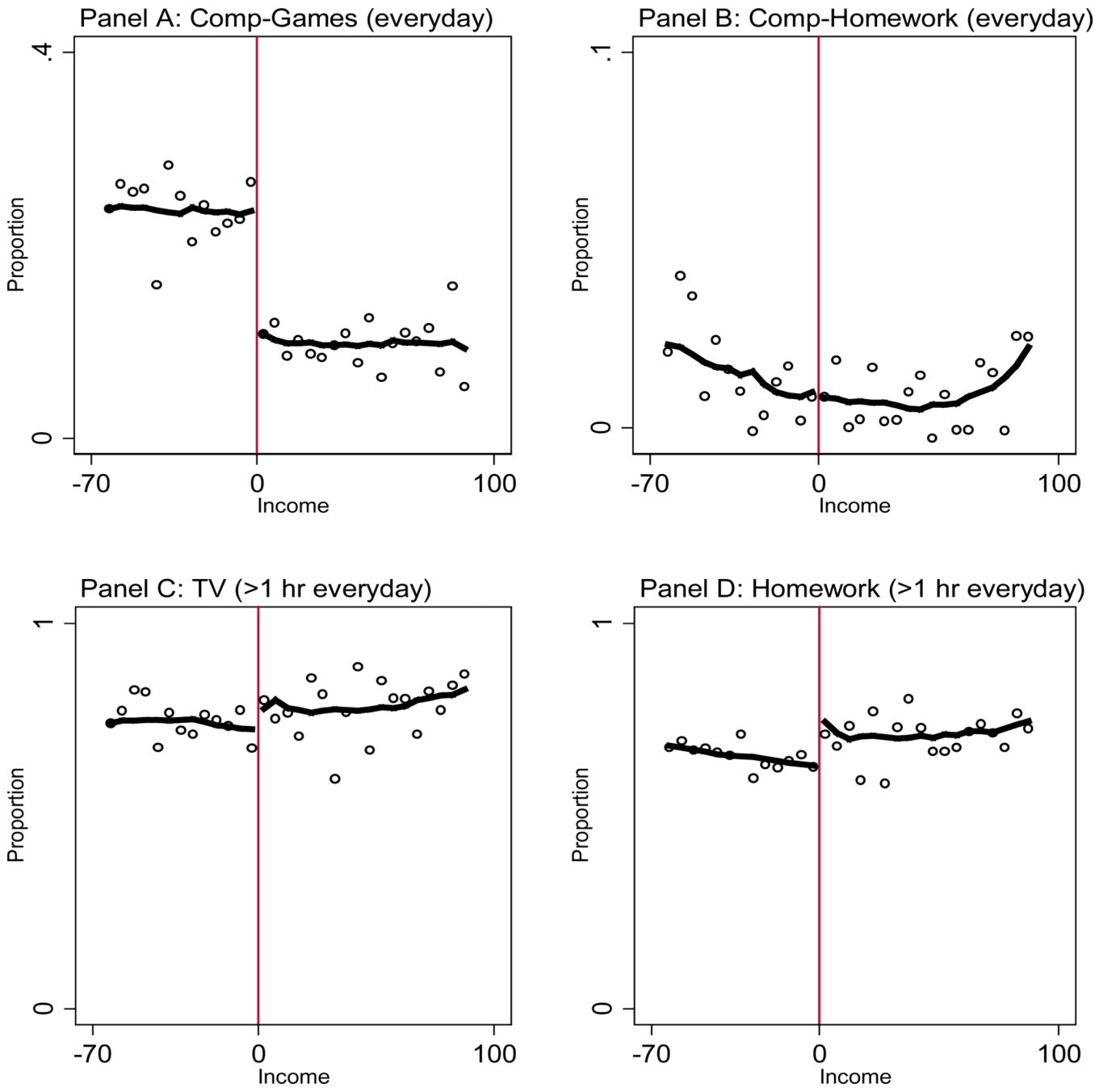

Figure II. Time Use

Notes: The dependent variables are defined in Tables I, II, and III. The open circles plot the residuals from regressions of the dependent variables on our standard set of controls for 5 RON intervals. The solid lines are fitted values of residuals from local linear regressions of the dependent variable using a rectangular kernel with a bandwidth of 30. The income variable is the monthly household income per family member used by the Euro 200 program and is normalized to be 0 at the 62.58 RON cutoff. Source: 2009 Euro 200 Survey.

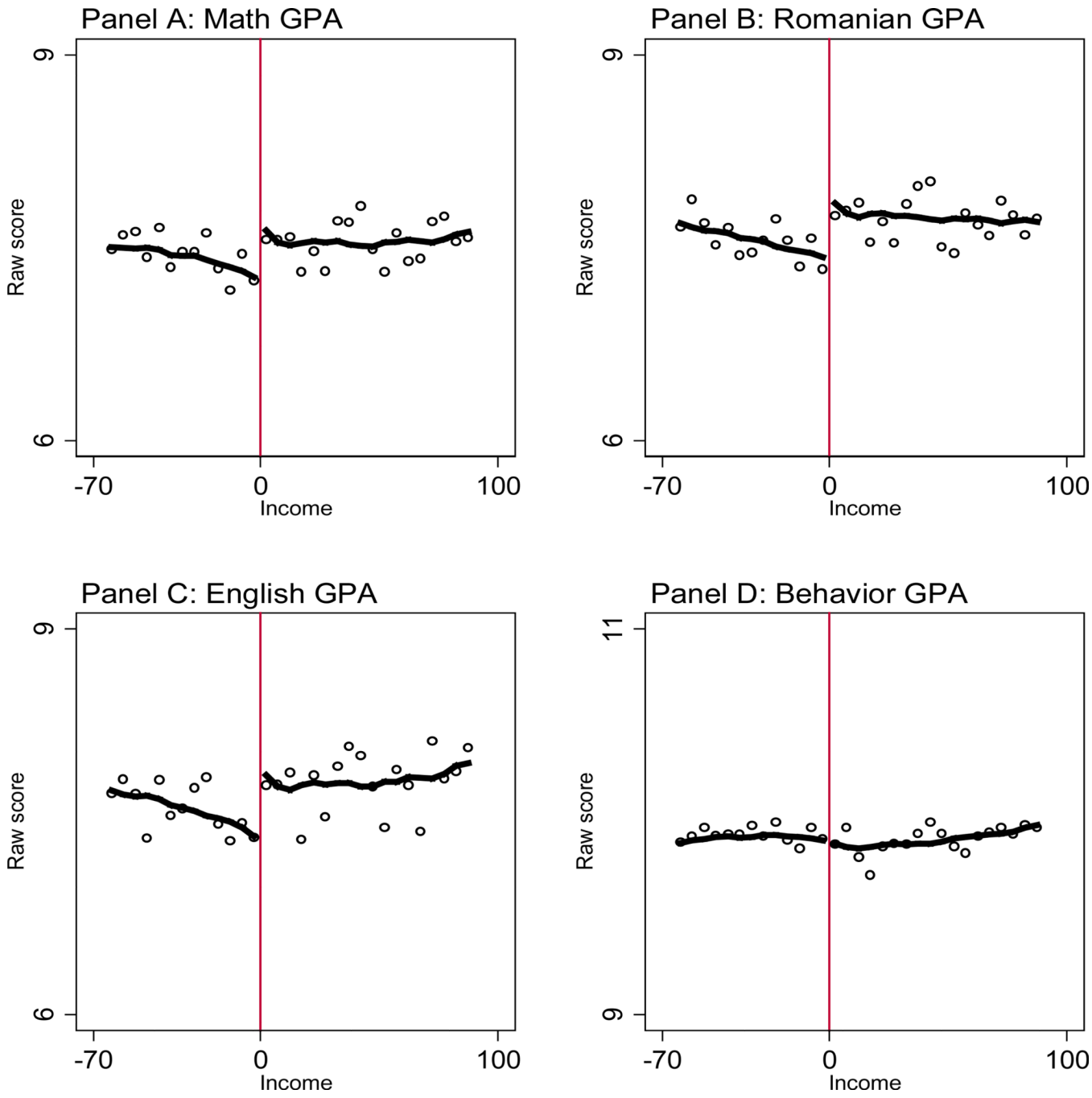

Figure III. Academic Achievement

Notes: The dependent variables are defined in Tables I, II, and III. The open circles plot the residuals from regressions of the dependent variables on our standard set of controls for 5 RON intervals. The solid lines are fitted values of residuals from local linear regressions of the dependent variable using a rectangular kernel with a bandwidth of 30. The income variable is the monthly household income per family member used by the Euro 200 program and is normalized to be 0 at the 62.58 RON cutoff. Source: 2009 Euro 200 Survey.

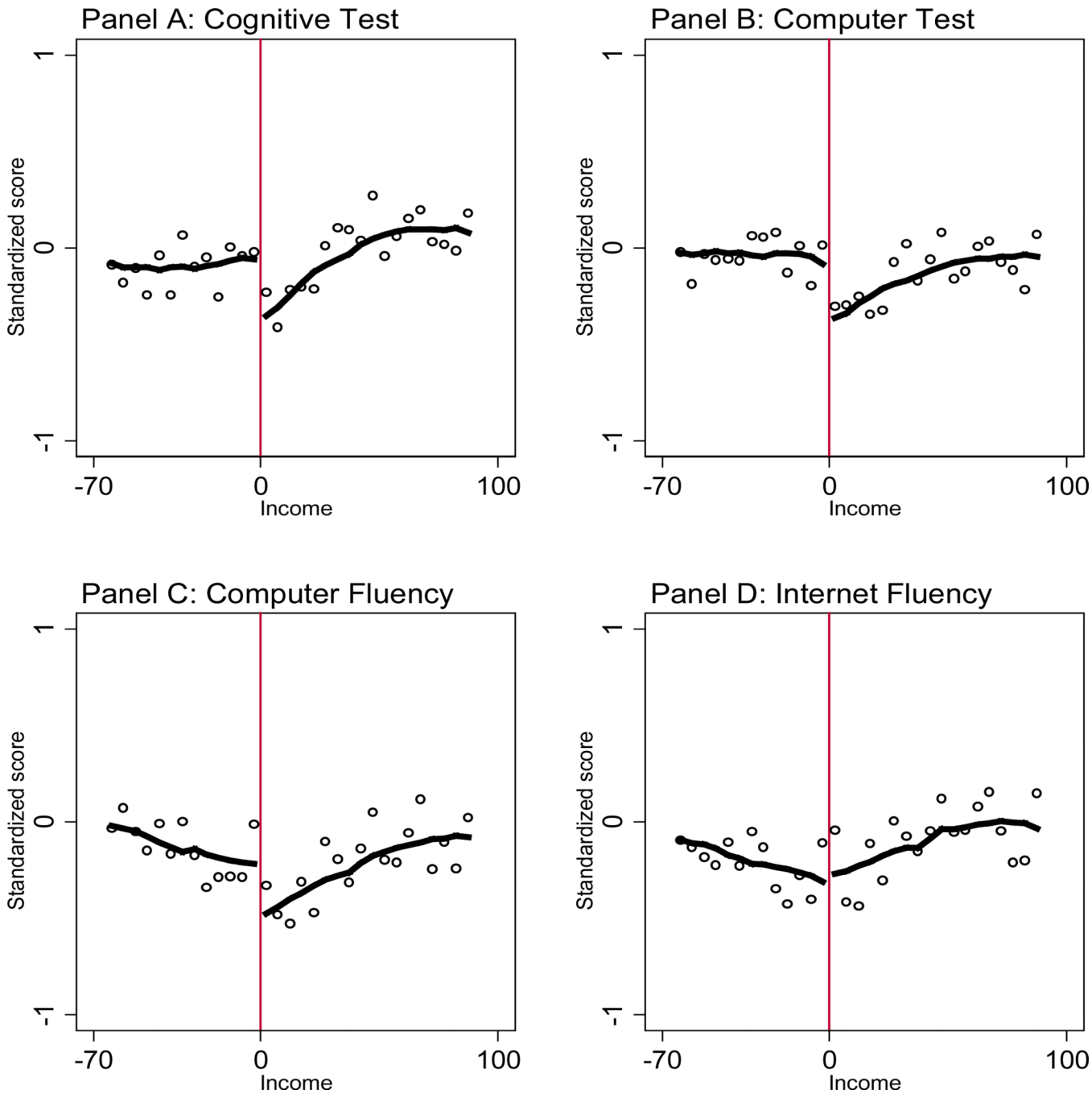

Figure IV. Cognitive and Computer Skills

Notes: The dependent variables are defined in Tables I, II, and III. The open circles plot the residuals from regressions of the dependent variables on our standard set of controls for 5 RON intervals. The solid lines are fitted values of residuals from local linear regressions of the dependent variable using a rectangular kernel with a bandwidth of 30. The income variable is the monthly household income per family member used by the Euro 200 program and is normalized to be 0 at the 62.58 RON cutoff. Source: 2009 Euro 200 Survey.

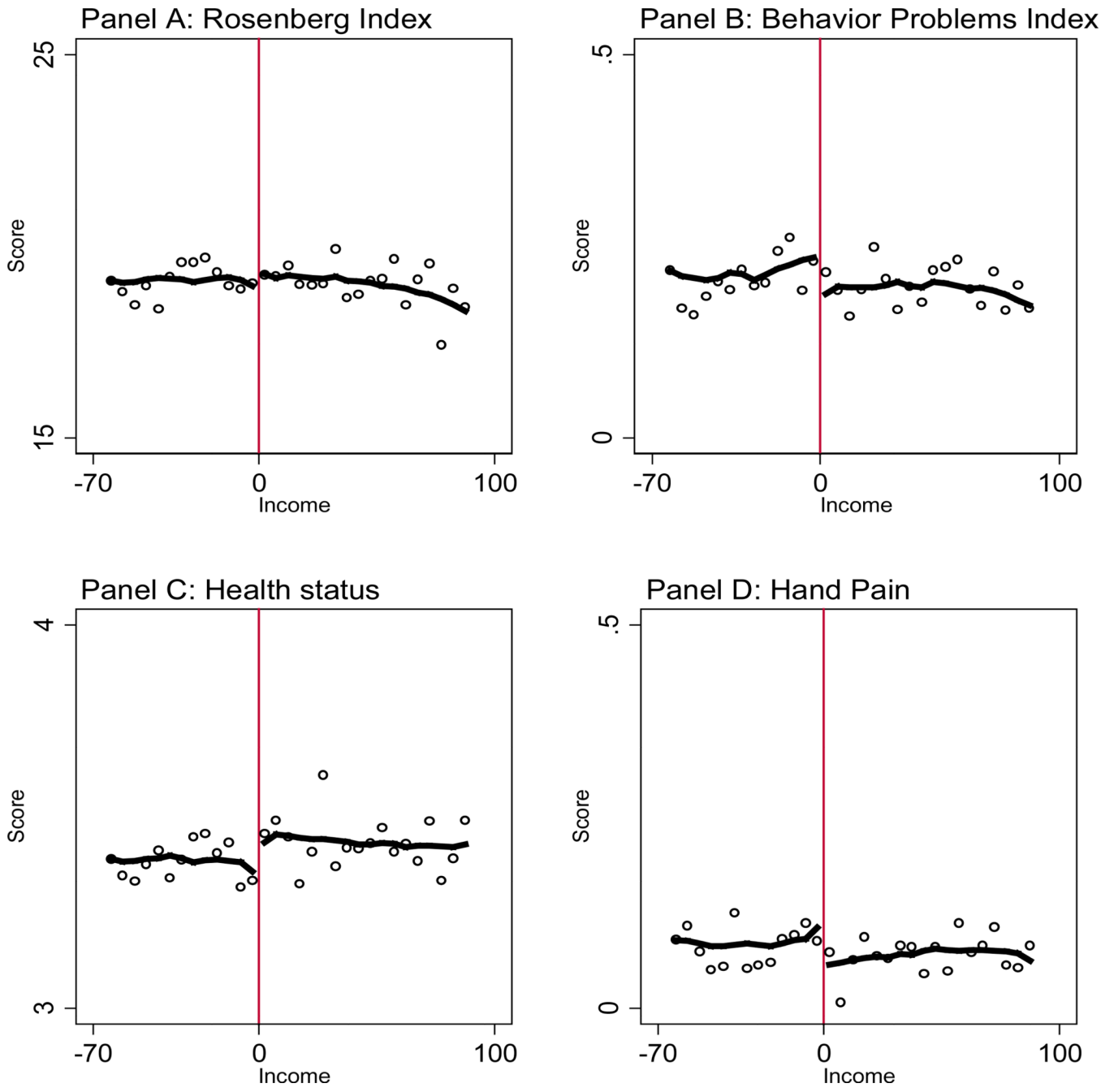

Figure V. Non-Cognitive Outcomes

Notes: The dependent variables are defined in Tables I, II, and III. The open circles plot the residuals from regressions of the dependent variables on our standard set of controls for 5 RON intervals. The solid lines are fitted values of residuals from local linear regressions of the dependent variable using a rectangular kernel with a bandwidth of 30. The income variable is the monthly household income per family member used by the Euro 200 program and is normalized to be 0 at the 62.58 RON cutoff. Source: 2009 Euro 200 Survey.

Table I

Summary Statistics of Household Characteristics

	Mean	SD	N
Winner	0.647	0.478	3,356
Income	47.614	50.683	3,356
Used Voucher	0.638	0.481	3,356
Female HoH	0.119	0.324	3,376
Age of HoH	40.666	8.012	3,358
Ethnicity of HoH			
Romanian	0.676	0.468	3,376
Hungarian	0.149	0.356	3,376
Gypsy	0.107	0.309	3,376
Other	0.068	0.253	3,376
Education of HoH			
Primary	0.126	0.332	3,340
Secondary	0.857	0.350	3,340
Tertiary	0.017	0.128	3,340
Computer ownership			
Have a Computer	0.727	0.446	3,350
Have Internet	0.144	0.351	3,344
Have a Computer w/ Games Installed	0.649	0.477	2,856
Have a Computer w/ Education Software	0.091	0.288	2,507
Hours Computer is On (per day)	1.453	1.590	3,140

Notes: SD is the standard deviation and N is the sample size. "Winner" is defined as 1 for individuals with an income below the program cutoff of 62.58 RON, and 0 otherwise. Income is the monthly household income per family member used by the Euro 200 program (normalized to be 0 at the 62.58 RON cutoff in regressions and graphs). Used Voucher indicates vouchers that were cashed according to records by the Ministry of Education. Gender, age, ethnicity and education of the head of household represent the main household demographic covariates. "Have a Computer" indicates whether households had a computer in the home. "Have Internet" indicates whether households had an internet connection in the home. Variables indicating having a computer with games or educational software installed are unconditioned on having a computer. Source: 2009 Euro 200 survey.

Table II

Summary Statistics of Parental Reports

	Mean	SD	N
Female	0.487	0.500	5,936
Age	12.225	3.334	5,928
Time use			
Computer Use (hours per week)	5.245	6.510	5,283
Homework ≥ 1hr everyday	0.661	0.473	5,483
TV ≥ 1hr everyday	0.746	0.436	5,498
Reading ≥ 1hr everyday	0.053	0.224	5,244
Academic outcomes			
Math GPA	7.602	1.474	4,462
Romanian GPA	7.762	1.422	4,478
English GPA	7.822	1.501	3,536
Behavior GPA	9.931	0.388	4,835
Non-cognitive outcomes			
Behavior Problems Index (BPI)	0.207	0.235	4,791
BMI	19.783	3.814	4,611
Sports	2.722	1.589	5,392
Service	1.845	0.997	5,457

Notes: SD is the standard deviation and N is the sample size. Child gender and age are reported by primary caregiver. Computer Use is measured in hours per week. Homework, TV, and Reading are indicator variables for daily activity of more than 1 hour per day. GPAs represent raw scores ranging from 1 to 10. BMI is the body-mass index calculated from reported height and weight of the child. BPI ranges from 0 to 1 with higher scores indicating more behavior problems associated with trouble getting along with teachers, disobedience at home, disobedience at school, hanging around with troublemakers, bullying others, inability to sit still, and whether the child prefers to be alone. Sports and Service are frequencies ranging from 1 to 5. Source: 2009 Euro 200 survey.

Table III

Summary Statistics of Child Reports

	Mean	SD	N
Female	0.495	0.500	4,643
Age	12.187	3.003	4,637
Computer and Time use			
Computer Use (hours per week)	5.465	6.349	4,384
Computer for Games everyday	0.189	0.391	4,606
Computer for Homework everyday	0.015	0.120	4,614
Computer for Ed Software everyday	0.003	0.051	4,611
Computer for Web/Email everyday	0.052	0.221	4,614
Homework > 1hr everyday	0.682	0.466	4,539
TV > 1hr everyday	0.759	0.428	4,512
Academic outcomes			
Math GPA	7.493	1.512	4,279
Romanian GPA	7.653	1.471	4,302
English GPA	7.717	1.539	3,476
Behavior GPA	9.910	0.427	4,367
Cognitive and Computer Assessments			
Raven's Progressive Matrices Test	−0.059	0.999	4,628
Computer Test (raw)	3.352	2.810	4,375
Computer Operation Fluency (raw)	2.739	1.135	4,620
Applications Fluency (raw)	2.761	1.375	4,620
Web Fluency (raw)	2.163	1.359	4,620
Email Fluency (raw)	2.334	1.329	4,620
Non-cognitive outcomes			
Rosenberg Index (raw)	19.050	3.750	4,085
Health index	3.401	0.659	4,602
Hand pain	0.081	0.273	4,546
Overweight	0.086	0.281	4,483
Smoking	0.047	0.211	4,597
Drinking	0.065	0.247	4,611

Notes: SD is the standard deviation and N is the sample size. Child gender and age are derived from the parental reports. Computer use for games, homework, education, and web/email are indicator variables for daily activites. Homework and TV are indicator variables for daily activity of more than 1 hour per day. GPAs represent raw scores ranging from 1 to 10. The Raven's Progressive Matrices test is standardized with a mean of 0 and standard deviation of 1. The computer test represents raw scores from 1 to 12 but it is normalized to a mean of 0 and standard deviation of 1 in the graphs and regression tables. The fluency scores represent raw responses ranging from 1 (not at all fluent) to 5 (very fluent), again normalized with a mean of 0 and standard deviation of 1 in the graphs and regression ables. Rosenberg index is a raw score ranging from from 1 to 30 with higher scores indicating lower self-esteem, also normalized to a mean of 0 and standard deviation of 1 in the graphs and regression tables. Health status is self-reported health status ranging from 1 (poor) to 5 (very well). Hand pain is an indicator variable for any problems with pain in the hands. Overweight is an indicator variable for self-reported perception of being overweight. Smoking and drinking are indicator variables for any report of smoking or drinking during the past year. Source: 2009 Euro 200 survey.

Table IV

Effect of the Euro200 program on Academic Achievement

	Panel A: Children Survey					Panel B: Parent Survey				
dependent variable	**Have a Computer**	**Computer Use**	**Internet**	**Games Installed**	**Educational Software**	**Have a Computer**	**Computer Use**	**Internet**	**Games Installed**	**Educational Software**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**
Nonparametric	0.546***	3.407***	0.011	0.497***	0.117***	0.548***	2.397***	−0.007	0.594***	0.134***
Bandwidth - 30	[0.060]	[0.754]	[0.049]	[0.058]	[0.046]	[0.059]	[0.778]	[0.049]	[0.063]	[0.054]
Observations	1,070	1,027	1,069	1,053	975	1,438	1,300	1,436	1,255	1,164
Nonparametric	0.518***	3.352***	0.029	0.476***	0.187***	0.541***	2.219***	0.005	0.544***	0.238***
CV Bandwidth	[0.048]	[0.725]	[0.060]	[0.056]	[0.066]	[0.048]	[0.640]	[0.052]	[0.053]	[0.075]
Observations	1,818	1,138	821	1,169	465	2,319	2,053	1,237	1,813	647
Nonparametric	0.699***	4.093***	0.066	0.751***	0.036	0.721***	2.492***	0.117	0.562***	0.163
IK Bandwidth	[0.119]	[1.227]	[0.094]	[0.109]	[0.089]	[0.109]	[1.201]	[0.108]	[0.155]	[0.146]
Observations	199	310	113	210	111	268	482	196	168	123
Parametric	0.520***	3.851***	0.068	0.491***	0.137***	0.541***	2.313***	0.038	0.570***	0.148***
Quadratic Spline	[0.054]	[0.709]	[0.044]	[0.054]	[0.040]	[0.053]	[0.771]	[0.045]	[0.058]	[0.051]
Observations	4,510	4,295	4,503	4,348	4,001	5,756	5,172	5,743	4,931	4,354

Notes: Robust standard errors clustered at the household level are in brackets.

***, ** and * indicate statistical significance at the 1, 5 and 10 percent level respectively. The dependent variables are defined in Tables I, II, and III. The reported coefficients are for the variable "Winner" is defined as 1 for individuals with an income below the program cutoff of 62.58 RON, 0 otherwise. All non-parametric specifications use a rectangular kernel. CV refers to the modified cross-validation procedure used to derive the optimal bandwidth; IK refers to the Imbens-Kalyanarman optimal bandwidth. All regressions include controls for age, gender, ethnicity and education of the head of household, as well as gender and age dummy variables of the child. Source: 2009 Euro 200 survey.

Table V

Effect of the Euro200 program on Time Use

	Panel A: Children Survey						Panel B: Parent Survey		
dependent variable	**Computer for Games**	**Computer for Homework**	**Computer for Ed Software**	**Computer for Internet**	**Homework**	**TV**	**Homework**	**TV**	**Reading**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
Nonparametric	0.136**	0.002	0.010	0.019	−0.096	−0.070	−0.013	−0.092	−0.093***
Bandwidth - 30	[0.054]	[0.009]	[0.012]	[0.027]	[0.059]	[0.064]	[0.059]	[0.065]	[0.034]
Observations	1,074	1,079	1,081	1,080	1,070	1,053	1,356	1,362	1,304
Nonparametric	0.134**	0.001	0.000	0.019	−0.072	−0.084*	−0.049	−0.084*	−0.093*
CV Bandwidth	[0.053]	[0.014]	[0.000]	[0.026]	[0.057]	[0.049]	[0.048]	[0.050]	[0.047]
Observations	1,103	505	49	1,144	1,156	1,755	2,131	2,250	605
Nonparametric	0.230*	−0.004	0.000	0.041	−0.127	−0.230*	−0.201*	−0.341**	−0.135**
IK Bandwidth	[0.117]	[0.011]	[0.000]	[0.058]	[0.137]	[0.124]	[0.116]	[0.136]	[0.064]
Observations	190	136	83	142	221	214	282	268	177
Parametric	0.144***	−0.007	0.014	0.021	−0.085	−0.109*	−0.036	−0.123**	−0.071**
Quadratic Spline	[0.051]	[0.011]	[0.012]	[0.025]	[0.055]	[0.057]	[0.054]	[0.059]	[0.028]
Observations	4,502	4,509	4,506	4,509	4,438	4,411	5,365	5,377	5,130

Notes: Robust standard errors clustered at the household level are in brackets.

***, ** and * indicate statistical significance at the 1, 5 and 10 percent level respectively. The dependent variables are defined in Tables I, II, and III. The reported coefficients are for the variable "Winner" is defined as 1 for individuals with an income below the program cutoff of 62.58 RON, 0 otherwise. All non-parametric specifications use a rectangular kernel. CV refers to the modified cross-validation procedure used to derive the optimal bandwidth; IK refers to the Imbens-Kalyanarman optimal bandwidth. All regressions include controls for age, gender, ethnicity and education of the head of household, as well as gender and age dummy variables of the child. Source: 2009 Euro 200 survey.

Table VI

Effect of the Euro200 program on Academic Achievement

	Panel A: Children Survey				Panel B: Parent Survey			
dependent variable	Math GPA	Romanian GPA	English GPA	Behavior GPA	Math GPA	Romanian GPA	English GPA	Behavior GPA
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Nonparametric	−0.435**	−0.562***	−0.634***	0.008	−0.415**	−0.370**	−0.534**	−0.059
Bandwidth - 30	[0.171]	[0.181]	[0.225]	[0.070]	[0.180]	[0.176]	[0.231]	[0.072]
Observations	998	1,002	804	1,018	1,058	1,062	843	1,156
Nonparametric	−0.411**	−0.313**	−0.343*	−0.047	−0.418**	−0.311*	−0.306*	−0.063
CV Bandwidth	[0.179]	[0.153]	[0.193]	[0.081]	[0.185]	[0.163]	[0.186]	[0.065]
Observations	1,077	1,372	1,287	859	987	1,222	1,337	1,331
Nonparametric	−0.669**	−1.090***	−0.683	−0.229	−0.470	−0.592*	−0.205	−0.360*
IK Bandwidth	[0.329]	[0.320]	[0.449]	[0.188]	[0.332]	[0.324]	[0.491]	[0.206]
Observations	263	266	216	207	290	286	199	240
Parametric	−0.368**	−0.392**	−0.473**	0.014	−0.389**	−0.353**	−0.356*	−0.067
Quadratic Spline	[0.158]	[0.165]	[0.203]	[0.064]	[0.165]	[0.164]	[0.210]	[0.066]
Observations	4,179	4,201	3,387	4,266	4,358	4,372	3,440	4,717

Notes: Robust standard errors clustered at the household level are in brackets.

***, ** and * indicate statistical significance at the 1, 5 and 10 percent level respectively. The dependent variables are defined in Tables I, II, and III. The reported coefficients are for the variable "Winner" is defined as 1 for individuals with an income below the program cutoff of 62.58 RON, 0 otherwise. All non-parametric specifications use a rectangular kernel. CV refers to the modified cross-validation procedure used to derive the optimal bandwidth; IK refers to the Imbens-Kalyanarman optimal bandwidth. All regressions include controls for age, gender, ethnicity and education of the head of household, as well as gender and age dummy variables of the child. Source: 2009 Euro 200 survey.

Table VII

Effect of the Euro200 program on Cognitive and Computer Skills

	Children Survey					
dependent variable	**Raven's Progressive Matrices Test**	**Computer Test**	**Computer Fluency**	**Applications Fluency**	**Web Fluency**	**Email Fluency**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Nonparametric	0.327**	0.268**	0.212*	0.250**	0.021	−0.065
Bandwidth - 30	[0.134]	[0.114]	[0.118]	[0.118]	[0.116]	[0.118]
Observations	1,084	1,027	1,082	1,082	1,082	1,082
Nonparametric	0.306**	0.237*	0.214*	0.213**	0.016	−0.049
CV Bandwidth	[0.125]	[0.121]	[0.124]	[0.104]	[0.126]	[0.120]
Observations	1,247	887	1,006	1,320	906	1,006
Nonparametric	0.030	0.579***	0.254	0.077	−0.181	−0.281
IK Bandwidth	[0.302]	[0.216]	[0.272]	[0.261]	[0.255]	[0.244]
Observations	265	242	223	254	246	244
Parametric	0.381***	0.331***	0.244**	0.277***	0.104	0.025
Quadratic Spline	[0.120]	[0.099]	[0.103]	[0.104]	[0.103]	[0.106]
Observations	4,532	4,276	4,516	4,516	4,516	4,516

Notes: Robust standard errors clustered at the household level are in brackets.

***, ** and * indicate statistical significance at the 1, 5 and 10 percent level respectively. The dependent variables are defined in Tables I, II, and III. The reported coefficients are for the variable "Winner" is defined as 1 for individuals with an income below the program cutoff of 62.58 RON, 0 otherwise. All non-parametric specifications use a rectangular kernel. CV refers to the modified cross-validation procedure used to derive the optimal bandwidth; IK refers to the Imbens-Kalyanarman optimal bandwidth. All regressions include controls for age, gender, ethnicity and education of the head of household, as well as gender and age dummy variables of the child. Source: 2009 Euro 200 survey.

Table VIII

Effect of the Euro200 program on Non-Cognitive Outcomes

	Panel A: Children Survey						Panel B: Parent Survey			
dependent variable	**Rosenberg Index**	**Overweight**	**Smoking**	**Drinking**	**Health**	**Hands**	**BPI**	**BMI**	**Sports**	**Service**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**
Nonparametric	−0.026	0.022	0.022	−0.009	−0.134	0.057*	0.056*	0.409	0.056	−0.212
Bandwidth - 30	[0.151]	[0.039]	[0.022]	[0.028]	[0.083]	[0.034]	[0.034]	[0.492]	[0.225]	[0.166]
Observations	921	1,047	1,072	1,078	1,074	1,046	1,208	1,101	1,305	1,329
Nonparametric	0.045	0.013	0.009	−0.012	−0.096	0.067*	0.047*	0.092	0.252	−0.162
CV Bandwidth	[0.118]	[0.040]	[0.019]	[0.023]	[0.066]	[0.039]	[0.027]	[0.382]	[0.201]	[0.156]
Observations	1,543	975	1,408	1,621	1,718	861	2,025	1,784	1,731	1,476
Nonparametric	0.623**	−0.028	−0.019	0.053	−0.184	−0.006	0.045	−0.823	−0.725	−0.206
IK Bandwidth	[0.260]	[0.111]	[0.069]	[0.065]	[0.185]	[0.092]	[0.065]	[0.953]	[0.500]	[0.361]
Observations	231	195	118	191	247	115	165	304	299	251
Parametric	0.067	0.041	0.017	0.006	−0.102	0.060*	0.074**	0.359	0.244	−0.208
Quadratic Spline	[0.133]	[0.035]	[0.021]	[0.026]	[0.078]	[0.031]	[0.031]	[0.466]	[0.208]	[0.152]
Observations	3,985	4,382	4,493	4,507	4,500	4,446	4,841	4,504	5,280	5,339

Notes: Robust standard errors clustered at the household level are in brackets.

***, ** and * indicate statistical significance at the 1, 5 and 10 percent level respectively. The dependent variables are defined in Tables I, II, and III. The reported coefficients are for the variable "Winner" is defined as 1 for individuals with an income below the program cutoff of 62.58 RON, 0 otherwise. All non-parametric specifications use a rectangular kernel. CV refers to the modified cross-validation procedure used to derive the optimal bandwidth; IK refers to the Imbens-Kalyanarman optimal bandwidth. All regressions include controls for age, gender, ethnicity and education of the head of household, as well as gender and age dummy variables of the child. Source: 2009 Euro 200 survey.

Table IX

Effects of Parental Rules

dependent variable	Computer Use	Homework	Math GPA	Romanian GPA	English GPA	Raven's Test	Computer Test	Computer Fluency	Applications Fluency
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A									
Winner	3.525***	−0.097**	−0.258**	−0.418***	−0.358***	0.119	0.263***	0.172**	−0.028
	[0.481]	[0.038]	[0.104]	[0.109]	[0.133]	[0.081]	[0.069]	[0.069]	[0.070]
Computer Rules	4.071***	0.044	0.250***	0.294***	0.320***	0.105	0.322***	0.341***	0.310***
	[0.389]	[0.028]	[0.083]	[0.080]	[0.092]	[0.069]	[0.056]	[0.056]	[0.060]
Winner*Computer Rules	−3.231***	0.046	0.003	−0.027	−0.064	−0.014	−0.188***	−0.097	−0.106
	[0.471]	[0.034]	[0.097]	[0.095]	[0.113]	[0.080]	[0.066]	[0.065]	[0.070]
Observations	4,268	4,412	4,155	4,176	3,368	4,504	4,255	4,488	4,488
Panel B									
Winner	3.055***	−0.104***	−0.251**	−0.443***	−0.418***	0.147*	0.244***	0.174**	−0.019
	[0.507]	[0.039]	[0.107]	[0.111]	[0.137]	[0.082]	[0.071]	[0.070]	[0.071]
Homework Rules	0.644*	0.061**	0.061	−0.014	−0.090	0.071	0.086	0.085*	0.093*
	[0.340]	[0.027]	[0.075]	[0.077]	[0.092]	[0.059]	[0.052]	[0.052]	[0.053]
Winner*Homework Rules	0.204	0.085***	0.130	0.215**	0.340***	−0.016	0.012	0.055	0.011
	[0.434]	[0.032]	[0.090]	[0.093]	[0.113]	[0.073]	[0.065]	[0.062]	[0.064]
Observations	4,182	4,335	4,112	4,133	3,335	4,411	4,165	4,395	4,395

Notes: Robust standard errors clustered at the household level are in brackets.

***, ** and * indicate statistical significance at the 1, 5 and 10 percent level respectively. The dependent variables are defined in Tables I, II, and III. "Winner" is defined as 1 for individuals with an income below the program cutoff of 62.58 RON, 0 otherwise. "Computer Rules" is an indicator for whether parents have rules regarding computer use. "Homework Rules" is an indicator for whether parents have rules regarding homework use. All regressions include controls for age, gender, ethnicity and education of the head of household, as well as gender and age dummy variables of the child. The estimation is based on the linear spline specification using the full sample. Source: 2009 Euro 200 survey.