– PRELIMINARY DRAFT: DO NOT QUOTE OR CITE –

The Effect of Computer Use on Child Outcomes

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Abstract

This paper examines the impact of having access to a home computer on various child outcomes. To avoid the bias due to non-random access to home computers, we exploit a unique government program which provided vouchers towards the purchase of a personal computer for low-income children enrolled in Romanian public schools. Since the fixed number of vouchers were allocated based on a simple ranking of family income, this program affords a stark regression discontinuity which allows comparisons across students very similar in family income and other respects, but who experienced markedly different access to having a computer at home. In 2007, we conducted a household survey of children who participated in the program in 2005. Using these data, we show that children who received a voucher were 25 percent more likely to own a computer. Next, we show that receipt of a voucher had a large impact on time spent in front of the computer and decreased the amount of time spent watching TV and doing homework. Children in household that won a voucher also report having lower school grades and lower educational aspirations. Finally, there is some suggestive evidence that winning a voucher is associated with negative behavioral outcomes.

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1. Introduction

The development of the personal computer in the late 1970s enabled households to purchase a computer for the home, and children to gain access to an important new technology. At present, over three-quarters of all American children aged 3 to 17 years now live in a household with a computer. (U.S. Census Bureau, 2005) However, there remain large disparities in computer ownership by race and family income. Data from the 2003 Current Population Survey (CPS) indicate that less than half of children with family incomes under $25,000 lived in a household with a computer, compared to 97 percent of those with family incomes over $100,000. Furthermore, access to computer technology is far less common among children in developing countries, and the disparities between the rich and poor are often much greater. Estimates from the OECD's 2003 Programme for International Student Assessment (PISA) show that most 15 year old students in developed countries have access to a computer at home (91 percent in the United States). In contrast, about half of 15 year olds enrolled in school have access to a home computer in emerging Eastern European countries such as Poland, Latvia and Serbia.[1] Among 15 year olds in the bottom SES quartile within these countries, only about a quarter have access to a home computer.[2] (OECD, 2005)

Many government and non-governmental organizations are trying to bridge the digital divide across nations and between households. For example, Brazil embarked on some of the earliest government-run initiatives to bring inexpensive computers to its citizens. In 2003, the government announced a new plan to encourage domestic manufacturers to develop inexpensive consumer PCs for Brazilians with incomes between $140 and $1,400 USD. (Rebelo, 2005) Most recently, the One Laptop per Child (OLPC) program has received substantial publicity in its efforts to develop a cheap laptop computer suitable for children in

[1] This is probably an understatement of cross-country disparities in computer access since 15 year olds who remain enrolled in school in developing countries are more likely to come from advantaged family backgrounds.
[2] 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.

developing countries.[3] Peru and Uruguay have already placed orders for thousands of computers while others, such as Ethiopia, Thailand, and Nigeria have made preliminary commitments. (eWeek, 2007) However, these major efforts to increase computer access among children are happening despite relatively little credible evidence regarding the effect of home computers on children's educational and behavioral outcomes.

The risks and benefits of increased computers use among children has been a matter of substantial public debate. Similar to concerns with television, many have expressed worries that children may become "addicted" to the interactive computer products.[4] Some negative physical consequences are associated with long periods of computer use, such as repetitive strain injuries, eye strain, and increased risk of obesity. Excessive computer use is sometimes hypothesized to lead to decreased social involvement and isolation. If computers are used for playing games or for accessing the Internet, children may also be exposed to content that can have detrimental effects on social and behavioral outcomes. More generally, it is possible that time spent on computers displaces other activities more valuable from a developmental perspective. On the other hand, computers may help introduce children to an important new technology. This may foster the development of skills which lead to better labor market outcomes as adult.[5] Computers may also facilitate learning through the use of educational software. In contrast to television, computers demand more interaction from children, something that may ultimately help develop important skills.[6]

This paper seeks to provide a credible estimate for the effect of home computer access on educational and behavioral outcomes for children and adolescents. We analyze a

[3] See http://laptop.org/ for more details on the mission and implementation of this program.
[4] Wartella and Jennings (2000) document numerous examples of public commentaries during the 1980s expressing these concerns in popular magazines.
[5] Krueger (1993) estimated a large wage premium among Americans who use a computer at work. However, DiNardo and Pishke (1997) have cast some doubt on whether these represent causal estimates for the effect of computer use by taking advantage of more detailed information on work activities from Germany.
[6] Nevertheless, recent evidence on the effect of early exposure to television on test scores suggests that (1950s) television may not lead to lower cognitive achievement. (Gentzkow and Shapiro, 2007) In related studies, Olken (2007) finds that television and radio reduces social participation in Indonesia while Jensen and Oster (2007) show that access to cable TV improves women's status in India.

government program administered by the Romanian Ministry of Education which subsidized the purchase of home computers for children. The program offered about 27,000 vouchers worth 200 Euros (about $240) in 2005 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 low-income 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 very similar in family income and other respects, but markedly different in their access to a computer at home. With data that we collected using household surveys, we estimate the impact of winning a program voucher on computer ownership, computer use, as well as academic and behavioral outcomes.

We find that winning a 200 Euro voucher increases the likelihood that households own a home computer by 25 percentage points, or 50 percent higher compared to households that had incomes above the program threshold. As might be expected, higher rates of computer ownership among winners also led to increased computer use. Computers were turned on for approximately 1 hour longer each day in households that were just under the program threshold for winning. Children in households that won a program voucher used the computer significantly more than their counterparts who did not win a voucher. In terms of time-use, we find that children who won a voucher reduced the time spent watching television and doing homework by about 3 hours a week. Children in household that won a voucher also had lower school grades and lower likelihood of planning to go to college. However, the effect of winning a computer voucher on behavioral outcomes is somewhat less conclusive. While we find evidence that winners of the voucher received lower behavior grades in school, we find no effects with regard to drinking behavior, weight and two indexes of behavior (Behavioral Problem Index and Rosenberg Self-esteem Index). In sum, providing home computers for

low-income children in Romania may not have led to improved educational and behavioral outcomes. This may not be surprising given that relatively few children report having educational software installed in their computer.

The paper is organized as follows: Section 2 discusses the related literature regarding the effect of home (and school) computers on child outcomes. Section 3 provides some background on the Euro 200 program. Section 4 details the data collection effort and describes the resulting data. Section 5 explains the empirical strategy. Section 6 presents the results and Section 7 concludes.

2. Related Literature

There is a small but growing literature examining the effect of home computer use on educational outcomes using readily available survey data. Attewell and Battle (1999) use the 1988 National Educational Longitudinal Survey (NELS) to show that having a home computer is associated with higher test scores in both mathematics and reading. After controlling for differences in demographic and individual characteristics, they find that students with home computers score 3 to 5 percent higher on these tests than those students without home computers. Using data from the Computer and Internet Use Supplement to the 2001 Current Population Survey (CPS), Fairlie (2005) shows that having access to a home computer is associated with a higher likelihood of being enrolled in school. He finds that teenagers with home computers are 10 percentage points more likely to be enrolled in school than their counterparts without home computers. Controlling for family income, parental education, parental occupation and other observable characteristics, this differential declines to 1.4 percentage points. Beltran, Das, and Fairlie (2006) extend this work using the 2000-2003 CPS Supplements and National Longitudinal Survey of Youth (NLYS) 1997. They find that teenagers with access to home computers are 6 to 8 percentage points more likely to

graduate from high school after controlling for various individual, parental, and family characteristics.[7]

In contrast to these findings, Fuchs and Woessmann (2004) find a negative relationship between home computers and student achievement using student-level data from the (PISA) database. They begin by showing that the bivariate relationship between the availability of home computers and student performance on math and reading tests is positive, similar to the findings from other studies. However, when they control for detailed student, family and school characteristics, they find that the relationship between availability of home computer use and test scores becomes negative and significant. Students with home computers score about 5 achievement points (approximately .05 of a standard deviation) lower on both math and reading tests. Interestingly, evidence concerning the effect of computer use in school on educational attainment is also quite mixed. Angrist and Lavy (2002) find that the quasi-random installation of computers in Israeli schools did not lead to improvements in math test scores. Rouse and Krueger (2004) present evidence from a randomized experiment showing that an instructional reading computer program improved certain limited aspects of students language skills but did not improve broader language abilities. However, a recent study by Barrow, Markman and Rouse (2007) evaluated a randomized experiment which provided computer instruction in algebra and found significant effects on mathematics achievement. Finally, Banerjee et. al. (2007) examine the effect of an computer-assisted learning program in India which offered children two hours of computer time per week to play games that involve solving math problems. They find a positive effect of computer use on math test scores.

[7] Schmitt and Wadsworth (2004) also provide evidence of a positive relationship between home computer ownership and subsequent academic achievement in Britain. Using the British Household Panel Survey, they find that access to a home computer is associated with higher rates of completion of British school examinations (GCSEs and A-levels) after including individual, household and geographical controls, as well as proxies for household wealth and prior educational attainment

Closely related to research on educational outcomes, the psychological literature has explored the effect of computer and internet use on children's time-use, as well as cognitive and behavioral outcomes. Subrahmanyam et. al. (2000, 2001) review some findings from recent US-based studies: children with a computer at home spend more time using it and substitute away from watching television (Kraut et al., 2001; Stanger, 1998); children playing computer based games display higher levels of spatial ability (Subrahmanyam and Greenfield, 1994); effects on social and behavioral outcomes are quite mixed. Again, the possibility of omitted variables implies that these findings are merely suggestive. However, these cognitive and non-cognitive (social and behavioral) outcomes may play an important role in enhancing educational outcomes.

3. 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, in order to promote competence in computing knowledge. Although the incumbent party suffered a narrow electoral defeat in the November-December 2004 elections, the new governing coalition actually expanded the resources allocated to the voucher program: thus, whereas 25,051 families received vouchers in 2004, the number of awards increased to 27,555 in 2005, 28,005 in 2006 and over 38,379 in 2007.[8] The law also specified that the computers bought through the program had to be new and had to meet the

[8] Along with the total number of vouchers, the proportion of applicants who received computers also increased dramatically from about 20% in 2004 to 53% in 2005, 96% in 2006 and 100% in 2007. As a result, the most recent two rounds of the program cannot be used for the current research design, since they do not provide meaningful control groups against which to evaluate treatment effects.

following minimum specifications: 1.6 GHz processor, 128 MB RAM memory, 40 GB hard-disk with a keyboard, mouse and monitor, as well as some preinstalled software.

The 200 Euro ($240) subsidy covered a substantial part of the cost of a new computer that met the minimum specifications. Nevertheless, households did need to "top up" the vouchers with their own income. For example, the voucher covered about 75 percent of the price of a system at Romania's largest computer retailer, who sold almost 40 percent of the program computers in 2005.[9] (Comunicatii Mobile, 2005) According to data from the Ministry of Education, 94 percent (25,908 of 27,555) of the issued vouchers were converted into computer purchases by the recipients.[10] Overall, the Euro 200 program was sizable by national standards and accounted for about 4.4% of total new computer sales in Romania in 2005.

The program was targeted towards children from low income families. To be eligible 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 of a private or public school or attending university. At the same time only households with monthly family income per household member of less than 1,500,000 lei (around $50) were eligible to apply. In 2005, 51,748 households applied for the program and met the threshold. Following the application deadline, all the applicants were ranked based on their family income per household member. Since the government had a limited budget, it restricted the number of vouchers to 27,555 in the 2005 program round, which corresponded to a maximum income of 506,000 lei ($17). Neither the number of winners nor the income threshold was known to the applicants in advance. This feature of the program is essential for implementing the regression discontinuity design which enables us to

[9] Comunicatii Mobile (http://www.comunic.ro/article.php/Aproape_jum%C4%83tate_din_sistemele_v%C3%A2ndute_%C3%AEn_programul_guvernamental_quotEuro_200quot_au_fost_oferite_de_Flamingo/1459/)

[10] Vouchers were issued in the name of the child, and therefore not transferable. Nevertheless, it is possible that families, in turn, sold their computer to other buyers. We show that this was not an important issue.

compare students with incomes close to the 506,000 lei threshold who experienced a discontinuity in access to a home computer.

In order to encourage the use of these computers for educational purposes, the Ministry of Education also offered a number of 530 multimedia educational lessons to voucher winners. The computer retailers who participated in the Euro 200 program were encouraged to install these lessons at no charge on the computers of program winners. These lessons were designed during 2001 to 2004 as part of a larger effort to introduce information technology into the education process. 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. These lessons were initially designed for use in the computer labs of Romania's public schools.

4. Data

The primary data used in this paper are from a 2007 household survey conducted with families who applied to the 2005 round of the *Euro 200* program.[11] In order to conduct this survey, we obtained the list of 1554 families who participated in this round of the Euro 200 program in the Romanian counties of Valcea and Covasna. 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. There is also information on the income per family member in the three months prior to the application deadline, which is essential for implementing the regression discontinuity design. With the help of *Gallup Romania*, we then surveyed a target sample of 1317 families who lived in localities with at least four families that applied to the program.[12] Of these remaining 1317 families, 858 were successfully interviewed for a response rate of

[11] The survey was conduct in the spring of 2007, between May and June, while most kids were still in school.
[12] This restriction helped minimize the high cost of surveying individuals in areas with few program participants.

65%, which is in line with Gallup's interview rate for this population. While the remaining sample is not completely representative of the program applicant pool or the population of the two counties more generally, we found no evidence that attrition differed between winners and losers of the program.

The household survey had three separate components. First, we interviewed the family in order to obtain demographic information about each member of the household and basic household characteristics, including information about computer ownership. Table 1 presents summary statistics for the main variables in this part of the survey. Average monthly income per household member is about 525,000 Romanian lei, which translates into approximately $20. Since the program was targeted towards low income families, it is not surprising that the sample population is predominantly rural and has comparatively low levels of educational attainment (almost half of the heads of household did not complete any form of secondary school). Compared to national averages, our sample contains an unusually large fraction of Hungarians reflecting the fact that one of the two counties in the study (Covasna) has a large Hungarian majority. Among our 858 applicant families, 49 percent received a voucher in the 2005 round of the Euro 200 program and 98 percent of the vouchers awarded were observed to have been cashed out. Computer ownership is quite high at around 75 percent, suggesting that about half of households who did not qualify for a voucher in the 2005 round had a computer by the spring of 2007. The high computer ownership at the time of our survey in 2007 among program losers in 2005 is mostly explained by the fact that many families received a similar voucher in the 2006 and 2007 Euro 200 program. Interestingly, only about 30 percent of households had educational software installed on their home computer, despite the fact that educational software was available from the Ministry of Education at no cost. On average, computers were reported to be turned on for approximately 1.8 hours each day, or about 2.5 hours conditional on having a computer.

Secondly, we used the parental interview to elicit additional information about the outcomes of each child in the family.[13] Panel A of Table 2 presents parental reports concerning some important time-use, academic, and behavioral outcomes for almost 1,800 children. In some regressions, we restrict our attention to the 1,351 children enrolled in grade school (grades 1 to 12). The sample is pretty evenly split between boys and girls and the children's average age is 13.5 years. We elicited the frequency of home computer use on a scale of 1 (less than once a month) to 5 (every day use).[14] Among the entire sample, almost a quarter used their home computer every day and another 18 percent used their home computer several times a week. Among those households with a home computer, over 80 percent of children used their computer more than once a week. At the same time, access to the internet among families in our sample is extremely limited. Only about 7% of families with a computer can also access the internet from home. When interpretating our results, it is important to keep in mind that the voucher program increased access to a computer at home for households with limited access to the internet. On average, children watched about 2.1 hours of television per day. In order to get a more accurate measure, we also construct a weekly measure of TV viewing by multiplying the hours by the frequency of TV use over time.[15] Given the high frequency of TV viewing, we determine that children watched almost 13 hours of television per week. Only about 30 percent of children were reported to read at least several times a week. In terms of academic outcomes, the average GPA reported by the head of household during 2005-06 is 8.36 out of a possible 10. About three-quarters of children are said to have plans to go to college, and approximately 10 percent have plans for a career related to computer work. In terms of behavioral outcomes, the average grade for school behavior during 2005-06 was extremely high at 9.93 out of a possible 10. We also

[13] We allowed the head of household to report on up to 5 children. This sample censoring applied to only two families who had 7 and 9 children respectively.
[14] In addition, we recorded 2 (once or twice in the past month), 3(once a week), and 4 (several times a week).
[15] The frequency of TV viewing was reported in a similar fashion to the frequency of computer use.

asked household heads if their children had exhibited various behavior 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" to 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]

Thirdly, we conducted interviews with any of the children present in the household at the time of the visit. Panel B of Table 2 presents these child reports of various time-use, academic, and behavioral outcomes for over 1,110 children. As before, we sometimes restrict our attention to the 1,013 children enrolled in grade school (grades 1 to 12). Average age and child gender in this sample are broadly similar to those in the sample of parental reports. We also asked children about the frequency with which they used their computers for games, education, and other activities.[17] Among those with computers, almost 70 percent of children report that they play games at several times a week. In contrast, only 20 percent of children report that they use educational software more than once a week (in part because only 40 percent of families with computers actually own educational software). On average, children reported doing about 1.9 hours of homework per day. Again, we also construct a weekly measure of homework hours by multiplying the hours by the frequency of homework over time. According to this measure, children spend about 12.5 hours a week doing homework assignments. Children also report spending about 8.8 hours a day sleeping. We also asked about several academic and behavior outcomes. Average GPA for 2005-2006 reported by the children was, at 8.35, almost identical to that reported by parents. In addition, we conducted the 10 item Rosenberg Self-Esteem Scale in order to provide a self-reported measure of non-

[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] The tables report average frequency (reported as in time-use variables) unconditioned on computer ownership.

cognitive skills.[18] Finally, we also asked children about the frequency with which they drunk alcohol in recent months.

5. Empirical strategy

As mentioned above, the Romanian Ministry of Education offered approximately 27,000 computer vouchers to low-income students enrolled in Romania's public schools in 2005. Since these computer vouchers were allocated according to a simple income cutoff, we employ a regression discontinuity (RD) design to compare outcomes across families with similar income and other characteristics but experienced different levels of program entitlements. This enables us to address the possibility of omitted variable bias between recipients of government benefits and their counterparts who were ineligible. The basic regression model used through the analysis is as follows:

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

where $outcome_i$ represents a particular child outcome such as computer use, hours doing homework, or GPA, by child i. $\mathbf{X}_i$ includes a set of control variables, such as age, ethnicity, gender, and educational attainment. In practice, these control variables have very little effect on our estimates of the discontinuity and serve mainly to increase precision. $winner_i$ is an indicator variable equal to 1 if monthly household income per capita is less than the minimum cut-off for the voucher program of 506,250 lei, and 0 otherwise. The coefficient δ, our main coefficient of interest, indicates the effect of receiving a 200 euro computer voucher on the relevant outcome. Finally, *f(income)* is a smooth function of income, which is the forcing

[18] 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 negatively worded items, scores range from 10 to 40, with higher scores indicating lower self-esteem.

variable in the context of this regression discontinuity design. As in many recent studies employing this technique, we specify a linear model of this forcing variable, but allow it to vary on either side of the discontinuity.[19] While our primary specification uses a linear spline in income, we also estimate regressions with alternative polynomial functions for robustness.

Note that we restrict our analysis to the reduced-form effects of winning a voucher on various child outcomes. Since many families who did not win a voucher in 2005 successfully reapplied during the next two rounds (summer of 2006 and spring of 2007), computer ownership at the time of the survey in 2007 underestimates the difference in access between the treatment and control groups during the period 2005-2007. In other words, we have variation in the exposure to computer ownership that isn't captured by observed ownership in 2007. Therefore, instrumenting for computer ownership with having received a voucher would not "scale up" our estimates in the appropriate fashion.

The central assumption underlying the RD design is that we have correctly specified the function of income (the forcing variable) which determines assignment of the government subsidy (the computer voucher). Another important assumption is that households were not able to manipulate the forcing variable, by reporting a lower income. While it is of course possible that individual families underreported their income, such cheating should not be a serious concern for our results for at least two reasons. First, the minimum cut-off of 506,250 lei for the voucher program was not known ex-ante. This cutoff was determined by the amount of funds available and by the number of households that applied and their corresponding income, none of which were known prior to the start of the program. Indeed, in later rounds, almost all household who applied ended up receiving vouchers. Nevertheless, we did test for manipulation of the forcing variable by examining the density of reported income around the cutoff, (McCrary, 2007) and found no evidence of cheating. Second,

[19] See Dinardo and Lee (2004) for use of parametric functions in regression discontinuity design. Estimating this equation using non-parametric methods, along the lines of Hahn, Todd, and van der Klaauw (2001) and Porter (2003), also leads to similar results.

underreporting would only create a problem for our identification strategy if it varied differently on either side of the income cut-off. This situation could only happen if families had information about the cut-off at the time they applied for the program.

6. Results

Effect on Computer Ownership and Computer Use

The 2005 round of the Euro 200 program provided vouchers towards the purchase of a computer to all families with monthly incomes per family member below the cutoff of 506,000 lei. We begin by showing the dramatic effect of winning a voucher on computer ownership in these households. In Panel A of Figure 1, we normalize the household income per family member for the families in our sample to be 0 at the 506,000 lei cutoff. The sharp discontinuity at the cutoff mark is clearly visible and illustrates the empirical strategy which underlies our regression discontinuity design. Panel B documents that the proportion of awarded vouchers actually cashed in to buy computers was extremely high. Column (1) of Table 3 confirms a "take-up" rate of over 90 percent, consistent with the fact that these vouchers accounted for substantial fraction of annual income for most of these households. Column (2) simply estimates this rate at the child level (i.e. weighted by the number of children per household). Column (3) of Table 3 indicates that households who won a voucher were about 25 percentage points more likely to have a computer at home, a 50 percent increase over the likelihood of owning a computer among those who did not win a voucher. Panel D of the Figure 1, which plots the probability of owning a computer based on residuals from a regression of computer ownership on our standard set of controls, reveals a similar discontinuity and confirms that families around the cutoff with very similar family incomes experienced a very different likelihood of owning a computer at home. As mentioned earlier, computer ownership at the time of the survey in 2007 underestimates the difference in access

between the treatment and control groups during the period 2005-2007. Hence, in Panel C of Figure 1, we use information on 2006 and 2007 program winners to define computer ownership in our sample at the end of the 2005-2006 year. Using this alternative definition, the difference in the probability of computer ownership for households who won a 2005 voucher increases to about 50 percentage points.

Given that winning a voucher does indeed lead to increased computer ownership, we examine whether it also affects the numbers of hours the computer is turned on and actual computer use among children. Panels E of Figure 1 show the discontinuity in hours that the computer is turned on. Column (5) of Table 3 indicates that households who won a voucher had a computer on for almost 1 additional hour a day as compared to those household who did not receive a voucher. Estimating this same result at the child level indicates a slightly lower magnitude, at 0.78 hours, but still significant. We also examine the probability that households who won a voucher had a computer installed with educational software, since this may have some influence on whether the computer is used in activities that enhance academic outcomes. The effect of winning on having a computer with educational software is not significant at the household level (column 7) but statistically significant at the child level (column 8). Finally, parents also reported the frequency of computer use among each child in the family. Column (9) of Table 3 and Panel F of Figure 1 indicate that parents in households who won a voucher report their children using a home computer significantly more frequently.

Effect on Time-Use

Having established the large and discontinuous impact around the income cut-off on computer ownership and computer use, Table 4 presents estimates for the effect of winning a voucher on children's time-use. Column (1) shows that children just below the income cut-off were

spending about 0.3 hours less of homework at each sitting. In column (2), the frequency of doing homework and the typical time usually spent on homework are combined into a variable that measures the total hours spent doing homework in a given week. Among children in families who applied to the Euro 200 program, winners spent 2.3 hours less per week doing homework compared to those who did not win a voucher. In addition to homework, ownership of a computer also seems to crowd out time spent watching TV. In column 4 of Table 4 we can observe that winning a computer voucher decreases the time spent watching TV by 0.4 hours. When we combine TV hours with the frequency of TV use over time, this translates into a reduction of 3.5 hours of TV watching per week (column 5 of Table 4). Table 4 also presents results for two additional outcomes of interest. Children who live in a family that won a computer voucher are 8 percent less likely to read at least weekly and they also sleep about 27 minutes less each day. These results, although sizable, need to be interpreted with care since they are rather imprecisely measured and are not statistically significant at conventional levels.

In Figure 2 we repeat the graphical analysis of Figure 1 to examine discontinuities in these time-use variables around the program threshold. As expected, the first four panels show a visible discontinuity for homework hours per session (Panel A), homework hours per week (Panel B), hours TV per session (Panel C) and hours TV per week (Panel D). The discontinuities for reading and sleep in Panels E and F of Figure 2 are not as stark. Overall the findings in Table 4 and Figure 2 provide strong evidence that the increase in time spent in front of a computer among winners of the Euro 200 program led to large reductions in hours spent watching TV and doing homework, as well as some indication that children spent less time reading and sleeping.

Effect on Academic and Behavioral Outcomes

In Table 5 we explore the impact of winning a computer voucher on a range of socio-economic outcomes. Given the large decreases in time spent doing homework, we first examine the effect on a number of measures of school performance. Both the parent and child survey asked for information about the child's GPA in the school year 2005-2006, the first year following the distribution of the computers. Columns (1) and (2) of Panel A show a decreases in reported GPA. The effect is statistically significant for the child reports, at 0.36 grade points or about one third of a standard deviation. The decrease in GPA based on parental reports is smaller and not statistically significant at conventional levels. Similarly, winners are 13 percentage points less likely to report an intention to attend college. Panel A and B of Figure 3 display visible discontinuities around the income cut-off for GPA and the intention to attend college. Interestingly, winning a voucher does not increase the intention to major in computer science in college.

Panel B explores the impact of winning a voucher on various behavioral outcomes. Children in households who received a voucher show a large reduction in their behavior grade during the 2005-2006 school-year. This result is large and statistically significant, and the discontinuity is also visible graphically in Panel D of Figure 3. We also explore the effect of computer ownership on the Rosenberg Self-Esteem index, the Behavioral Problem Index (BPI), as well as child weight and drinking behavior. However, we find no significant impacts on these variables. To summarize, the evidence on GPA, college plans and the school behavior grade presented in Table 5 suggests that, if anything, computer ownership has a negative impact on child academic and behavioral outcomes.

Heterogeneous Effects

Next we try to understand how the effect of owning a home computer varies according to individual and household characteristics of children. In this section, we estimate equations

in which the variable for winning a Euro 200 voucher is interacted with characteristics such as age and gender of children or parental education. Table 6 presents results from estimating this equation for six of our main outcome variables (computer use at home, homework hours per week, TV hours per week, reading, GPA, behavior grade and college plans). In Table 6, we do not find evidence of significant differences among program winners who have the characteristics indicated in Panels A to C.

In Panel D of Table 6, we explore how the effect of winning a voucher on our main outcome variables varies with respect to parental rules about computer use. One of our survey questions asked parents whether they had rules that regulated computer use for each child and indeed about one third of parents in homes with a computer indicated the existence of such rules.[20] The first column of Panel D in Table 7 show that for the variables *hours computer on*, the interaction between computer rules and being a program winner is large, negative and statistically significant, implying that the largest increases in computer use happen in families where parents to do restrict the access of children to the computer. The same table also shows differential changes in time spent watching TV.

Robustness Checks

Our first set of robustness checks tries to determine whether a number of the background controls used in our analysis are continuous around our income cutoff. In Appendix Table 1 we present evidence that indeed for the vast majority of our control variables, the estimated discontinuities for age, gender and education of the primary caregiver and age, gender and ethnicity of the child are generally small and statistically insignificant. Out of a total of 10 background variables, in only one case (probability of being Roma) we can reject the null hypothesis of continuity. The smoothness of these controls around the

[20] The coefficients in Panel D need to be interpreted with care. They are consistent with rules having an effect on outcomes, but they could also be driven by the fact that parents who use rules have unobservable characteristics different from parents who do not use them.

discontinuity can also be observed in Appendix Figure 1, which shows plots corresponding to a number of background variables included in Appendix Table 1.

Our results so far used the samples of all children included in either the parent or children surveys and was based on a linear spline specification for the income function (the forcing variable). Panel A of Appendix Table 2 present results for six of our main outcome variables of interest (hours computer on, homework hours per week, TV hours per week, GPA, behavior grade and college plans) using a number of different specifications for the income function. The five specifications are linear, quadratic and cubic trends in income as well as a quadratic and cubic spline. In the same table we also consider two alternative samples that restrict the windows around the cutoffs to 500,000 and 300000 lei. We expect the precision of the estimates to be lower in the narrow windows. Finally, we present results using two alternative sets of possible control variables. One specification uses no control variables while another specification includes in addition to the controls used in the main analysis also a number of additional household characteristics such as availability of sewage, hot water and toilet. The results across the rows for our six outcome variables are generally similar in terms of magnitude and statistical significance and confirm the robustness of our main results to a number of different specification checks.

7. Conclusion

This paper examines the effect of access to a home computer on educational and behavioral outcomes among low-income children and adolescents. Using data that we collected using detailed household surveys in 2007, we estimate the impact of winning a government-funded voucher worth 200 Euros towards the purchase of personal computer in 2005. We find that winning such a voucher significantly increases the likelihood that households own a home computer by 25 percentage points. Since the voucher only covered

about 75 percent of the cost of a new computer, this result indicates that households expended further resources to acquire this technology. As expected, higher rates of computer ownership among winners also led to increased computer use. Computers were turned on for almost 1 hour longer each day in households that were received a voucher and children in these households were significantly more likely to use computers than their counterparts who did not win a voucher. We find that children who won a voucher spent significantly less time watching television and doing homework. Moreover, the effect on homework appears to have had real consequences for school performance. We find evidence indicating that children who won a voucher had lower school grades and were said by their parents to have a significantly lower likelihood of going to college.

These findings suggest that providing home computers for low-income children in Romania may not have led to improved educational and behavioral outcomes. If anything, we observe that children from households who won a voucher have worse educational and behavioral outcomes than their counterparts who did not win a voucher. This may not be surprising given that relatively few children have educational software installed in their computer, and fewer still report to using educational software on a regular basis. This is especially striking given that the Romanian Ministry of Education tried to encourage the use of these computers for educational purchases (and provided educational lessons that were designed as part of an effort to introduce information technology into the education process). Our findings suggest caution regarding the broader impact of home computers on child outcomes and the usefulness of recent grandiose efforts to increase computer access for disadvantaged children around the world.

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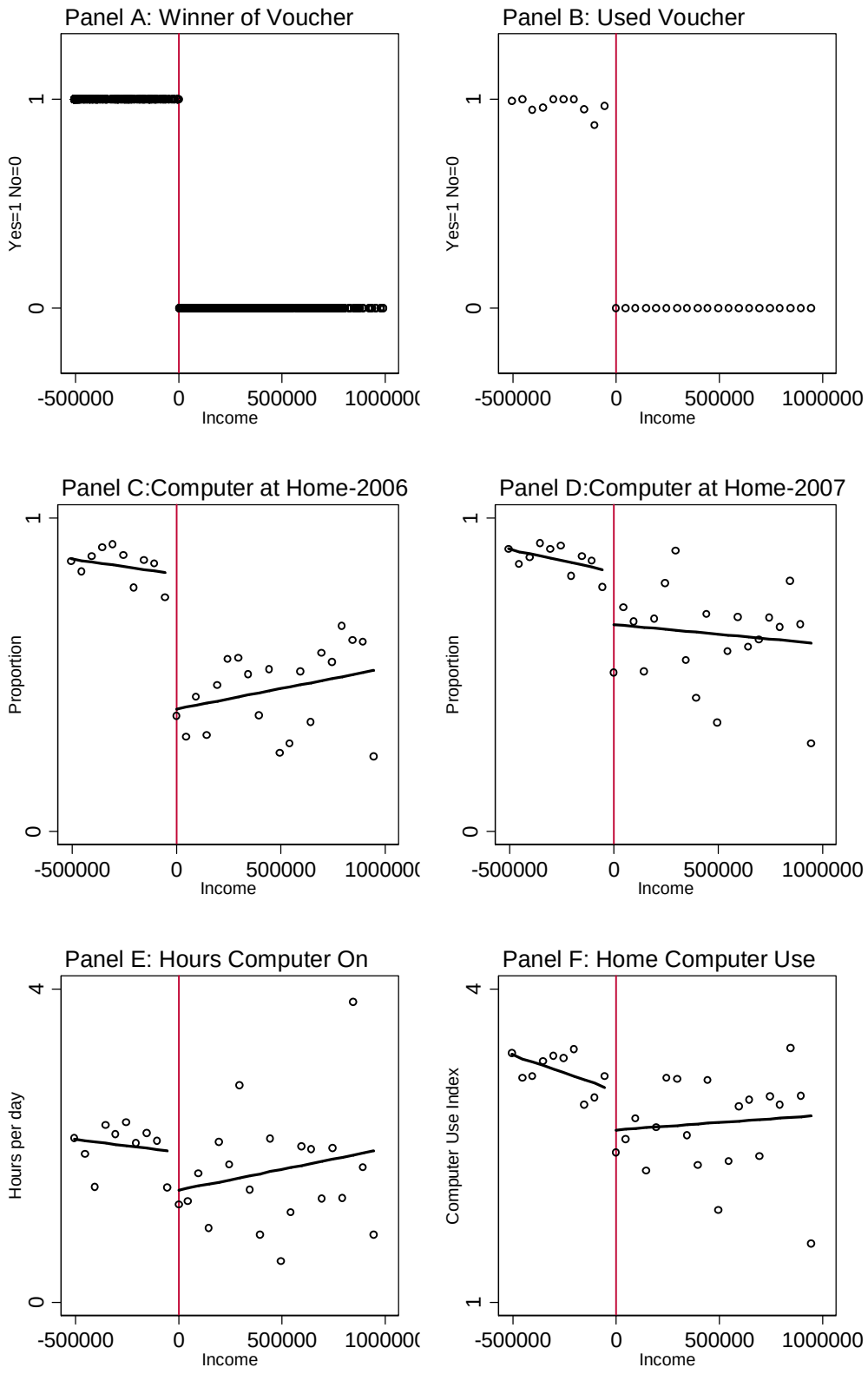
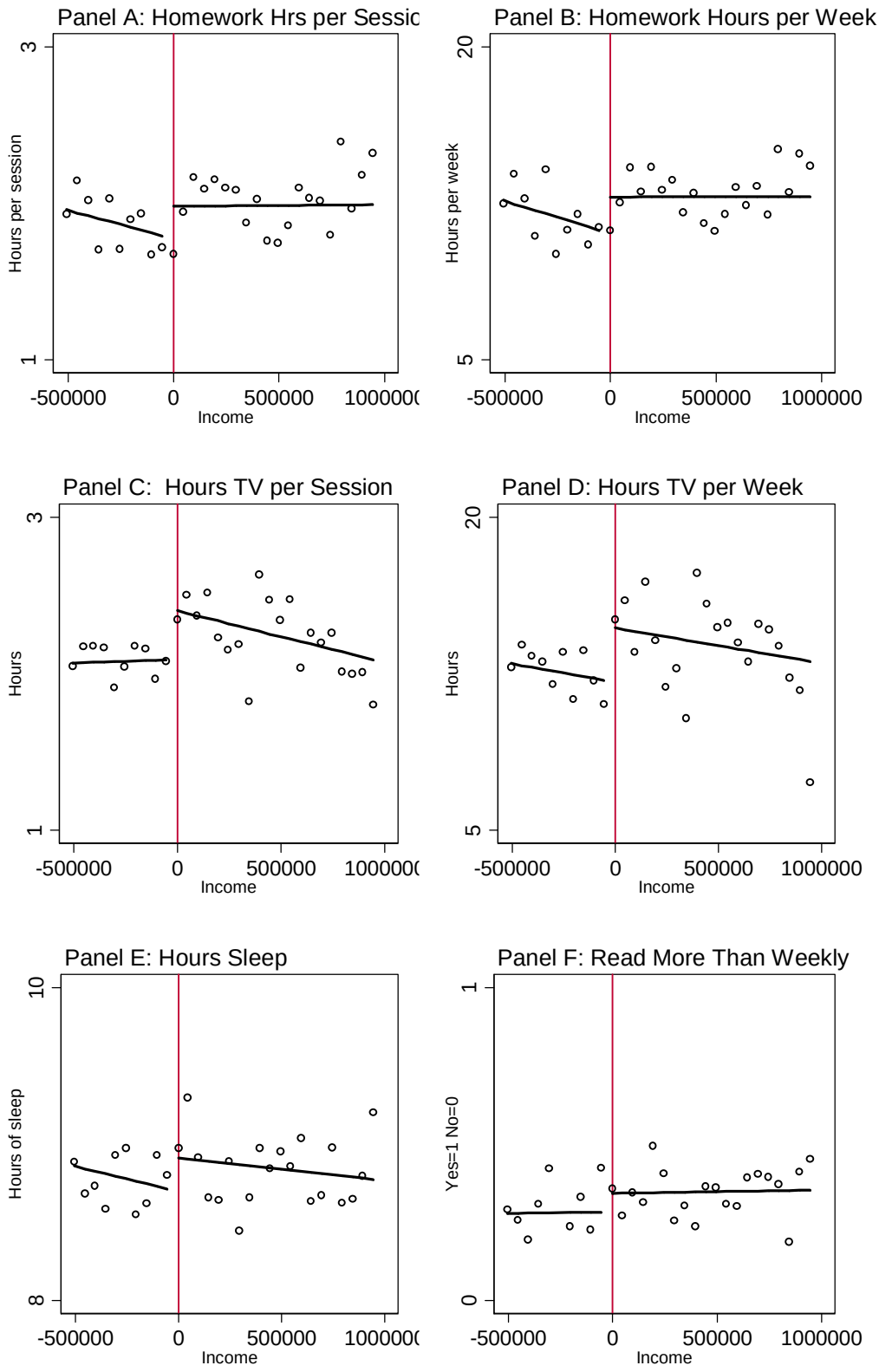
Figure 1 - Computer Ownership and Use



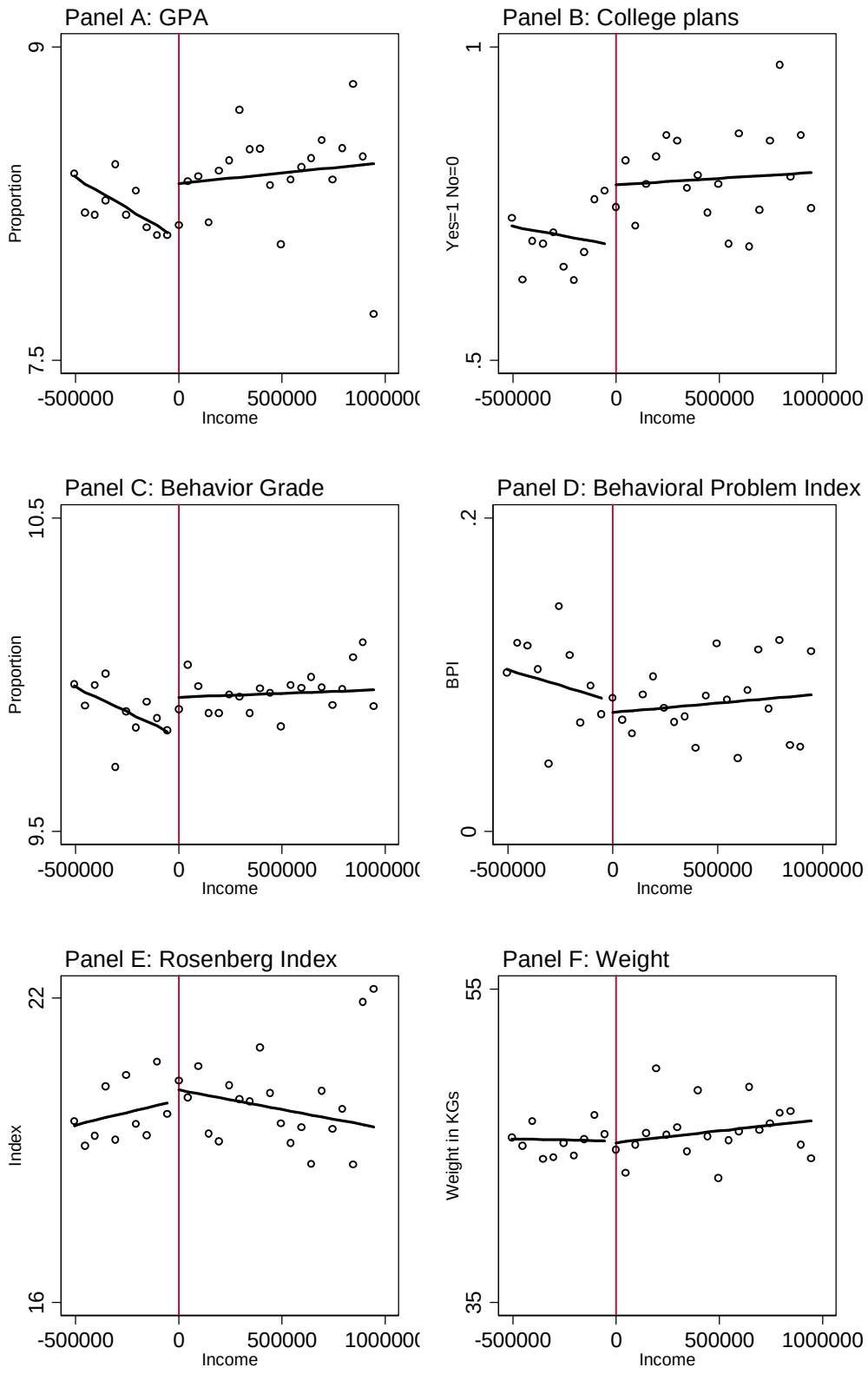
Notes: The dependent variables are defined in Table 2. In Panels C-F, the open circles plot residuals from regressions of the dependent variables on a number of parental and child background variables. The solid lines are fitted values to residuals from regressions of the dependent variable on a linear spline. 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 506,000 lei ($17) cutoff. Source: 2007 Euro 200 Survey.

Figure 2 - Time Use



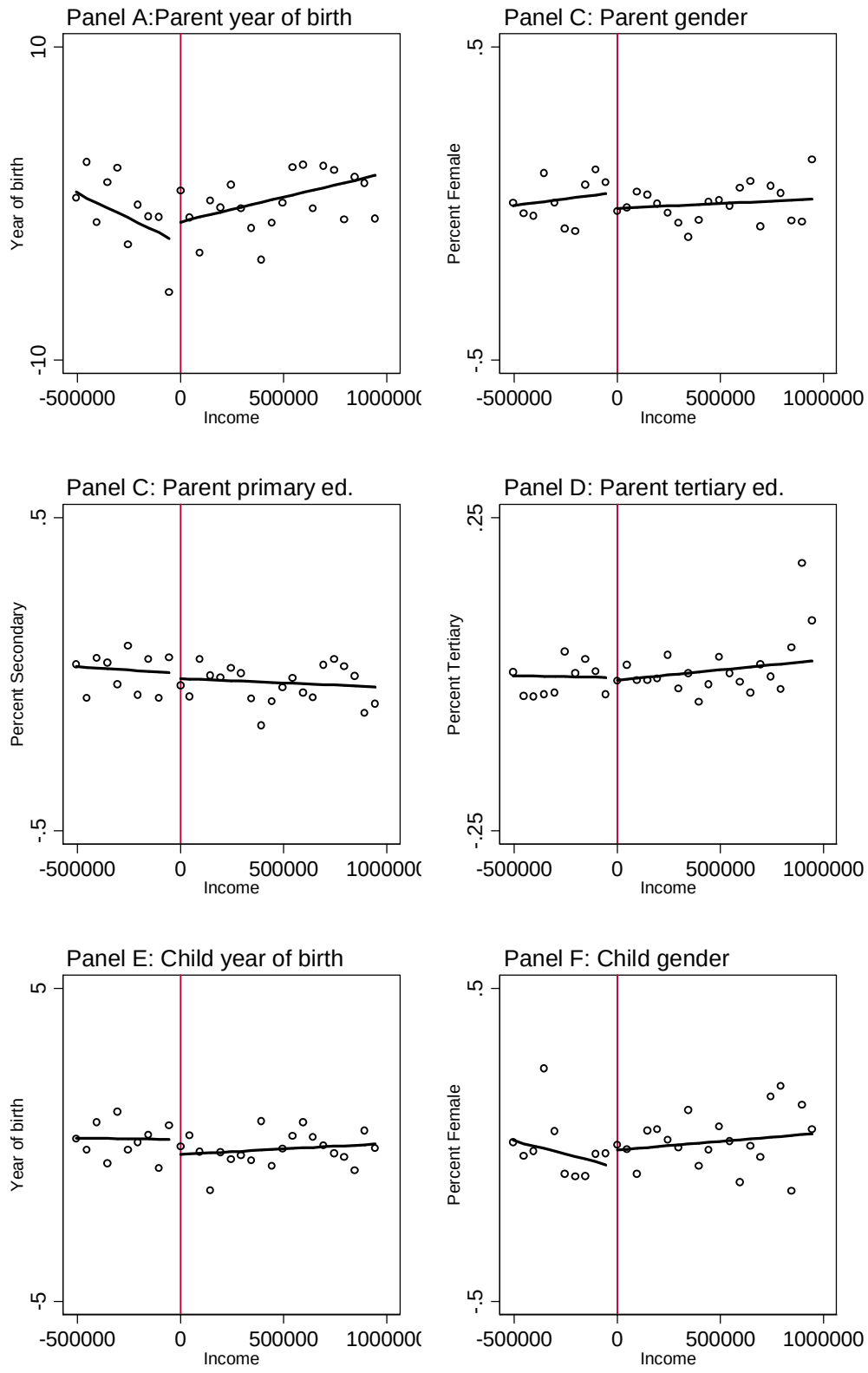
Notes: The dependent variables are defined in Table 2. The open circles plot residuals from regressions of the dependent variables on a number of parental and child background variables. The solid lines are fitted values to residuals from regressions of the dependent variable on a linear spline. The income variable is the monthly household income per family member used by the Euro 200 program and is normalized to be 0 at the 506,000 lei ($17) cutoff. Source: 2007 Euro 200 Survey.

Figure 3 - Academic and Behavioral Outcomes



Notes: The dependent variables are defined in Table 2. The open circles plot residuals from regressions of the dependent variables on a number of parental and child background variables. The solid lines are fitted values to residuals from regressions of the dependent variable on a linear spline. 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 506,000 lei ($17) cutoff. Source: 2007 Euro 200 Survey.

Appendix Figure 1 - Specification Tests



Notes: The dependent variables are defined in Table 2. The open circles plot residuals from regressions of the dependent variables on the remaining background variables. The solid lines are fitted values to residuals from regressions of the dependent variable on a linear spline. 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 506,000 lei ($17) cutoff. Source: 2007 Euro 200 Survey.

Table 1: Summary Statistics at the Household Level

	Mean	SD	N
Winner	0.490	0.500	858
Income (ven)	524,979	450,898	852
Used Coupon	0.480	0.500	858
Number of children	2.104	0.929	858
Female HoH	0.119	0.324	858
Age of HoH	43.009	8.057	855
Ethnicity of HoH			
Romanian	0.532	0.499	857
Hungarian	0.408	0.492	857
Gypsy	0.060	0.237	857
Education of HoH			
Primary	0.226	0.418	846
Secondary	0.748	0.434	846
Tertiary	0.026	0.159	846
Computer ownership			
Have a computer	0.749	0.434	856
Have a computer w/ educ software	0.303	0.460	769
Hours computer is on	1.785	1.967	844
Locality	58.81	33.45	858

Notes: SD is the standard deviation and N is the sample size. All summary statistics are based on the head of household. Source: 2007 Euro 200 survey.

Table 2: Summary Statistics at the Child level

	Mean	SD	N
Panel A: Parental survey reports			
Gender	0.478	0.500	1,794
Age	13.487	5.138	1,790
Time use			
Home computer use (frequency)	2.781	1.696	1,732
Hours TV per day	2.141	1.371	1,513
Hours TV per week	12.935	9.660	1,505
Read (every day)	0.271	0.445	1,698
Educational and Behavioral outcomes			
GPA 2005-2006	8.355	1.025	789
Behavior grade 2005-2006	9.931	0.391	934
Plan to attend high school	0.941	0.235	903
Plan to attend college	0.749	0.434	1,195
Career in computers	0.096	0.295	1,247
BPI Index	0.091	0.163	1,616
Weight (kilos)	45.331	17.106	1,726
Panel B: Child survey reports			
Gender	0.499	0.500	1,161
Age	14.133	4.307	1,161
Ethnicity			
Romanian	0.531	0.499	1,164
Hungarian	0.398	0.490	1,164
Roma	0.068	0.252	1,164
Computer use (more than once a week)			
for games	0.475	0.500	1,159
for education	0.152	0.359	1,161
for other activities	0.413	0.493	1,151
Time use			
Hours homework per day	1.944	1.124	1,091
Hours homework per week	12.400	8.437	1,086
Hours sleep	8.806	1.254	1,095
Educational and Behavioral outcomes			
GPA 2005-2006	8.347	1.047	693
Rosenberg index	19.710	3.834	1,055
Drunk	1.266	0.572	1,157

Notes: SD is the standard deviation and N is the sample size. Source: 2007 Euro 200 survey.

Table 3: Effect of the Euro200 program on Computer Ownership

dependent variable	Computer at home '06		Computer at home '07		Hours computer on		Computer with educational software		Home Computer use
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Winner	0.544***	0.525***	0.245***	0.276***	0.851**	0.772**	0.122	0.174**	0.529**
	[0.067]	[0.069]	[0.065]	[0.070]	[0.339]	[0.375]	[0.089]	[0.086]	[0.244]
Sample Size	834	1741	830	1729	818	1704	745	1555	1677
R2	0.53	0.54	0.44	0.45	0.25	0.26	0.3	0.33	0.35
Survey	household	household	household	household	household	household	household	household	household
Unit	household	child	household	child	household	child	household	child	child

Notes: Robust standard errors in brackets. In regressions where the unit of observation is the child, the standard errors are clustered at the household level. ***, ** and * indicate statistical significance at the 1, 5 and 10 percent level respectively. The dependent variables are defined in Tables 1 and 2. "Winner" is defined as 1 for individuals with an income above the program cutoff of 506,000 lei ($17), 0 otherwise. In the household level regressions, the controls include age, gender, ethnicity and education of the head of household as well as locality controls. In the child level regressions, we additionally also control for age, gender and ethnicity of the child. All regressions include a linear spline in income. Source: 2007 Euro 200 survey.

Table 4: Effect of the Euro200 program on Time Use

dependent variable	Homework hours	Homework hours per week	Reading every week	TV hours	TV hours per week	Hours sleep
	(1)	(2)	(3)	(4)	(5)	(6)
Winner	-0.284*	-2.341*	-0.081	-0.408*	-3.461**	-0.269
	[0.169]	[1.306]	[0.067]	[0.225]	[1.714]	[0.188]
Sample Size	997	994	1301	1157	1154	965
R2	0.27	0.31	0.29	0.25	0.25	0.3
Survey	child	child	household	household	household	child
Unit	child	child	child	child	child	child

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 1 and 2. "Winner" is defined as 1 for individuals with an income above the program cutoff of 506,000 lei ($17), 0 otherwise. All regressions include controls for age, gender, ethnicity and education of the head of household, age, gender and ethnicity of the child and locality controls. All regressions include a linear spline in income. Source: 2007 Euro 200 survey.

Table 5: Effect of the Euro200 program on Academic and Behavioral Outcomes

Panel A: Academic Outcomes

dependent variable	GPA (child report)	GPA (parent report)	College plans	HS plans	Career w/ computers
	(1)	(2)	(3)	(4)	(5)
Winner	-0.358*	-0.169	-0.132*	-0.063	-0.026
	[0.213]	[0.212]	[0.077]	[0.044]	[0.050]
Sample Size	665	756	1163	876	1105
R2	0.37	0.33	0.3	0.25	0.22
Survey	child	household	household	household	household
Unit	child	child	child	child	child

Panel B: Behavioral Outcomes

dependent variable	Behavior grade	BPI Index	Rosenberg Index	Weight	Drinking
	(1)	(2)	(3)	(4)	(5)
Winner	-0.174**	0.009	-0.258	0.067	0.077
	[0.077]	[0.027]	[0.622]	[1.261]	[0.088]
Sample Size	906	1277	932	1291	1017
R2	0.25	0.28	0.33	0.63	0.31
Survey	household	household	child	household	child
Unit	child	child	child	child	child

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 1 and 2. "Winner" is defined as 1 for individuals with an income above the program cutoff of 506,000 lei ($17), 0 otherwise. All regressions include controls for age, gender, ethnicity and education of the head of household, age, gender and ethnicity of the child and locality controls. All regressions include a linear spline in income. Source: 2007 Euro 200 survey.

Table 6: Heterogenous Effects

dependent variable	Computer on (hours)	Homework hours per week	TV hours per week	GPA (child report)	Behavior grade	College plans
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A						
Winner	0.791**	-3.085**	-3.542*	-0.343	-0.178**	-0.153*
	[0.394]	[1.374]	[1.863]	[0.235]	[0.077]	[0.081]
Female	-0.165	1.552**	-0.181	0.578***	0.037	0.136***
	[0.124]	[0.723]	[0.794]	[0.107]	[0.028]	[0.032]
Winner*Female	0.02	1.558	0.189	-0.029	0.01	0.05
	[0.171]	[1.036]	[1.062]	[0.171]	[0.053]	[0.048]
Panel B						
Winner	1.074**	-5.814**	-0.374	-0.407	-0.099	-0.03
	[0.466]	[2.402]	[2.858]	[0.578]	[0.194]	[0.135]
Age	-0.041	-0.485***	-0.226	-0.064	-0.014	-0.022
	[0.026]	[0.186]	[0.234]	[0.049]	[0.017]	[0.015]
Winner*Age	-0.02	0.244*	-0.221	0.004	-0.005	-0.007
	[0.020]	[0.139]	[0.185]	[0.033]	[0.011]	[0.009]
Panel C						
Winner	0.936**	-2.340*	-3.813**	-0.348	-0.169**	-0.121
	[0.372]	[1.342]	[1.827]	[0.220]	[0.080]	[0.079]
Parent_Primary_Education	0.274	-1.394	-2.347	-0.003	-0.012	0
	[0.379]	[1.141]	[0.000]	[0.000]	[0.000]	[0.058]
Winner*Parent_Primary_Education	-0.586	0.007	1.812	-0.042	-0.019	-0.057
	[0.456]	[1.373]	[1.963]	[0.234]	[0.061]	[0.080]
Panel D						
Winner	0.993***	-2.355*	-3.972**	-0.376*	-0.162**	-0.128
	[0.364]	[1.362]	[1.791]	[0.219]	[0.077]	[0.080]
Parent Has Rules for Computer	2.011***	-0.651	-2.208	0.128	0.008	0.054
	[0.274]	[0.986]	[1.531]	[0.148]	[0.029]	[0.047]
Winner*Rules	-1.435***	-0.287	2.114	0.129	-0.031	-0.014
	[0.336]	[1.233]	[1.771]	[0.199]	[0.064]	[0.064]
Survey	household	child	household	child	household	household
Unit	child	child	child	child	child	child

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 1 and 2. "Winner" is defined as 1 for individuals with an income above the program cutoff of 506,000 lei ($17), 0 otherwise. All regressions include controls for age, gender, and education of the head of household, age, gender and ethnicity of the child and locality controls. All regressions include a linear spline in income. Source: 2007 Euro 200 survey.

Appendix Table 1: Specification Tests (Effect of the Euro200 program on covariates)

Panel A: HH Characteristics

dependent variable	Age	Gender	Primary	Secondary	Tertiary
	(1)	(2)	(3)	(4)	(5)
Winner	1.128	0.104	0.028	-0.033	0.005
	[1.545]	[0.072]	[0.062]	[0.067]	[0.027]
Sample Size	837	837	837	837	837
R2	0.2	0.17	0.4	0.37	0.23
Survey	household	household	household	household	household
Unit	household	household	household	household	household

Panel B: Child Characteristics

dependent variable	Age	Gender	Romanian	Hungarian	Roma
	(1)	(2)	(3)	(4)	(5)
Winner	-0.122	-0.041	-0.037	-0.028	0.065**
	[0.476]	[0.086]	[0.029]	[0.037]	[0.033]
Sample Size	1023	1023	1023	1023	1023
R2	0.3	0.1	0.9	0.82	0.51
Survey	child	child	child	child	child
Unit	child	child	child	child	child

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 1 and 2. "Winner" is defined as 1 for individuals with an income above the program cutoff of 506,000 lei ($17), 0 otherwise. All regressions include a linear spline in income. Source: 2007 Euro 200 survey.

Appendix Table 2: Robustness checks

Panel A: Academic Outcomes

dependent variable	Computer on (hours)	Homework hours per week	TV hours per week	GPA (child report)	Behavior grade	College plans
	(1)	(2)	(3)	(4)	(5)	(6)
Alternative Trends						
Linear	0.937***	-1.416	-3.358*	-0.184	-0.083	-0.113*
	[0.311]	[1.168]	[1.821]	[0.192]	[0.061]	[0.065]
Quadratic	0.810**	-2.604*	-3.298*	-0.334	-0.204**	-0.140*
	[0.342]	[1.332]	[1.782]	[0.221]	[0.081]	[0.080]
Cubic	0.692*	-3.150**	-2.726	-0.182	-0.204***	-0.126
	[0.368]	[1.421]	[2.057]	[0.242]	[0.076]	[0.089]
Linear spline	0.851**	-2.340*	-3.461**	-0.357*	-0.174**	-0.132*
	[0.339]	[1.306]	[1.714]	[0.214]	[0.077]	[0.077]
Quadratic spline	0.578	-3.252*	-4.418**	-0.204	-0.186*	-0.013
	[0.438]	[1.969]	[2.243]	[0.350]	[0.101]	[0.119]
Cubic Spline	0.104	-1.722	-7.174**	-0.253	-0.249**	0.055
	[0.555]	[2.499]	[3.281]	[0.474]	[0.116]	[0.153]
Alternate Windows						
full window	0.851**	-2.341*	-3.461**	-0.356*	-0.173**	-0.132*
	[0.339]	[1.305]	[1.714]	[0.213]	[0.077]	[0.077]
500,000 lei window	0.574	-2.580*	-3.513*	-0.233	-0.165**	-0.193**
	[0.362]	[1.528]	[2.105]	[0.262]	[0.074]	[0.095]
300,000 lei window	0.51	-2.313	-5.635**	-0.058	-0.107	-0.086
	[0.540]	[2.186]	[2.223]	[0.436]	[0.079]	[0.140]
Alternative control						
No controls	1.082***	-0.905	-3.607**	-0.31	-0.137	-0.072
	[0.298]	[1.217]	[1.607]	[0.200]	[0.099]	[0.075]
Main controls	0.851**	-2.340*	-3.461**	-0.357*	-0.174**	-0.132*
	[0.339]	[1.307]	[1.714]	[0.213]	[0.077]	[0.077]
Additional controls	0.926***	-3.311**	-2.862*	-0.424**	-0.185**	-0.123
	[0.344]	[1.399]	[1.575]	[0.213]	[0.083]	[0.079]

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 1 and 2. "Winner" is defined as 1 for individuals with an income above the program cutoff of 506,000 lei ($17), 0 otherwise. Source: 2007 Euro 200 survey.

Appendix Table 3: OLS Results for Selected Variables

Panel A: Time Use

dependent variable	Hours of TV per week	Homework hours per week	Read every day	Sleep
	(1)	(2)	(3)	(4)
Computer	-0.983	1.17	-0.021	-0.05
	[1.530]	[0.956]	[0.055]	[0.138]
Sample Size	619	519	664	511
R2	0.29	0.34	0.35	0.38
Survey	household	child	household	child
Unit	child	child	child	child

Panel B: Academic and Behavioral Outcomes

dependent variable	GPA 05-06	College plans	Behavior grade	Rosen Index
	(1)	(2)	(3)	(4)
Computer	0.386***	0.146***	0.037	-0.818*
	[0.134]	[0.047]	[0.036]	[0.445]
Sample Size	413	600	473	495
R2	0.43	0.37	0.43	0.41
Survey	household	household	household	child
Unit	child	child	child	child

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 1 and 2. All regressions include controls for age, gender, ethnicity and education of the head of household, age, gender and ethnicity of the child and locality controls. All OLS regressions are restricted to the households that did not win a voucher in the 2005 round of the Euro 200 program. Source: 2007 Euro 200 survey.