

Djinovic, Vladana; Giannakopoulos, Nicholas

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# Home computer ownership and educational outcomes of adolescents in Greece

Vladana Djinovic<sup>\*,1</sup> and Nicholas Giannakopoulos<sup>2</sup>

## Abstract

In this paper we investigate whether human capital accumulation, during adolescence, depends on home investments in Information and Communication Technologies (ICT) equipment. Using micro-level data, for children aged 17-18 years old, drawn from the Greek part of the European Union Statistics on Income and Living Conditions (EU-SILC) for the period 2003-2019 we measure school dropout for individuals residing in households with and without access to home computer. We found that adolescents with access to ICT have better educational outcomes compared to their peers without access to such equipment (almost 5 percentage points lower probability of school dropout). These estimates are robust to different model specifications and data restrictions. Our results support the hypothesis that technology diffusion promotes educational outcomes and provides additional evidence regarding the formation of human capital during adolescence.

**Keywords:** Education; Technology Diffusion; Human Capital

**JEL Classification:** I24; O33; J24

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\*Corresponding Author

<sup>1</sup>Department of Economics, University of Patras, Email: vdjinovic@upnet.gr

<sup>2</sup>Department of Economics, University of Patras, Email: ngias@upatras.gr

# 1 Introduction

A large body of research emphasize the positive effects of investing in technologically advanced durables (e.g. home computer, internet) on early educational outcomes (Battle, 1999; Fairlie, 2005; Schmitt and Wadsworth, 2006; Beltran et al., 2008; Fairlie et al., 2010; Fairlie and London, 2012). These investments are expected to contribute in developing digital skills that are valuable in the labour market (Krueger, 1993; Malamud and Pop-Eleches, 2011; Malamud et al., 2019). While a lot of the studies analyze early childhood cognitive and non cognitive outcomes (Fiorini, 2010), an increasing amount of relevant research focus on late childhood educational outcomes (Fairlie, 2005; Beltran et al., 2008; Fairlie et al., 2010; Fairlie and London, 2012). Both strands of the literature provide evidence for the benefits of investing in ICT equipment concerning children living in households that undertake these investment decisions. To a large extent, cognitive outcomes are proxied by educational attainment, grades and test scores in specific examinations and courses. In addition, ICT equipment is usually proxied by the existence of computers at home or school and the availability of broadband internet connections.

In this paper, we analyze the impact of ICT use on the educational outcomes of adolescents using micro-level data from Greece. Using information on school dropout and the presence of personal computers at home, we complement the existing literature by offering evidence for the positive relationship between technology diffusion and human capital formation from a country where this relationship is largely unexplored. It should be noticed that in Greece, educational attainment has expanded in the last decades (Daouli et al., 2010) and although the educational system is exclusively financed and managed by the government, households invest a lot in the schooling of their offsprings (Tsakloglou and Antoninis, 1999; Psacharopoulos and Papakonstantinou, 2005; Goulas et al., 2018) and in ICT equipment at home (Demoussis and Giannakopoulos, 2006). To the extent that home computer is related to educational outcomes, then disparities in access to technology may translate into future disparities in educational attainments and consequently to life-time labour market inequalities (Attanasio, 2015; Aguirre, 2020). The relationship between

ICT and educational outcomes has been examined in many countries and in most of these studies the impact of home computer ownership on several educational outcomes (i.e. graduation rates, grades or test scores) is empirically estimated using survey data at the individual level (Dong and Kula, 2022). In many studies ICT at home is proxied not only by the existence of a home computer but also by previous ICT investment choices. The majority of the relevant studies found a positive relationship and in some cases the evidence is mixed or even negative.

With regard to the positive association between ICT and educational outcomes, evidence from the US shows that children with access to home computers have higher math and reading test scores (Battle, 1999), school enrollment rates (Fairlie, 2005), grades on multiple courses (Fairlie and London, 2012) and school graduation rates (Fairlie et al., 2010), compared with students without access to a home computer. Similarly, in the UK, Schmitt and Wadsworth (2006) found a positive association between home computers and the number of grades obtained in secondary schooling. Kubiato and Vlckova (2010) using data for Czech students also found that students familiarised with the use of ICT have better results in science, especially if the ICT equipment is used for school-related tasks. Also, Spiezia (2011) using student-level data from the OECD Programme for International Student Assessment shows a positive and significant effect of the frequency of computer use on science scores in most countries, however, this effect seems larger when computer is used at home rather than at school. However, this positive association is often questioned. For example, in Australia, Fiorini (2010) finds that computer ownership has a positive effect on cognitive skills, but for the non-cognitive skills the evidence is mixed with the effect depending on the score and the age of the children. Mixed effects, are also reported in the study of Fuchs and Woessmann (2004) who found that, in developed and emerging countries, there is a negative relationship between home computer availability and student achievement, but a positive relationship between home computer use for internet communication and educational achievements. Also, Cristia et al. (2017) in Peru showed that there was no evidence found of effects on test in math and language but there is some evidence, though inconclusive, about positive effects on general cognitive skills. Moreover, there are some studies, that found no effects on the educational outcomes

of children regarding home computer usage. In this context, Fairlie and Robinson (2013), for the US and Beuermann et al. (2015) and Cristia et al. (2014) for Peru, found that the use of computers at home has no effect on children's educational outcomes. Also Faber et al. (2015) for the UK, found that even large changes in available broadband connection speeds have a precisely estimated zero effect on children educational attainment. On the negative association between ICT and education, Vigdor et al. (2014) for the US report worse test scores on math and reading conditional on home computer ownership. Also, Malamud and Pop-Eleches (2011) using data from Romania, show that students who won a voucher for a home computer had significantly lower school grades in math, English, and Romanian but showed improved computer skills, as well as better cognitive skills. With a more detailed analysis on the use of ICT at home, Agasisti et al. (2020) find that, in most OECD countries, there is an association between the great use of home computers for homework and the lower test scores across all subjects.

The present study attempts to explicitly make a linkage between educational outcomes with ICT investments by analyzing school dropout conditional on access to a personal computer at home, for a period of more than 15 years (2003-2019). For analytical purposes, we use a longitudinal household-level micro dataset, with detailed information on the individuals of each household. Data on ICT at home and schooling outcomes are drawn from the Greek part of the EU-SILC keeping households with children aged 17 to 18 years old. The EU-SILC data set is publicly provided by the Hellenic Statistical Authority (ELSTAT). With the EU-SILC data we are able to define whether ICT equipment is present in the household and for each child we can define their schooling outcome, i.e. dropout. In addition, the ability to follow the same household (and its members) over the course of 4 years allows us to compare the schooling outcomes of children that reside in households who adopted ICT latter in time given that all households in the first year had no ICT equipment in their disposal. For estimation purposes, we rely on nonlinear discrete choice probability models. In all model specifications additional controls are used regarding parental background characteristics, family composition, income and location indicators. Overall, our findings suggest that children residing in households with ICT equipment, are less likely to drop out of school (Beltran et al., 2008;

Fairlie et al., 2010). It is important to highlight that these findings are also robust to past realizations regarding investments in ICT equipment. We note, however, that although our estimates are robust to different model specification, data sets and time periods they should not be interpreted as causal since the data at hand does not allow to examine formal models in this direction (e.g. educational production functions). Instead, our findings point out that early educational inequalities are related to differences in ICT investments at the household level.

The rest of this paper is structured as follows: Section 2 describes the procedure followed for the data collection, the final data used for the estimations and the summary statistics. Section 3 explains the empirical modeling. Section 4 presents the main empirical findings and Section 5 concludes.

## **2 Data**

### ***2.1 Data Sources***

We use yearly micro-level data from the the EU-SILC and focus on the linkage between the presence of ICT equipment at home and the educational outcomes of the children that reside in it. In particular, the data set contains information on the availability of ICT equipment at home, the children's schooling outcome, as well as detailed demographic and socio-economic attributes of the household (e.g., income, region of residence) and its members (e.g., age, gender, education, labour market status). The detailed longitudinal data available in the EU-SILC data set allow for the estimation of specifications that include detailed demographics, regional and time fixed effects and past ICT equipment ownership. We used the available data for the years 2003 to 2019, for the children of ages 17 to 18 years old. We only include children of this age group, because this data set does not provide information on the labour market status and the educational level of younger children. The data set consists of 7,946 children of ages 17 to 18 years old and detailed information on them, on the personal computer (ICT) ownership, on the head of the household and the socio-economic status of the household, as well as its structure. The EU-SILC data set keeps

records of all members within a household, but, does not provide a variable with information on the relationship between family members, although, it contains a number of, so called, pointer variables (e.g. the father's ID, mother's ID and the spouse's/partner's ID) with which we can identify the relationship between the household members. By employing the several available identifiers for the family relationships within the households we constructed the variable for the relationship between the household members.

To identify children in the EU-SILC, we create an indicator that takes the value of 1 if a member has non missing values for either the father's ID or the mother's ID, meaning that it has at least one parent, as we took into consideration both households that have both of the parents present, as well as the households that have only one parent present. We also took into consideration that there are multi-generational households in the data set, so our indicator treats the members that have their parents present in the household but they also have children themselves, as non children, giving them the value of 0 for the child indicator. Using the month and year of birth we select children in the age group of 17 to 18 years old. For each child we construct an indicator regarding school dropout. In order to create the indicator for the school dropout, we take into consideration the variable that describes the employment status of the members of the household. The values of the variable suggest that a member can either be in the labour market or out of it, and in this case it can either be inactive, retired or a student. Our indicator, concerning the dropout, takes the value of 1 if the child is not a student and 0 otherwise.

With regard to the existence of ICT equipment in the household, the data set provides detailed information on it, and our indicator takes the value of 1 when there is ICT equipment present in the household and 0 otherwise. For the household head, since there is no information about the family relationships we examined the children and the IDs that were provided for the father and the mother. As the majority of the literature considers that when both parents are present the father is usually considered the head of the household we followed the same strategy, but when only one parent was present he/she is automatically the head of the household. This combination of variables, was used to also create the indicator on the single-parent households. If only one parent

was present, our indicator takes the value of 1 and 0 otherwise. The income was already available as the total disposable household income without inflation factors, so we created a variable containing 4 categories with the income's quartiles.

## **2.2 *Summary Statistics***

Table 1 presents the summary statistics of the variables used in the analysis for the sample consisting of 7,946 children aged 17 to 18 years old. We observe that 83 percent of the children have access to a personal computer at home. The overall dropout rate is 7.34 percent, but for the children that don't have access to a home computer this rate is 14.81 percent while it is much lower for those children with access to a home computer (5.81 percent). This comparison shows that children without ICT access have 9 percentage points higher probability of dropping out of school compared to their peers who however have access to ICT equipment at home. These educational inequalities will be examined in more detail in the next section where the correlation with possible confounding variables will be taken into consideration.

With regard to other child-specific attributes, we observe that there is no difference in the average age of children with and without ICT access. However, the share of females in the group of non ICT users is larger than the corresponding share in the group of ICT user. The gender-specific difference shows that males have a higher probability to use a personal computer compared to females, a finding that is well-established in the related literature. Also, there is a small difference in the share of children born in Greece, where the share of children not born in Greece being larger in the group without ICT access. Regarding the age of the head of the household we do not observe substantial differences between children with and without ICT access. However, children in households without ICT access are more likely to live with a female head (13.78 percent) compared to children residing in households with access to home computer. As for the head's education, children in households with access to personal computer have 28.97 percent probability to live with a head holding a tertiary education degree while this figure is much lower (6.89 percent) for those children that do not have access to a personal computer at home. Although,



the identified positive relationship between head's education and home computer ownership is well established in the literature (e.g. Demoussis and Giannakopoulos (2006)) it requires further attention in the estimation of the effect of home computer ownership on children's educational outcomes. Regarding the head's labour market outcomes and the probability of the child having access to ICT infrastructure at home we do not find large differences between households. However, worth mentioning differences are found between households regarding the distribution of income. More specifically, children in households with access to a home computer have also access to more financial resources compared to those children living in households without access to a home computer. These kind of disparities (i.e. positive association between household income and home computer ownership, Demoussis and Giannakopoulos (2006)) should be taken into consideration when someone investigates the linkage between children's educational outcomes and access to ICT infrastructure at home. Lastly, children in households without access to a home computer are more likely to reside in single-parent household compared to children with access to a home computer. As far as the structure of the household (i.e the presence of children of different age groups), we find that there are no substantial differences in the shares of the children of different age groups among those that have access to a personal computer at home and those that do not have access to such ICT equipment. As for the the region of residence, we find that the share of children living in the region of Attica and the islands is smaller in the group without personal computers but larger in the regions of Northern and Central Greece, potentially showing differences in the overall ICT infrastructures of the regions (e.g. internet connectivity, ICT adoption, attributes of the residents).

[Table 1 about here]

### **3 Empirical Modeling**

As already mentioned in the Introduction, students in more advantaged environments with highly educated parents often pursue higher levels of education due to the intergenerational effects of education (Daouli et al., 2010) and due to the access to more educational resources, home instruction,

motivation and so on (Behrman and Rosenzweig, 2002; Sacerdote, 2002; Plug and Vijverberg, 2003). This effect could be the reason, the ICT equipment ownership is highly concentrated in households with children of ages 17 to 18. The parents of such households are probably highly educated, want to provide the maximum inputs into their children's learning process and see the ICT equipment as an educational resource. Since, the effects of home ICT use on school enrollment may differ from those on measures of school achievement, such as course grades, test and examination scores, in the present study we restrict our analysis only on school dropout. For analytical purposes, a child's educational outcome is expected to be a function of socioeconomic factors, region of residence and household composition. We model school dropout ( $Y_{it}$ ) as follows:

$$Y_{it} = \alpha + \beta PC_{it} + \gamma CD_{it} + \delta H_{it} + \theta F_{it} + T_t + \varepsilon_{it} \quad (1)$$

where  $Y_{it}$  is an indicator that takes the value of 1 when the child  $i$  at time  $t$  has dropped out of school and 0 otherwise,  $PC_{it}$  is an indicator regarding ICT access at home (personal computer) for the child  $i$  at time  $t$ ,  $CD_{it}$  is a vector containing child-specific demographic variables (e.g. age, gender, country of birth) referring to child  $i$  at time  $t$ ,  $H_{it}$  is a vector that contains variables capturing several demographic and socioeconomic characteristics of the head of the household (e.g. age, gender, education, employment status) for the child  $i$  at time  $t$ ,  $F_{it}$  is a vector that contains variables for the household income and composition (e.g. year-specific income quantiles, existence of children of other age groups, family size, single-parent household, region of residence) for the child  $i$  at time  $t$ ,  $T_t$  is a vector of time-specific fixed effects and  $\varepsilon_{it}$  is the usual i.i.d disturbance term.

We start the analysis by observing the ICT diffusion over time and over different types of households (i.e. with children of different age groups) in order to see whether the ICT ownership was concentrated in specific household types. We found the higher ICT ownership in households with children of ages 15 to 18 years old, from approximately 49 percent of the households having children of ages 15 to 18 years old having personal computers at home in 2003 to approximately 97 percent in 2019.

We continue by showing the effect the ICT equipment ownership can have on a specific educational outcome for children, during their adolescence. We will use the EU-SILC data set, for children of ages 17 to 18 years old and the effect the personal computer ownership can have on the probability of dropping out of school. We will employ nonlinear discrete choice probability models for our analysis and the marginal effects to examine the impact of the ICT ownership on the aforementioned educational outcome.

## 4 Estimation Results

### 4.1 *Baseline estimates*

Table 2 reveals that owning ICT equipment, lowers the probability of dropping out of school by approximately 5.3 percent in the first specification of the model to 4.4 percent in the last one <sup>1</sup>. The age of the child has a positive effect on the probability of the child dropping out of school, a result that was anticipated since as getting older the probability of completing the school is higher. The gender of the child plays an important role, as already pointed out in the literature, into the decision of dropping out of school, exhibiting a solid lower probability of 1.8 percent of doing so, even when we include various household and socioeconomic characteristics. The country of birth is also an important variable as children that where born in Greece exhibit a lower probability of dropping out of school by 7 percent to 6.2 percent.

As far as the head is concerned, his age has a negative but small effect, meaning that children with older heads have lower probabilities of dropping out of school by approximately 0.1 percent to 0.2 percent. Children living with a female head, have lower probabilities of dropping out of school

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<sup>1</sup>For comparison purposes we use data for children aged 17-18 from the Greek Household Budget Survey (HBS) dataset for the years 1993, 1998 and 2004 where we are able to estimate equation [1]. Using a probit model we found that the estimated coefficient of access to home computer reduces the probability of school dropout by 9.1 percentage points. In addition, using micro-level census data (IPUMS, 10% sample) for children aged 17-18 where we are able to define whether the household has internet access and whether the child has dropout school, we estimated a probit model (as equation 1) and found that internet access reduces dropout rates by 6.3 percentage points. Results are available upon request

by 3.5 percent in the last specification of the model, where various household characteristics were included. Socioeconomic status is highly correlated with educational success and this is the reason we used the head's educational level, his employment status and the total disposable household's income. As pointed out by the literature, having ICT equipment in the household was associated with higher family income and greater parental education. If the head holds a tertiary degree, the child has a lower probability of dropping out of school by 2.4 percent to 1.7 percent. And lastly, the head's employment status seems to greatly affect the probability of the child dropping out of school, by 6.6 percent in the first specification to 4.9 percent in the last one, when the head is unemployed compared to being employed.

The household's income, seems to affect the poorest households, as the children living in households that fall into the first quartile have a higher probability of 3.1 percent and 3.5 percent, respectively, of dropping out of school, when compared to the wealthiest households, but for the children that live in households that fall into the second and the third quartile it seems that the effect is not significant. As far as the structure of the household is concerned, there seems to be a lower probability, by 2.3 percent, of the child dropping out of school when there are also children of ages 6 to 12 present in the household. As the literature points out, family size plays an important role in the educational attainment so we included it in our analysis and it seems to worsen the probabilities of the child dropping out of school, as shown in our results, by a higher probability of 1.5 percent. Lastly, whether the household is a single-parent one or not, seems to have no effect on the probability of the child dropping out of school.

[Table 2 about here]

#### **4.2 *Lagged home computer ownership***

Table 3 reveals that owning ICT equipment computer in the previous year lowers the probability of dropping out of school by 5.2 percent in the first specification of the model to 4.1 percent in the last one. The age of the child has a positive effect on the probability of the child dropping out of school by approximately 5.7 percent, again an anticipated result. The gender of the child exhibits a

lower probability of 1.6 percent of dropping out of school, even when we include various household and socioeconomic characteristics. The country of birth is also an important variable as children that where born in Greece exhibit a lower probability of dropping out of school by 8 percent to 7 percent. As far as the head is concerned, his age and gender do not seem to have a strong effect on the outcome, as the age lowers the probability of the child dropping out of school by 1 percent and the female head lowers the same probability by 3.7 percent. If the head holds a tertiary degree, the child has a lower probability of dropping out of school by 2.2 percent and if the head is unemployed the effect is a lower probability of the child dropping out of school by 4.9 percent to 3.2 percent.

The household's income, seems to affect the poorest households, as the children living in households that fall into the first quartile have a higher probability of 3.4 percent and 3.8 percent, respectively, of dropping out of school, when compared to the wealthiest households, but for the children that live in households that fall into the second and the third quartile it seems that the effect is not that strong but remains at 1.9 percent to 2.1 percent lower probabilities of the child dropping out of school and 1.7 percent, respectively. Regarding the structure of the household, there seems to be a lower probability, by 2.5 percent, of the child dropping out of school, when there are also children of ages 0 to 5 present in the household, and by 2.2 percent, when there are also children of ages 6 to 12 present in the household. As the literature points out, family size plays an important role in the educational attainment so we included it in our analysis and it seems to worsen the probabilities of the child dropping out of school, as shown in our results, by a higher probability of 1.6 percent. Again, whether the household is a single-parent one or not, seems to have no effect on the probability of the child dropping out of school.

[Table 3 about here]

### ***4.3 Longitudinal analysis***

The nature of the EU-SILC data set, allows us to observe the same individuals up to four consecutive years. This attribute of the data allows us to use a smaller sample of the data, using only children that appear for four consecutive years in our data set, and in the first year of the quadrennium they

did not have any ICT equipment. We will divide our sub-sample into two distinct groups, the adopters and the non adopters. The first one, is the adopters group, which refers to the children that during the second or third year of the quadrennium purchased a personal computer and the non adopters group, which refers to the children that did not purchase a personal computer in any given time during the course of the quadrennium.

Table 4 reveals that children that belong in the group of the adopters, meaning that they are in their last year of schooling and in any given time during their adolescence acquired some ICT equipment, have better educational outcomes than those in the group of the non adopters. More specifically, children belonging in the group of the adopters exhibit lower probabilities of dropping out of school by 5.7 percent in the first specification to 5.2 percent in the last one. The age of the child has a positive effect on the probability of the child dropping out of school by approximately 8.1 percent to 7.7 percent, again an anticipated result. The gender of the child exhibits a lower probability of 5.9 percent of dropping out of school to 5.6 percent, even when we include various household and socioeconomic characteristics. The country of birth is also an important variable as children that where born in Greece exhibit a lower probability of dropping out of school by 11.5 percent to 10.6 percent.

As far as the head is concerned, his age does not seem to have a strong effect on the outcome, as it lowers the probability of the child dropping out of school by 0.5 percent but the female head has a strong and negative effect and lowers the dropout rates by 18.5 percent. If the head holds a tertiary degree, the child has a lower probability of dropping out of school by 9.7 percent to 10.5 percent but the employment status of the head does not seem to have an effect.

The household's income, seems to highly affect the poorest households, as the children living in households that fall into the first quartile have a higher probability of 9.7 percent and 9.9 percent, of dropping out of school, the children living in households that fall into the second quartile have a higher probability of 9.6 percent and 8.7 percent and the children living in households that fall into the third quartile have a higher probability of 10.3 percent and 9.4 percent, when compared to the wealthiest households. Concerning the structure of the household, there seems to be a lower

probability, by 7.2 percent, of the child dropping out of school, when there are also children of ages 6 to 12 present in the household, and by 7.5 percent, when there are also children of ages 13 to 16 present in the household. Again, family size plays an important role in the educational attainment and it seems to worsen the probabilities of the child dropping out of school, as shown in our results, by a higher probability of 4.4 percent. Whether the household is a single-parent one or not, seems to have a strong and positive effect on the probability of the child dropping out of school, with the probability rising by 8.7 percent.

Overall, we found that there is an association in our representative samples between having ICT equipment in the household, either in the last year of schooling or in any time during adolescence, and educational success, even after controlling for a broad range of other factors. We examine how socioeconomic status and main household determinants interact with ICT equipment in terms of educational outcomes. Our findings reveal that children have a greater probability of dropping out of school when they have no ICT equipment available at home. This was our motivation for the analysis, as it offers an explanation on why we observe higher concentration of home computers in households with children of ages 15 to 18.

[Table 4 about here]

## 5 Conclusions

Home computers may increase high school enrollment and achievement by decreasing non-productive activities and altering the relative price and time cost of certain activities (Malamud, 2019). Also, any change in the mix of activities could result into changes in children's human capital developmental and subsequent adult outcomes (Malamud, 2019). The objective of this paper was to identify whether there is a link between home ICT equipment ownership and multiple educational outcomes during adolescence, using longitudinal data from the EU-SILC data set for the years 2003 to 2019. In order to study the link between the educational outcomes and the ICT equipment ownership we followed a methodology where we first identified the factors leading

individuals to purchase a home computer just to confirm with the pre-existing literature and then, we examined whether children in their last year of schooling had better educational outcomes when ICT equipment existed in the household in the year of the survey as well as examining separately the outcomes when ICT equipment was purchased the previous year or in any time during their adolescence.

Firstly, we found strong evidence that the probability of ICT equipment ownership was mainly influenced by the existence of children of ages 15 to 18 in the household. In addition, the probability of home ICT equipment ownership is positively affected by the high educational level of the head of the household and the household's income. Households with children of any other type of age groups than the aforementioned exhibit lower probability of owning ICT equipment.

As also suggested by the literature the observed differences in the home ICT ownership could be the result of a variety of socio-economic differences as wealthier households are more likely to own technologically advanced durables (Fuchs and Woessmann, 2004), highly-educated parents are more likely to have a different perspective towards new technologies and to invest in their children's human capital and lead them to higher levels of education as well, as the intergenerational mobility literature shows persistently, where children from households with highly educated parents are more educated than children from households with less educated families (Plug and Vijverberg, 2003; Daouli et al., 2010). Based on the literature, we would expect to find a higher concentration of ICT equipment in households with highly educated parents, that are employed, have a higher income and have children that would probably follow their steps and that is the reason they would invest in the purchase of a durable that would offer exactly that. But our results show that there are households that do not have ICT equipment in the first place and households that for some reason choose to invest to ICT equipment. As Fairlie and Robinson (2013) mention, if households are rational and face no other frictions, those households without computers (ICT) have decided not to buy such devices because the returns are relatively low meaning that the ones buying them have found that the returns are high, either for them or for someone else in their household. Is the reason that we find the highest concentration only in households with children of ages 15 to 18 an indicator



of who is benefiting the most when ICT equipment is present?

In order to find an answer for the aforementioned question, we explored the causes of the observed differences in ICT equipment ownership for the different age groups of the children in the household. For this reason, we used a sub-sample of the EU-SILC data set, focusing only on households with children in their last year of schooling, of ages 17 to 18 years old, where we had information on both the existence of ICT equipment in the household in the year of the survey and in the previous years but also information on the educational level of the children over time. We wanted to find the effect the ICT equipment could have on the educational outcomes of the children and see whether it could be explained by the indicators found early in the analysis.

The results of the analysis reveal that the observed differences in the ICT equipment ownership are due to the impact ICT equipment can have on the children during their adolescence. We found that children, in their last year of schooling, have a greater probability of dropping out of school.

Our results on ICT equipment and the educational outcomes corroborate previous work such as Fairlie (2005), Schmitt and Wadsworth (2006), Beltran et al. (2008), Fairlie et al. (2010) and Fairlie and London (2012), who also find positive results in terms of effects on students' educational outcomes. Our results on ICT equipment availability and the educational outcomes extend this evidence, by illustrating that there is a positive relationship between ICT equipment ownership and student achievement, showing that households with children of ages 15 to 18 are more likely to have ICT equipment because later on, children in their last year of schooling at 17 or 18 years old can benefit the most from it.

This paper contributes to the literature on the impacts of ICT equipment ownership on the educational outcomes by exploring the relationship between the ICT equipment ownership during adolescence and the school enrollment using recent longitudinal data from Greece, covering a period of more than 15 years, from 2003 to 2019. Our results, suggest that the decision of the ICT equipment ownership is influenced by the existence of children of 15 to 18 years old. Leading to the conclusion, that the higher concentration of home computer ownership in households with children of ages 15 to 18 we found in the statistics, is an indicator that the parents of children that are still in

school but have already finished the primary school, want to invest in their children's human capital by providing as much input as they can in their learning process and getting them familiarised from a younger age with a technologically advanced durable like the personal computer, as they have already seen that they can have better chances of being enrolled in school and having better educational outcomes during their last year of schooling. This finding is also supported by the Household Budget Survey dataset we used for robustness check, where we examined the expenses the households made on the education of their children and on different types of ICT equipment. Children in households that made expenses on the education of their children and on ICT had better educational outcomes, showing as a potential mechanism where households that invest in their children's education also invest in ICT, considering it an additional input into their educational process.

Further analysis, should there is adequate data, could shed light to even further results, such as the following labour market outcomes of these children and their income levels and comparing them to those that did not have ICT equipment at this age. Maybe the decision of the parents is influenced by the fact that children that are familiarised from a younger age with ICT equipment have better educational outcomes and better labour market outcomes later on, but this needs to be further investigated in order to be answered.

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## Tables

**Table 1 Summary Statistics**

	Overall	PC=1	PC=0
(C) School dropout <sup>d</sup>	7.34	5.81	14.81
(C) Age <sup>y</sup>	17.51	17.52	17.51
(C) Female <sup>d</sup>	48.46	48.12	50.15
(C) Native-born <sup>d</sup>	95.43	96.97	87.93
(H) Age <sup>y</sup>	50.43	50.65	49.35
(H) Female <sup>d</sup>	10.70	10.07	13.78
(H) Tertiary education <sup>d</sup>	25.22	28.97	6.89
(H) Unemployed <sup>d</sup>	7.46	7.20	8.74
(HH) Income: <25% <sup>d</sup>	24.82	21.13	42.81
(HH) Income: 25% - 50% <sup>d</sup>	24.92	24.04	29.19
(HH) Income: 50% - 75% <sup>d</sup>	25.12	26.18	19.93
(HH) Income: >75% <sup>d</sup>	25.14	28.64	8.07
(HH) Children's age 0-5 <sup>d</sup>	2.84	2.52	4.44
(HH) Children's age 6-12 <sup>d</sup>	19.66	19.10	22.37
(HH) Children's age 13-16 <sup>d</sup>	32.38	32.57	31.48
(HH) Children's age 17-18 <sup>d</sup>	100.00	100.00	100.00
(HH) Children's age 19 or more <sup>d</sup>	36.01	35.57	38.15
(HH) Family size <sup>n</sup>	4.07	4.05	4.16
(HH) Single-parent family <sup>d</sup>	11.19	10.58	14.15
(HH) Region: Attica <sup>d</sup>	24.96	26.41	17.85
(HH) Region: Aegean and Crete <sup>d</sup>	16.03	16.92	11.70
(HH) Region: Northern Greece <sup>d</sup>	33.50	32.66	37.63
(HH) Region: Central Greece <sup>d</sup>	25.51	24.01	32.81
Number of observations	7,946	6,596	1,350
(HH) Home computer ownership <sup>d</sup>	83.01	100.00	0.00

*Source:* EU-SILC (2003-2019), Hellenic Statistical Authority (ELSTAT, Public Use Files).

*Notes:* C: Child, H: Head, HH: Household; <sup>d</sup>: Dummy indicator, <sup>y</sup>: Years, <sup>n</sup>: Number.



**Table 2 School dropout and ICT ownership**

	(1)	(2)	(3)
(HH) PC=1	-0.053*** (0.013)	-0.047*** (0.013)	-0.044*** (0.013)
(C) Age	0.056*** (0.006)	0.056*** (0.006)	0.055*** (0.006)
(C) Female	-0.018*** (0.007)	-0.018*** (0.007)	-0.018*** (0.007)
(C) Native-born	-0.070*** (0.024)	-0.063*** (0.023)	-0.062*** (0.022)
(H) Age	-0.001*** (0.001)	-0.001*** (0.001)	-0.002*** (0.001)
(H) Female	0.013 (0.012)	0.005 (0.012)	-0.035** (0.018)
(H) Tertiary education	-0.024*** (0.008)	-0.018** (0.008)	-0.017** (0.008)
(H) Unemployed	0.066*** (0.018)	0.053*** (0.017)	0.049*** (0.016)
(HH) Income: < 25%		0.031*** (0.012)	0.035*** (0.012)
(HH) Income: 25% – 50%		0.011 (0.009)	0.012 (0.009)
(HH) Income: 50% – 75%		0.013 (0.009)	0.013 (0.009)
(HH) Children's age 0-5			0.008 (0.022)
(HH) Children's age 6-12			-0.023*** (0.009)
(HH) Children's age 13-16			-0.008 (0.010)
(HH) Children's age 19 or more			-0.007 (0.010)
(HH) Family size			0.015*** (0.006)
(HH) Single-parent family			0.102 (0.073)
<i>Observations</i>	7,946	7,946	7,946
<i>Pseudo R<sup>2</sup></i>	0,110	0,114	0,120

*Source:* EU-SILC (2003-2019), Hellenic Statistical Authority (ELSTAT, Public Use Files).

*Notes:* Estimates are average marginal effects. The sample consists of children aged 17-18, living in households with a head aged between 35 and 64 years old. All model specifications include dummy indicators for the region of residence, child-specific year fixed effects and survey-specific year fixed effects. In parentheses, heteroskedasticity robust estimated standard errors are reported. C: Child, H: Head, HH: Household.

\*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

**Table 3 School dropout and ICT ownership (1-Year Lag)**

	(1)	(2)	(3)
(HH) PC=1 (1-Year Lag)	-0.052*** (0.018)	-0.044*** (0.017)	-0.041** (0.016)
(C) Age	0.057*** (0.007)	0.057*** (0.007)	0.055*** (0.007)
(C) Female	-0.016* (0.009)	-0.016* (0.009)	-0.016* (0.009)
(C) Native-born	-0.080** (0.035)	-0.070** (0.033)	-0.070** (0.033)
(H) Age	-0.001 (0.001)	-0.001 (0.001)	-0.001* (0.001)
(H) Female	0.017 (0.017)	0.008 (0.016)	-0.037* (0.020)
(H) Tertiary education	-0.022** (0.010)	-0.015 (0.011)	-0.014 (0.011)
(H) Unemployed	0.049** (0.020)	0.038* (0.019)	0.032* (0.018)
(HH) Income: < 25%		0.034** (0.015)	0.038*** (0.015)
(HH) Income: 25% – 50%		0.019* (0.011)	0.021** (0.011)
(HH) Income: 50% – 75%		0.017 (0.011)	0.017* (0.010)
(HH) Children's age 0-5			-0.025* (0.014)
(HH) Children's age 6-12			-0.022** (0.011)
(HH) Children's age 13-16			-0.006 (0.0212)
(HH) Children's age 19 or more			-0.04 (0.012)
(HH) Family size			0.016** (0.007)
(HH) Single-parent family			0.115 (0.085)
<i>Observations</i>	4,953	4,953	4,953
<i>Pseudo R<sup>2</sup></i>	0,107	0,111	0,117

*Source:* EU-SILC (2003-2019), Hellenic Statistical Authority (ELSTAT, Public Use Files).

*Notes:* Estimates are average marginal effects. The sample consists of children aged 17-18, living in households with a head aged between 35 and 64 years old. All model specifications include dummy indicators for the region of residence, child-specific year fixed effects and survey-specific year fixed effects. In parentheses, heteroskedasticity robust estimated standard errors are reported. C: Child, H: Head, HH: Household.

\*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

**Table 4 School dropout and ICT ownership (4-Year analysis)**

	(1)	(2)	(3)
(HH) PC=1 (Anytime)	-0.057** (0.026)	-0.056** (0.026)	-0.052** (0.025)
(C) Age	0.081*** (0.019)	0.080*** (0.018)	0.077*** (0.019)
(C) Female	-0.059** (0.028)	0.061** (0.027)	-0.056** (0.026)
(C) Native-born	-0.115** (0.052)	-0.108*** (0.051)	-0.106** (0.052)
(H) Age	-0.005* (0.002)	-0.004** (0.002)	-0.005** (0.002)
(H) Female	0.005 (0.040)	0.001 (0.040)	-0.185*** (0.030)
(H) Tertiary education	-0.097*** (0.027)	-0.092*** (0.027)	-0.105*** (0.021)
(H) Unemployed	0.094 (0.059)	0.095 (0.059)	0.050 (0.051)
(HH) Income: < 25%		0.097*** (0.027)	0.099*** (0.027)
(HH) Income: 25% – 50%		0.096*** (0.027)	0.087*** (0.025)
(HH) Income: 50% – 75%		0.103*** (0.031)	0.094*** (0.031)
(HH) Children's age 0-5			-0.035 (0.052)
(HH) Children's age 6-12			-0.072** (0.028)
(HH) Children's age 13-16			-0.075** (0.031)
(HH) Children's age 19 or more			-0.048 (0.035)
(HH) Family size			0.044** (0.021)
(HH) Single-parent household			0.869*** (0.100)
<i>Observations</i>	1,224	1,224	1,224
<i>Pseudo R<sup>2</sup></i>	0,098	0,109	0,134

*Source:* EU-SILC (2003-2019), Hellenic Statistical Authority (ELSTAT, Public Use Files).

*Notes:* Estimates are average marginal effects. The sample consists of children aged 17-18, living in households with a head aged between 35 and 64 years old. All model specifications include dummy indicators for the region of residence, child-specific year fixed effects and survey-specific year fixed effects. In parentheses, heteroskedasticity robust estimated standard errors are reported. C: Child, H: Head, HH: Household.

\*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

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