PRELIMINARY FIRST DRAFT

"Does time spent playing video games crowd out time spent studying?"

Michael R. Ward

University of Texas at Arlington

mikeward@uta.edu

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ABSTRACT

As new ICT technologies are developed and adopted, they will be increasingly incorporated into our lifestyles and displacing other activities. Video games, in particular, have greatly risen in popularity and can consume a great deal of time in gamers' lives. I examine the effect of video game time use on the likely activities that it displaces using week-to-week variation in video game popularity to identify causal effects of game quality from selection into gaming. The results indicate that each hour of increased video gaming displaces 26 minutes of human capital accumulating activities.

1. Introduction

How does consumer use of Information and Communications Technologies (ICTs) affect non-ICT based activities? The role of ICTs as inputs into the production has been studied in some depth. The subject matter ranges from skills-biased technical changed, the development of e-commerce, and even telephone calls facilitating planning. Increasingly, entertainment applications are being developed for ICTs that directly affect consumer preferences and crowd out non-ICT based activities (e.g. social media such as Facebook and Twitter). With unit sales doubling every decade, one of the fastest growing ICT entertainment applications is playing video games. Video game sales are over $10 billion in the US and approach $20 billion globally in 2011, turnover amounts that rival those of the movie industry.

Besides pecuniary costs, consumer participation in video game playing takes time. A typical game may take 20-40 hours before the gamer has “beaten” the game. As yet another entertainment choice, this time could crowd out time spent on alternative entertainments, such as television, movies, and sports. However, since video games predominantly appeal to a younger demographic segment, they have the potential of crowding out time devoted to human capital investments such as class attendance, study time and time spent doing homework. If so, the social cost of the increased time spent playing video games could be lower productivity future workers.

I exploit the American Time Use Survey (ATUS) to document the time use substitution patterns related to video gaming. For the period from 2005-2009, the ATUS includes complete diaries of over 50,000 respondents’ time use over a given 24 hour period. The ATUS includes over 100 separate possible activities on which respondents could spend their time. These activities include time spent playing games as well as time spent going to classes, doing homework, watching television, using a computer, and many other activities. However, any raw association between gaming time and, say, homework time could reflect reverse causality. For example, low ability students spend less time on homework and, thus, select into playing games for more time.

To address this problem of interpretation, I adopt an instrumental variables approach to identifying a plausibly causal relationship. This is accomplished by merging information about the popularity of games on the market in a given week. Specifically, I first show that video gaming time is positively related to the volume of sales of video games in the previous week. Gamers prefer new games of high quality. If the recently released games are of superior quality, gamers purchase them and spend more time playing them. This allows me to examine the time spent on alternative activities due to changes in time spent on video game using video game sales as an instrumental variable for time spent gaming. This way, I am more confident that the week-to-week change in time spent video gaming is due to changes in the popularity of the currently available games and not due to the attributes of individual survey respondents.

The results indicate that video gaming time comes from a variety of other activities. The entertainment activities to be crowded out the most are television viewing followed by computer use. However, for every hour of additional video gaming time, the time respondents spent either in class or doing homework falls by almost half an hour. It is not clear how valuable the marginal hour of educational time is for human capital accumulation. However, it appears that, on the margin, respondents are sacrificing some investment in human capital for entertainment consumption. If so, current video gaming at could eventually lower future worker productivity.

Video games are just one of the growing entertainment uses of ICTs. Time spent on social media is also rising steadily. It is possible, and perhaps likely, that these other uses have similar crowding out effects for time spent in educational endeavors. Parents who want to foster the education of their children may need to exercise restrictions on their children's video game usage as well as other ICT based entertainment activities. In one sense, the situation is not too different from parents restricting their children's television viewing over the past half century.

2. Method

A. Identification

The substitution between time spent on video game playing and time spent on other activities is identified using variation in video game sales from week to week. New video games are constantly being introduced and quickly fade in popularity. Moreover, video game quality is highly heterogeneous. As a result, there is considerable week-to-week variation in the desirability of the games currently available. When the currently available games are more popular, as indicated by recent sales volume, the amount of time spent playing games is expected to increase.

The time use data include observations of different individuals for every day over multiple years. Individuals are not sampled at multiple points in times precluding the use individual fixed effects. However, otherwise similar individuals in two different periods would react similarly to the availability of current games of higher quality. Thus, the popularity of the currently available games is likely to induce a behavioral response in the gaming activity of those with a propensity to lay video games.

A potential negative association between video game play and other activities may be due to selection of individuals with different preferences as well as a causal result of videos on behavior. It can be expected that, say, teenagers who are poor students and enjoy who video games will select into spending less time on homework and more time on video games. Other teenagers who are good students without strong video game preferences will tend to select into relatively more time on homework and less time on video games. This will tend to induce a negative correlation between homework time and video game time due solely to differences in preferences across individuals. Thus, video games, *per se*, were not the cause of the diversion of time from studies to gaming.

The availability of popular games is likely not related to the selection of individuals with differing preferences into video game playing at the expense of other activities. The data on time use includes individuals sampled on every day over multiple years. The data on video game sales vary from week-to-week. The main identification assumption is that the incidence of individuals of differing preferences for video games and activities they potentially substitute for are independent of the week-to-week variation in video game sales. The inducement of individuals into gaming by high quality, popular games occurs to varying degrees to any individual with some propensity for playing video games. These considerations amount to an exclusion restriction for game sales into any non-gaming activity:

$$\begin{aligned} ActivityMin_{it}^{k} &= f^{k}\left(GameMin_{it}, X_{it}\right) \\ GameMin_{it} &= g\left(GameSales_{t}, X_{it}\right) \end{aligned} \qquad (1)$$

where *i* and *t* index individuals and time periods and *k* indexes alternative activities.

B. Specification

We seek to understand the impacts on a variety of activities from increased time spent on video games as well as from other control variables. However, these activities usually take on both extensive and intensive margins of adoption and intensity. Importantly, the factors that lead to the choice of whether to partake in an activity or not need not have the same effect on the choice of how much time to spend in the activity. One can view the minutes that one spends in an activity as non-negative valued count data but with many more “zero” values than would be predicted from a traditional Poisson or negative binomial specification. The zero-inflated negative-binomial variant of a hurdle model is adopted to account for possible differences in the adoption and usage decisions. Operationally, this implies two estimating equations for each relationship:

$$\begin{gathered} Prob\left(\text{ActivityMin}_{it}^{k} = 0\right) \sim F(GameMin_{it}, X_{it}) \\ Prob\left(\text{ActivityMin}_{it}^{k} | \text{ActivityMin}_{it}^{k} > 0\right) \sim H(GameMin_{it}, X_{it}) \end{gathered} \tag{2}$$

where *F* is the standard logit distribution and *H* is the negative binomial distribution. With this specification, the marginal effect of any covariate in the logit equations is estimated independently from the marginal effect of the same covariate in the negative binomial equation. However, it is still possible to combine the estimated extensive and intensive effects to calculate the overall marginal effect of the covariate on the activity.

This specification raises an issue for the hypothesis testing regarding the effect of gaming minutes on other activities. Because of the identification restrictions imposed by equations (1), $GameMin_{it}$ is an estimated generated regressor and has a non-zero variance. The coefficient estimates from the second stage will typically have larger standard errors than those based on the usual Student’s t distribution. Relying on them may lead one to reject the null hypothesis of a no effect when in fact the effect is not different from zero.

In the usual exclusion restriction identification strategy, as used here, information from the identifying equation is used to adjust standard errors. This adjustment has not been developed for the zero-inflated negative-binomial estimator. Instead, I report standard errors and preform hypothesis tests based on bootstrapped standard errors that will tend to mitigate this issue.

3. Data

The primary data used is the American Time Use Survey (ATUS). A growing literature that is based on the ATUS tackles many disparate subjects. Connolly (2008) examines labor-leisure tradeoffs from inclement weather. Agular and Hurst (2007) show that a doubling of time spent shopping reduces prices paid by 7-9 %. Kalenkoski, Ribar and Stratton (2007) examine how family structure affects the time mothers and fathers spend on primary and passive child care and on market work. Sen (2012) shows that increased costs of driving due to higher gasoline prices can increase the physical activity levels of those affected. Price (2008) finds that first-borns receive more quality time with parents than second children.

The ATUS was begun by the Bureau of Labor Statistics in 2003 and has been updated continuously since then. The ATUS uses a random sample drawn from households that have recently completed their participation in the Current Population Survey (CPS). Sample households are selected based on the characteristics of the CPS reference person, and the respondent is then randomly selected from the list of adult (age 15 or older) household members. All adults within a household have the same probability of being selected. The ATUS collects over 1,000 diaries per month with some coverage of every single day. The ATUS respondent describes each activity (such as sleeping or watching television) over a 24 hour period to an interviewer which is ultimately coded to a three-tier scheme, going from broad top-level category to finer sub-categories. For each episode, the ATUS collects either the ending time or the duration of the activity.

For this study, data on specific likely substitute activities is collected over a period spanning 2005-2009. I use sub-categories associated with playing games, watching television, using the computer, reading, doing homework, and going to class. The time coded as playing games includes “playing computer, board, or card games” and so includes activities other than playing video games. However, the identification strategy outlined above will tend to isolate the change in time spent in this activity due to increased video game sales which is likely to be dominated by playing video games. Table 1 reports summary statistics for the activities. Figures 1 describe histograms for each activity conditional on participation, i.e. time spent greater than zero.

In addition, basic demographic information from the current Population Survey (CPS) is merged for every survey respondent. Since the American Time Use Survey uses the Current Population Survey as a sampling frame, the ATUS data files contain the same demographic information as the CPS. Video game playing is predominantly, but not exclusively, an activity that males in their teens and twenties engage in. Accordingly, information on age, sex, race, household income, household size and school activities from the CPS is used. Because there are there are weekly cycles in the opportunity costs of time, dummy variables for day-of-week for the activities are constructed. Finally, because video game sales, and likely video game playing, follow seasonality patterns, month dummy variables are included in all specifications. Table 2 reports summary statistics for the various control variables in the estimations.

My main identifying variable for video game sales is derived from the volume of video game unit sales data from VGChartz[1]. Beginning consistently in 2005, this site has provided unit sales volume information for each of the top 50 selling video console based games each week. Among other information, sales volumes are reported worldwide as well as for several geographical areas including USA, Japan, Europe, Middle East, Africa or Asia. In our sample period January, 2005 to May, 2009 the VGChartz dataset contains over one thousand different titles over the 236 weeks for the US with some of these titles being the same game for different gaming consoles. While VGChartz includes the top 50 selling games each week, it only covers a portion of all sales in the US video game market. Not included in this measure would be computer based video games and mobile phone based video games. One of the most striking features of figure 2, describing weekly video game sales, is the importance of seasonality, primarily due to purchases as Christmas gifts. Nevertheless, figure 2 also indicates much week-to-week variation in video game sales not related to seasonality. This variation will be key to the identification of changes in video game time use.

3. Results

First stage results of two different specifications are reported in table 2. Each specification has two columns – one for the equation describing the negative binomial regression of minutes spent video gaming conditional on participation and one for the equation describing the logit regression for non-participation in video gaming. Since the variation in the popularity of games varies only week-to-week, standard errors are all clustered at the week level. Both equations include the same control variables including school enrollment, sex, marital status,

[1] http://www.vgchartz.com/

race, and dummy variables for age, income and education categories, days of the week, and months of the year. All of these controls have statistically significant effects in either the logit or the negative binomial equation. Finally the value of ln(alpha)

The main difference between the first and second specifications is that the first includes only video games sales in the prior week while the second includes this along with various interactions to measure potential differences in the marginal effects of popular games on different populations. In the first specification, video game sales are shown both to increase the number of minutes played conditional on playing and to decrease the probability of not playing at all. The implied marginal effect of a one standard deviation in video game sales calculated at the average sample values is to increase game playing by 1.25 minutes or by about 10%. This effect is significant both statistically and economically. Even though the time use variable includes all gaming, this increase is likely to be due to increases in video gaming and not to other forms of gaming. In the second specification, the most of coefficients related to video game sales are not individually significant but unreported tests indicate that they are jointly significant. As expected, this specification indicates that video game sales have a stronger effect on those aged 15-22. Since all survey respondents are 'treated' with the same 'exposure' to changes in sales, these effects are likely not due to selection into gaming. Instead, this is more likely to represent changes in behaviors due to the current prevalence of higher quality games.

Second stage results for activities related to human capital investments are reported in table 4. The specification is identical to the video game regressions reported above except that the video game sales variable is replaced by one measuring the predicted time spent playing video games from the second specification of the first stage regressions reported in table 3. Because this variable is a generated regressor, it has a non-zero variance causing the actual standard errors to be greater than those reported by standard regressions. To address this, tables 4 and 5 report bootstrapped standard errors based on 200 repetitions. The main results found here are that increased video game time significantly decreases the probability that a student will attend class or engage in doing homework and decreases the time spent on homework. These are relatively large. Table 6 calculates the time diverted for various activities due to an additional time playing video games calculated at sample averages. Each additional hour of video gaming leads to a 0.29 hour (17 minute) reduction in class attendance and to a 0.14 hour (8.4 minute) reduction in study time.

Video gaming time diverts time away from other entertainment activities as well as from human capital investments. Table 5 reports the effects of video gaming time on television viewing time, computer time and reading time. Since the number of non-participants into television viewing is much smaller (see table 1), a negative binomial without the zero-inflation correction was used. This table reports that the number of minutes of television viewing falls significantly with increased video gaming. For computer use, both the likelihood of using and the time spent using fall with increased video gaming. However, for reading, there are offsetting effects. With increases in video gaming, survey respondents are less likely to engage in reading but if they do, they read for longer. Again, the marginal effects are reported in table 6 as an additional hour of video gaming leading to 0.65 hours (39 minutes) less television time and 0.20 hours (12 minutes) less computer time.

4. Conclusion

The continuous advent of new technologies will tend to lead to the declining use of older technologies. Likewise, to the extent that these technologies engender engaging and entertaining activities, they will likely displace time spent in alternative activities. Some of these displaced activities will be other entertainment activities such as television viewing or computer use. However, some of these activities could be related to the development of human capital such as class attendance and doing homework. This paper finds evidence that both educational and non-educational activities are displaced by one such entertainment technology. Video games are likely to lead to somewhat lower levels of human capital accumulation. In light of this, parents and policy makers may prefer to devise new methods to ameliorate these effects. To some extent, this is similar to the decades-old debate on the effect of television viewing on children's study habits.

It is possible to develop a rough estimate of the effect of video games on over a decade. Over the time period of this data sample, 2005 to 2009, sales of computer and video games in the US rose by 29.7 million units.[2] Using the marginal effects calculated from table 3 of 0.83 minutes of video game use per million games sold, this implies an average of 24.7 more minutes of video gaming per person over the sample. Since human capital related time use fall by a combined 0.428 minutes for each minute of video game use (table 6), these estimates imply a reduction of 10.6 minutes in class time and homework time combined per person over the sample.

There are at least two problems with interpreting this estimate of video game time effects. First, it is not clear how valuable the marginal minute is for human capital accumulation. Surely, there is a return to time spent studying on educational outcomes and eventual earnings potential. However, the last 10 minutes are likely much less than the average 10 minutes. Second, the underlying reason for the increase in video game usage may also apply to education. Video

[2] See http://www.theesa.com/facts/pdfs/ESA_Essential_Facts_2010.PDF

games are increasingly becoming popular due to improvements in computer technology. Computer technology could be increasing the productivity of time spent on human capital investments. However, the best evidence on this effect is ambiguous (see Fuchs and Woessman, 2002, Angrist and Lavy, 2002, and Belo et al., 2010).

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Figure 1

Distribution of Activities Conditional on Participation

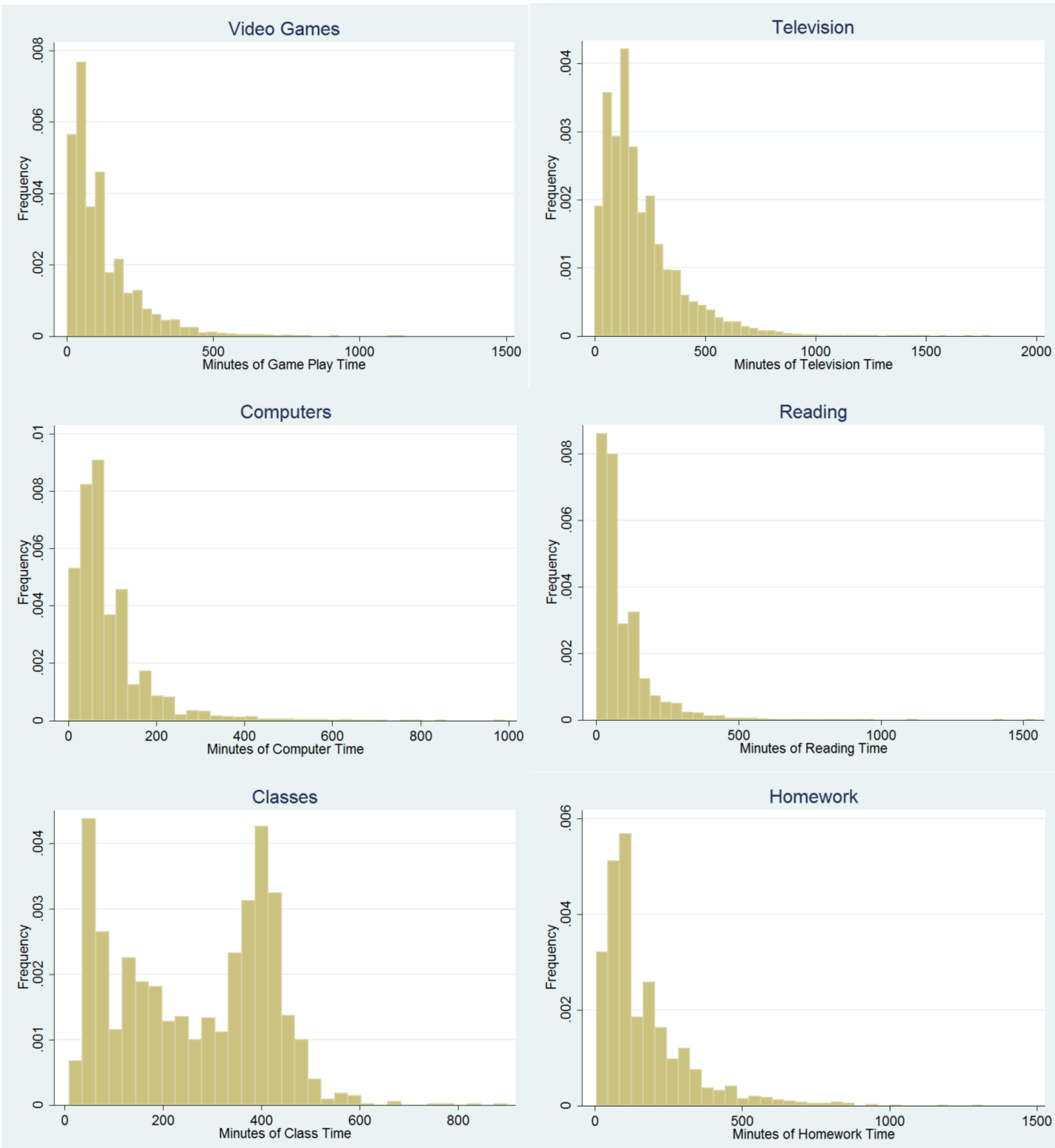

Figure 2

Video Game Sales Over Time

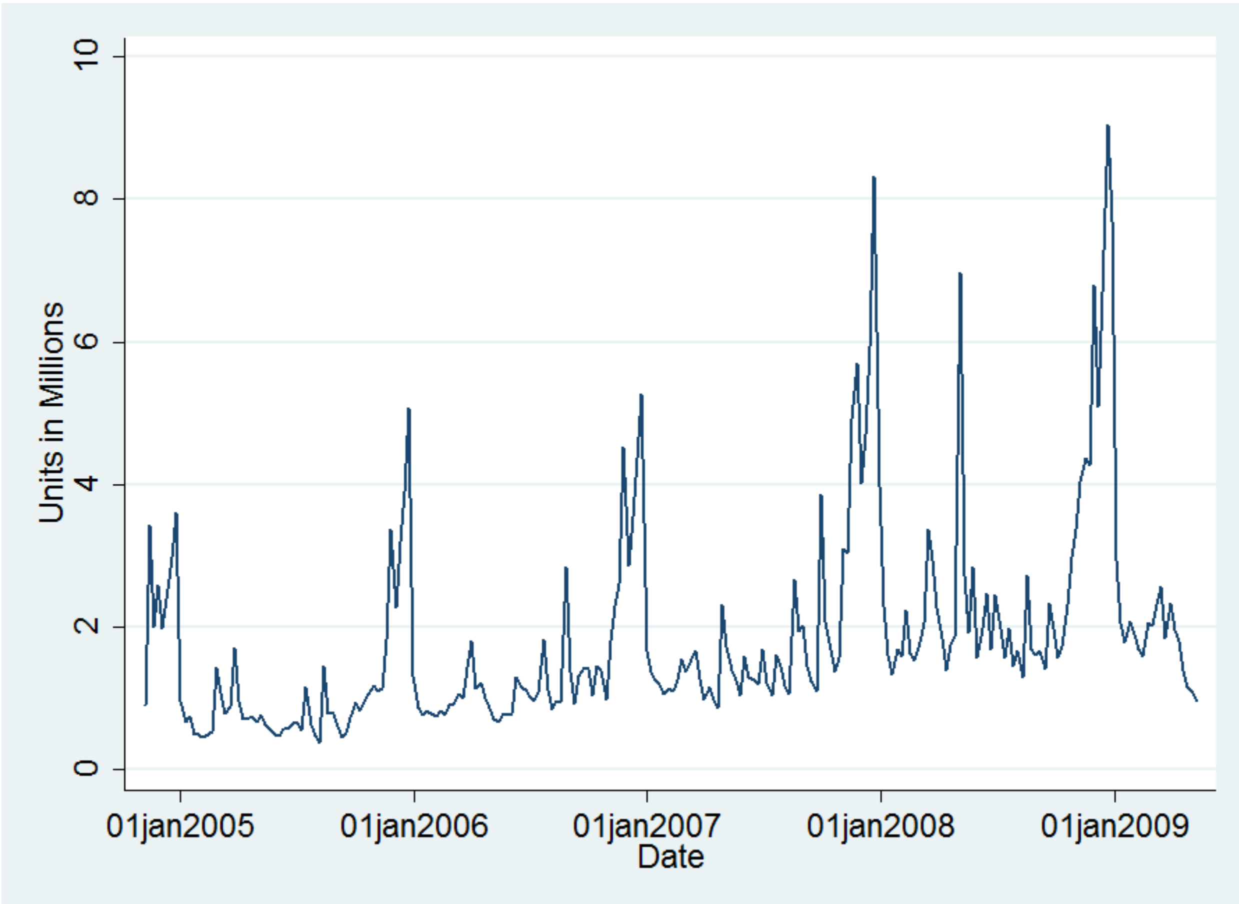

Table 1

Incidence and Intensity of Various Activities

	Percent Non-Zero	Average Duration in Minutes	Average Duration Conditional on Participation
Games	8.92%	11.42	128.10
Television	80.17%	159.95	199.52
Computer	9.59%	8.56	89.28
Reading	25.42%	21.45	84.38
Homework	5.38%	8.65	160.65
Classes	5.73%	16.62	290.12

Based on 55,740 observations from January, 2005 through May, 2009

Table 2

Summary Statistics for Control Variables

Variable	Mean	Std. Dev.
Male	0.484	0.500
Age 15-18	0.064	0.245
Age 19-22	0.035	0.183
Age 23-30	0.110	0.313
Age 31-50	0.416	0.493
Age 51-85	0.375	0.484
HH Income missing	0.137	0.344
HH Income $0-$15K	0.120	0.325
HH Income $15K-$30K	0.146	0.353
HH Income $30K-$50K	0.184	0.388
HH Income $50K-$75K	0.165	0.371
HH Income $75K+	0.248	0.432
Educ. Less than High School	0.171	0.376
Educ. High School Grad	0.266	0.442
Educ. Less than College	0.265	0.442
Educ. College Grad	0.191	0.393
Educ. Post Grad	0.107	0.310
Married	0.497	0.500
Black	0.132	0.339
Asian	0.031	0.174
Hispanic	0.132	0.339
HH Size = 1	0.245	0.430
HH Size = 2	0.251	0.433
Video Game Sales (millions)	1.796	1.381

Based on CPS merge for 55,740 observations

Table 3

The Effect of Video Game Sales on Video Game Time Use

	Intensive (Min|Min>0)	Extensive Pr(Min=0)	Intensive (Min|Min>0)	Extensive Pr(Min=0)
Video Game Sales	0.028*	-0.051**	-0.010	0.002
	(0.015)	(0.020)	(0.039)	(0.056)
Video Game Sales×Male			-0.017	-0.030
			(0.020)	(0.032)
Video Game Sales×Age 15-18			0.046**	-0.011
			(0.022)	(0.042)
Video Game Sales×Age 19-22			-0.015	-0.103*
			(0.039)	(0.056)
Video Game Sales Squared			0.005	-0.003
			(0.004)	(0.007)
In High School	-0.198**	-0.073	-0.209**	-0.072
	(0.084)	(0.112)	(0.083)	(0.112)
In College	-0.060	0.353***	-0.058	0.367***
	(0.072)	(0.117)	(0.072)	(0.118)
Male	0.257***	-0.232***	0.291***	-0.174**
	(0.035)	(0.045)	(0.054)	(0.071)
Married	-0.209***	0.213***	-0.211***	0.214***
	(0.055)	(0.064)	(0.054)	(0.064)
Black	0.008	0.402***	0.010	0.400***
	(0.056)	(0.075)	(0.056)	(0.075)
Asian	-0.060	0.411***	-0.055	0.410***
	(0.103)	(0.132)	(0.101)	(0.133)
Hispanic	-0.000	0.870***	0.010	0.872***
	(0.071)	(0.079)	(0.071)	(0.078)
Month Dummies	X	X	X	X
Dows Dummies	X	X	X	X
Age Dummies	X	X	X	X
Income Dummies	X	X	X	X
HH Size Dummies	X	X	X	X
Ln(alpha)	-0.499***		-0.501***	
	(0.025)		(0.025)	
Observations	55,316	55,316	55,316	55,316

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4

The Effect of Video Game Time on Human Capital Accumulation Time

	Class Time		Homework Time	
	Intensive (Min|Min>0)	Extensive Pr(Min=0)	Intensive (Min|Min>0)	Extensive Pr(Min=0)
Video Game Time	-0.002	0.049***	-0.009***	0.019**
	(0.003)	(0.010)	(0.003)	(0.008)
In High School	0.921***	-4.154***	-0.106	-4.386***
	(0.092)	(0.180)	(0.097)	(0.176)
In College	0.418***	-3.122***	0.113	-4.767***
	(0.072)	(0.105)	(0.082)	(0.115)
Male	-0.012	-0.226***	0.063*	0.145
	(0.031)	(0.086)	(0.038)	(0.089)
Married	0.027	0.097	0.094	0.392***
	(0.054)	(0.101)	(0.058)	(0.099)
Black	-0.015	0.158*	-0.294***	0.296***
	(0.039)	(0.088)	(0.055)	(0.099)
Asian	-0.043	0.095	0.227***	-0.592***
	(0.060)	(0.133)	(0.068)	(0.117)
Hispanic	0.022	0.481***	-0.204***	0.304***
	(0.052)	(0.122)	(0.059)	(0.113)
Month Dummies	X	X	X	X
Dows Dummies	X	X	X	X
Age Dummies	X	X	X	X
Income Dummies	X	X	X	X
HH Size Dummies	X	X	X	X
Ln(alpha)	5.713***	-1.571***	6.267***	-0.624***
	(0.348)	(0.048)	(0.349)	(0.029)
Observations	55,316	55,316	55,316	55,316

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5

The Effect of Video Game Time on Other Entertainment Time

	TV	Computer		Reading	
	Intensive	Intensive (Min|Min>0)	Extensive Pr(Min=0)	Intensive (Min|Min>0)	Extensive Pr(Min=0)
Video Game Time	-0.004**	-0.009**	0.018***	0.008**	0.009**
	(0.002)	(0.004)	(0.005)	(0.004)	(0.004)
In High School	-0.230***	-0.247***	-0.042	0.045	0.233**
	(0.037)	(0.084)	(0.096)	(0.115)	(0.115)
In College	-0.212***	-0.116**	-0.097	0.075	0.093*
	(0.022)	(0.047)	(0.078)	(0.052)	(0.055)
Male	0.241***	0.193***	-0.297***	-0.085***	0.302***
	(0.010)	(0.034)	(0.040)	(0.028)	(0.031)
Married	-0.104***	-0.167***	0.147***	-0.067**	-0.094**
	(0.013)	(0.042)	(0.051)	(0.031)	(0.039)
Black	0.158***	0.044	0.509***	-0.115***	0.733***
	(0.011)	(0.052)	(0.065)	(0.034)	(0.034)
Asian	-0.140***	0.105*	-0.322***	0.050	0.186***
	(0.028)	(0.054)	(0.061)	(0.042)	(0.061)
Hispanic	0.004	-0.068	0.725***	-0.092**	0.907***
	(0.018)	(0.058)	(0.065)	(0.042)	(0.044)
Month Dummies	X	X	X	X	X
Dows Dummies	X	X	X	X	X
Age Dummies	X	X	X	X	X
Income Dummies	X	X	X	X	X
HH Size Dummies	X	X	X	X	X
Ln(alpha)	0.836***	2.364***	-0.476***	0.298***	-0.425***
	(0.010)	(0.115)	(0.019)	(0.099)	(0.015)
Observations	55,316	55,316	55,316	55,316	55,316

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6

The Estimated Marginal Effects of an Hour of Video Game Playing Time

on Hours of Time Spent in Various Other Activities

Class	Homework	Television	Computer	Reading
-0.288***	-0.140***	-0.654**	-0.203***	0.064
(0.059)	(0.035)	(0.275)	(0.048)	(0.128)

Marginal effects calculated at the mean values of independent variables. Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1