An Investigation into the Effects of Video Games on Income

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I. Introduction:

As high technology becomes more and more integrated into our way of life, so too is it becoming more integrated into the way we as a society spend our leisure time. According to a study recently released by IGN Entertainment and Ipsos MediaCT, “gamers” now represent approximately 144 million of the 244 million American online consumers (Ipsos MediaCT 2008). For the first time in American history, presidential candidate Barack Obama released campaign ads in 18 different online video games (Kennedy 2008) and in the last two years, the video game industry has started seriously lobbying politicians in Washington (Schiesel 2008). Clearly, video games are becoming a large part of our society and thus, it is only natural to question what effect video games are having on our society and on the individual.

Currently, there is a growing body of research in the field of psychology (which will be addressed in the next section) investigating the various effects that playing video games has on the individual, including their effects on scholastic performance, aggressive and prosocial behaviors, their linkages to obesity and their potentially addictive qualities. To the best of my knowledge, however, there does not yet exist any economic investigation into the impact that playing video games can have on a person’s earning potential. This is precisely the question this paper will seek to address, namely, does playing video games have an adverse effect on an individual’s income?

Section II of this paper will briefly summarize some of the findings of the growing body of research into the effects video games have on an individual psychologically and motivate why the proposed question of this paper is one worth investigating. As well, it will discuss video games within the theoretical framework of time intensive goods and should be considered to be simultaneously determined with income in this investigation. Section III will discuss the variables of interest and their measurement as well as summarize the data to be used in this investigation. It will also discuss and defend the choice of instrumental variables used to control for the simultaneous determination of the amount of video games played and income and test for said endogeneity of video games. Section IV will detail the models to be estimated in answering the above question and sections V and VI will detail the estimation results and the conclusions reached.

II. Review of the Literature

Author Leonard Sax, M.D. and Ph.D. released a book in 2007 entitled "Boys Adrift: The Five Factors Driving the Growing Epidemic of Unmotivated Boys and Underachieving Young Men" in which he discusses five factors that he believes are responsible for a growing problem of (as stated in the title) unmotivated and underachieving boys in the United States. According to Dr. Sax, there are a number of ways in which video games – the second of those factors - are contributing to this problem and removing many young men's motivation and ambition due to their addictive, engaging and fun nature (Sax 2007).

One of the ways in which Dr. Sax suggests video games are hurting their players is by weakening their academic performance. He notes that in the past several years there have been a series of studies that "demonstrated clearly and unambiguously that the more time your child spends playing video games, the less likely he is to do well in school" at all levels of education, elementary to university, as can be seen in Anderson, Gentile and Buckley (2007), Gentile, Lynch, Linder and Walsh (2004) and Anderson and Dill (2000). It is noted that authors like Professor David Williamson Shaffer of the University of Wisconsin-Madison suggests certain types of games can be excellent training to make kids smarter and better prepared for our high-tech, digital world and work is being done to research how these games can be incorporated into the classroom (Mattmiller 2006). However, as Dr. Sax notes, no games of this type are commercial successes or even widely available. In a 2006 New York Times article by Tamar Lewin, it is reported that more and more young men at university want "to stay in their rooms, talk to no one, [and] play video games into the wee hours… [They] miss classes until they withdraw or flunk out" (Lewin 2006). If playing video games causes people to be less productive in school, then it is not a big leap to imagine it could also lead to lower productivity later in life as well. If we assume lower productivity workers earn less income, then it follows that playing video games could lead to a decrease in earnings. Moreover, if playing video games leads to weaker scholastic performance, then this also raises concern about the effect video games could have on the returns to education. Lower grades in school could translate into lower returns to education later in life.

Dr. Sax also addresses a point that has been the source of much controversy in the last 15 years, that violent video games (which he notes the majority of commercially successful video games are) causes their players to behave more violently themselves, increases their violent self-image and decreases their pro-social (helping) behavior and causes them to disengage from the real world. This point has been elaborated on in depth in a series of papers written by Dr. Craig Anderson of Iwoa State University, a leading researcher in the field, as well as many others. It has been shown that playing violent video games causes increases in aggressive behavior and thoughts and decreases in pro-social behavior in papers such as Anderson and Bushman (2001), Anderson (2004) and Anderson et al. (2003). Some of these studies find this effect to be larger in men then in women, such as Anderson and Dill (2000). For this reason it may also be interesting to test if the effect of playing video games on income is the same for both men and women.

In Vandewater, Shim and Caplovits (2004), the link between playing video games and obesity is investigated. The findings of this paper were that children with a higher weight tended to play a larger amount of video games while children with a low weight status either played very little or a lot of video games. However, it should be noted this is only a correlation and does not suggest a casual relationship. This is none the less worth noting as a 2004 study by John Cawley of Cornell University found that there is a statistically significant negative correlation between obesity and wages in white females (Cawley 2004). Finally, Salguero and Moran (2002) find excessive use of video games to be "associated with a number of problems which resemble a dependence syndrome", suggesting that problem video gaming could be treated like an addiction (Salguero and Moran 2002). It should be noted that these findings are included here as a summary of several potential channels through which playing video games can affect income and are not reflected in the model in this paper. Rather the effect of video games as a whole is investigated (see section IV).

With all of these factors combined, it is clear that the question of the impact playing video games has on an individual's income is one worth investigating. As it has been shown that video games can cause decreased performance in school, increases in violent behavior and thoughts, decreases in pro-social behavior, has been linked to obesity and can potentially be considered addicting, it is apparent that in the very least, playing large amounts of video games can have a profound negative effect on an individual.

It should be noted however that there is some evidence to suggest video games do not have a negative effect on their players. One such example is a study released by IGN Entertainment and Ipsos MediaCT in October 2008, which attempted to disprove some of the many negative stereotypes that exist about people who typically play video games. In addition to many interesting findings (for example, gamers are found to be more likely than non-gamers to have gone on a date in the past month), this study found that gaming households (households which own a video game console or a computer which was used for playing video games) had a considerably higher average household income (at $79,000) than the U.S. average online (connected to the internet) household (at $54,000). It does not appear however, that this study controlled for the potential of a two-way causality between video gaming and income (Ipsos MediaCT 2008). In addition, two papers by various leading minds in the field of the psychological effects of video games (namely, Gentile, et al. 2009 and Greitemeyer and Osswalk 2009) report of several studies from Singapore, Japan, the United States, Germany and Britain on subjects ranging in age from children to undergraduate students found that playing prosocial, non-violent games lead to increases in prosocial behavior and decreases aggressive cognitions.

While the above literature makes an argument for video games potentially having an effect on a person's income, it is likely that a person's income also has an effect on the amount of video games played. Video games can be thought of as a time intensive good, that is, utility is not gained simply from the purchase of a video game but rather from the subsequent time spent playing it. Becker (1965) lays out a theory of the allocation of time. As taught in any undergraduate economics course, traditional theory before this followed a model of consumers or households maximizing a utility function

$$U = U(y_1, y_2, \ldots, y_n)$$

where utility, U, is a function of y_i, goods that are consumed, which is maximized subject to a budget constraint given by

$$\sum p_i y_i = W + V$$

where p_i is the price of each good y_i, W is wage income and V is non-wage income. In Becker's theory, consumers maximize a utility function of a different form

$$Z = Z(x_i, T_i)$$

where Z is utility which is a function of x_i, a vector of goods consumed, and T_i, a vector of time inputs (including inputs of day/night or weekday/weekend time, for example). This is maximized subject to two constraints, the first a goods constraint

$$\sum p_i x_i = V + T_w \overline{w}$$

Similar to the above shown budget constraint of the traditional theory, p_i is the price of good x_i, V is non-wage income and T_w, a vector of work hours, and $\overline{w}$, the prevailing wage, together make up W, wage income. The second constraint is a time constraint

$$\sum T_i = T - T_w$$

Where T is total time available to the consumer. This constraint says time put into the production of utility, or consumption time, and work time together add up to the total time available. Solving the time constraint for T_w and substituting this into the goods constraint yields the budget constraint of Becker's theory

$$\sum p_i x_i + \sum T_i \overline{w} = V + T\overline{w}$$

Simply put, this budget constraint now says that goods consumed and consumption time must be equal to non-wage income and total time multiplied by the prevailing wage, which together make up what is known as full income, the highest possible income that could be earned if $T_w = T$.

When thought of in this context, utility yielded from playing video games is a function of the games purchased and the time spent actually playing the games, shown as

$$Z_{VG} = Z(x_{VG}, T_{VG})$$

Since T_{VG} is time consumed and thus, not put towards work, any $T_{VG} > 0$ will necessitate that $T_W < T$ and therefore the consumer will not be achieving full income. The ultimate result of this analysis is that time spent playing video games has an opportunity cost associated with it, namely forgone income, and the result is a theory that the consumer's income and time spent playing video games is simultaneously determined in a two equation model. More specifically, one could speculate that income can have an effect on the amount of video games played through two mechanisms, both an income and a substitution effect. Higher wages should lead to a higher opportunity cost of time in this framework and therefore to less time spent playing video games. However, higher wages and therefore higher income should translate into higher purchasing power and thus more video games being played assuming they are normal goods. Thus, while this paper seeks to investigate the effect of playing video games on income and it is theorized this effect may in fact be negative, it is entirely possible the effect of income on video games couple be positive or negative, depending on which effect is dominant in the data set. The simultaneous determination of income and video games played will require the use of appropriate instrumental variables in order to properly obtain an unbiased estimate of the effect playing video games can have on a person's income.

III. Data

The data set to be used in this investigation is taken from Cycle 19 of the General Social Survey, as administered by Statistics Canada. This was a survey of Canadian households (n = 19, 597) conducted from January to December of 2005 (Statistics Canada 2005). Cycle 19 focused on how Canadians made use of their time. The survey consisted of several different sections, one of which was the time use diary which asked respondents to record the activities on which they spent their time in minutes in a given 24 hour period, from 4 a.m. until 4 a.m. the following morning.

The particular variables of interest taken from this survey were income, the reported duration in minutes the respondent played video games on the diary day (which is assumed to be representative of an average day for the respondent) as well as a number of control variables. Income data in the survey was measured in non-regular intervals. The first interval was for respondents with no income, the next four are increments of $5000 and the rest are increments of $10000, with the exception of the last two which cover $80,000 - $99,999 and $100,000+. Of the respondents, the 25^{th} percentile was in the $10-14,999 interval, the 50^{th} percentile was in the $30-39,999 interval, the 75^{th} percentile was in the $50-59,999 interval and only the top 1% of respondents fell in the $100,000+ category.

The amount of video games played by the respondent is measured as the number of minutes per day that the respondent reported playing video games on the diary day. For the sake of this data overview the respondents will be broken up into categories of moderate- and heavy-gamers to make for a simpler analysis of the data. The same bounds will be used for these as are used in the IGN and Ipsos MediaCT report[1] (although scaled down by a factor of seven to adjust for the data being measured in days rather than weeks). Moderate-gamers are defined to be respondents who reported playing between 0 and 86 minutes (non-inclusive) of video games on the diary day (corresponding to less than ten hours per week) and heavy-gamers are defined to be respondents who reported playing more than 86 minutes of video games on the diary day (corresponding to more than ten hours of video games per week).

A number of control variables will be used in this paper as well. These include the age group, marital status, sex and highest level of education obtained by the respondent. The age group of the respondent was broken into five year intervals starting at 15-19 and ending with the final interval, 80+. For the sake of reducing multicollinearity problems, the 80+ category was dropped from the regressions and a single variable for age was made, rather than having 14 different indicator variables, with a value of one indicating the respondent belonged to the 15-19 category, two indicating the respondent belonged to the 20-24 category and so on up to 13 indicating the 75-79 category. Marital status was reported in the survey as any of married, common law, widowed, separated, divorced or single. For the sake of this analysis, married and common law were grouped together into an indicator variable called married and widowed, separated and divorced were grouped together into an indicator variable called separated. Sex of the respondent was coded into an indicator variable called female (equal to one if the respondent was female). The highest level of education obtained by the respondent was coded as a

[1] In this report, categories of light-, moderate- and heavy-gamers are used. However, when scaling these definitions down to be used in the data available, light-gamer corresponded to a respondent that reported playing 18 minutes or less of video games on the diary day. Only 20 of the 19, 597 respondents fell into this category so the light- and moderate-gamer categories were lumped together to form the moderate-gamer category discussed in this section.

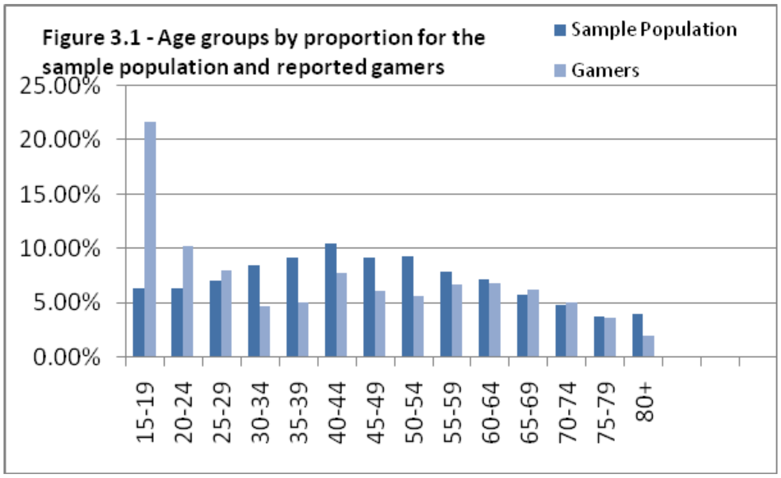
categorical variable, from which nine indicator variables were generated, equal to one if the respondent fell into the respective category (listed in section IV).

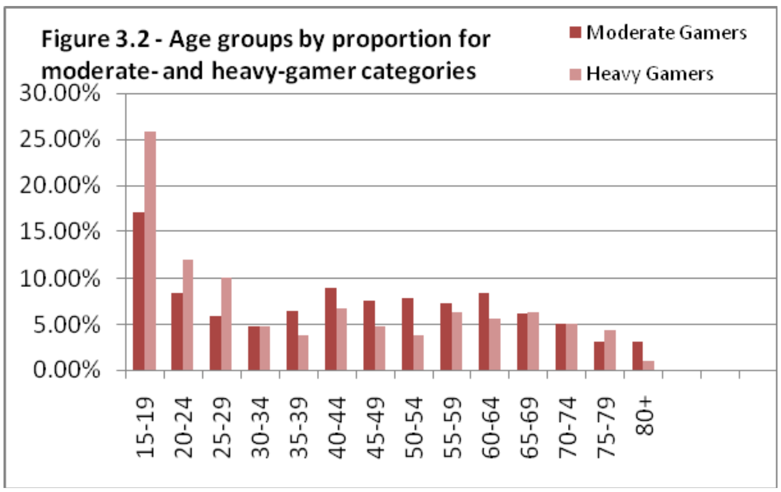
Of the respondents, 762 reported playing any video games at all on the diary day. The income of these respondents appears, on average, to be lower than non-gamers. Of these 762 respondents, the 25th percentile for income is in the $5-9,999 interval (one interval lower than in the whole sample), the 50th percentile is in the $20-29,999 interval, the 75th percentile is in the $50-59,999 interval and again, the top 1% of gamers fall in the $100,000+ category. Of the respondents that reported playing video games, 357 fall into the moderate-gamer category and 399 fall into the heavy-gamer category.

The age distribution of the respondents for the whole sample population, the respondents that reported playing video games and by moderate- and heavy-gamer categories is shown in table

Table 3.1 - Age breakdown by gaming status

Age Group	Sample Population	Gamers	Moderate Gamers	Heavy Gamers
15-19	6.36%	21.69%	17.09%	25.81%
20-24	6.34%	10.32%	8.40%	12.03%
25-29	7.10%	8.07%	5.88%	10.03%
30-34	8.52%	4.76%	4.76%	4.76%
35-39	9.16%	5.03%	6.44%	3.76%
40-44	10.50%	7.80%	8.96%	6.77%
45-49	9.21%	6.08%	7.56%	4.76%
50-54	9.37%	5.69%	7.84%	3.76%
55-59	7.92%	6.75%	7.28%	6.27%
60-64	7.21%	6.88%	8.40%	5.51%
65-69	5.79%	6.22%	6.16%	6.27%
70-74	4.78%	5.03%	5.04%	5.01%
75-79	3.78%	3.70%	3.08%	4.26%
80+	3.96%	1.98%	3.08%	1.00%





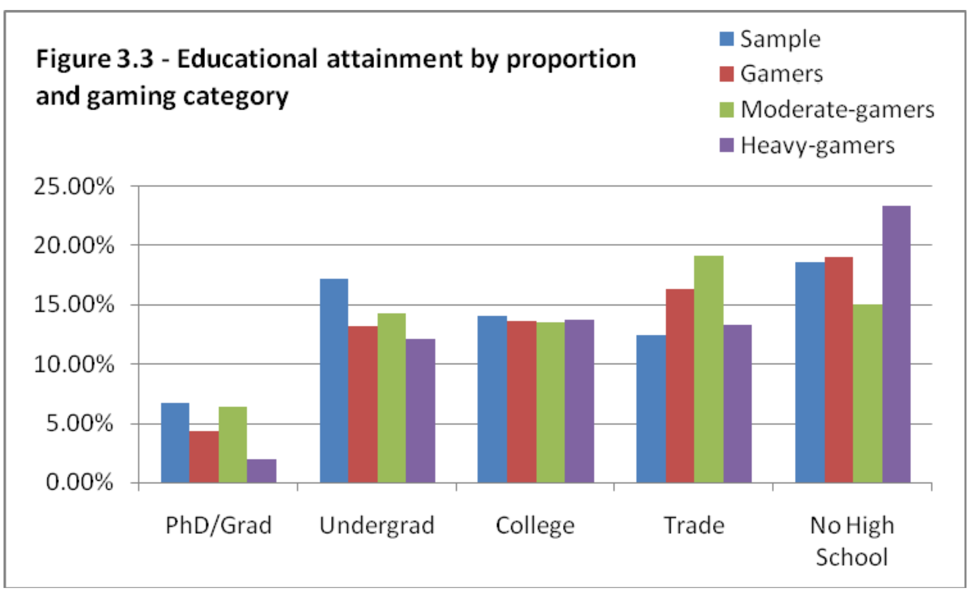
3.1 and figures 3.1 and 3.2. It is reported as the proportion of respondents that belonged to each age group. As can be seen, a large proportion (40.08%) of respondents who reported playing video games were age 29 or younger (vs. 19.80% in the sample population) and this proportion was even higher for heavy-gamers (45.87%).

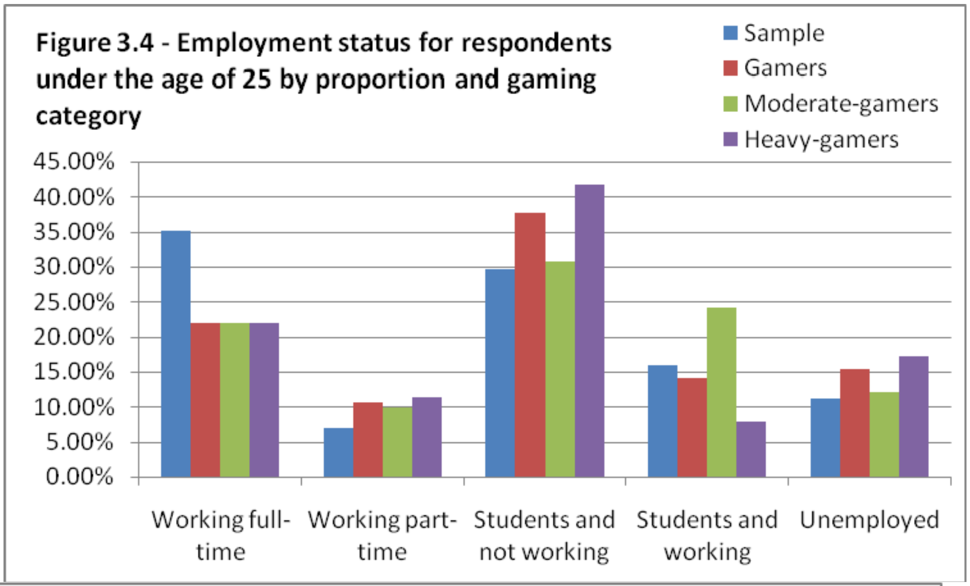
Table 3.2 and figures 3.3, 3.4 and 3.5 show the breakdown of gender, education, employment status and hours worked for the sample population, reported gamers and moderate- and heavy-gamers. Education is shown as highest level attained by the respondent. It should also be noted that unemployed in this case means simply not working, not the traditional definition of not working but looking for work.

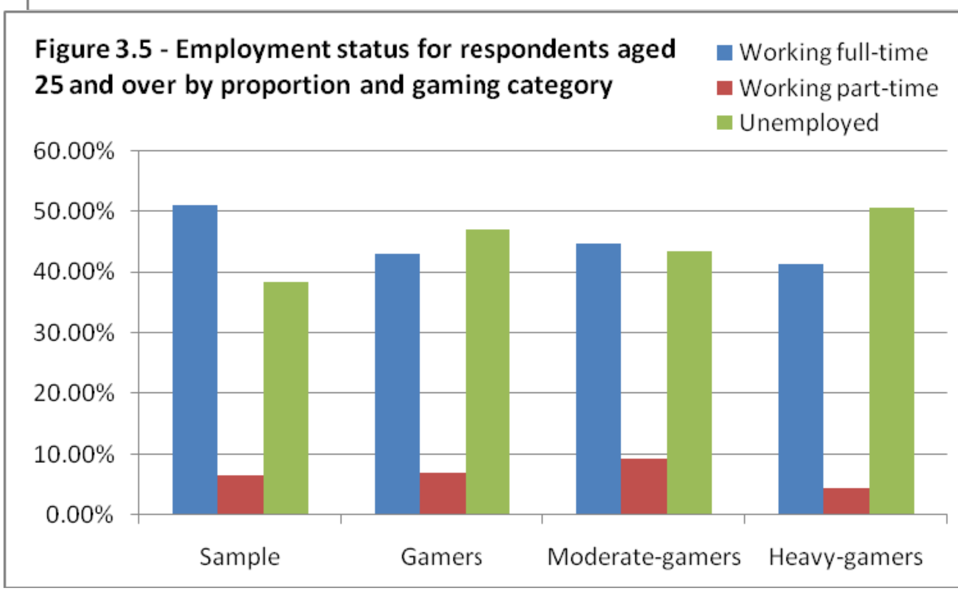
Table 3.2 - Breakdown of gender, education, employment and hours worked by gaming status				
	Sample	Gamers	Moderate-gamers	Heavy-Gamers
Proportion of female respondents	56.0%	40.0%	48.0%	33.0%
Under age 25:				
Proportion working full-time	35.2%	21.9%	22.0%	21.9%
Proportion working part-time	7.0%	10.7%	9.9%	11.3%
Proportion of students, not working	29.7%	37.6%	30.7%	41.7%
Proportion of students, working	16.0%	14.0%	24.2%	7.9%
Proportion unemployed	11.1%	15.3%	12.1%	17.2%
Age 25 and over:				
Proportion working full-time	51.2%	43.2%	44.7%	41.5%
Proportion working part-time	6.6%	7.0%	9.4%	4.4%
Proportion unemployed	38.5%	47.1%	43.6%	50.8%
Proportion with graduate degree	6.7%	4.3%	6.4%	2.0%
Proportion with undergraduate	17.2%	13.2%	14.3%	12.1%
Proportion with college degree	14.1%	13.6%	13.5%	13.7%
Proportion with trade school	12.4%	16.3%	19.2%	13.3%
Proportion without high school	18.6%	19.0%	15.0%	23.4%
Average hours worked per week	41.35	39.85	38.94	41.01

As can be seen, a much larger proportion of gamers and in particular, heavy-games, were male than in the sample population. On average, respondents who reported playing video games were somewhat less likely to have completed a university degree than the sample population although that effect appears to be almost entirely due to the heavy gamer category. Gamers and non-gamers seemed about equally likely to have attained a college degree while gamers, particularly moderate-gamers, seemed substantially more likely than non-gamers to have gone to trade school. While it seems about an equal proportion of gamers and non-gamers did not finish high school, moderate gamers actually have a much smaller proportion of high school drop outs while heavy gamers have a much larger proportion. At this point it should be noted that these proportions do not imply causation, simply a correlation. These statistics are summarized in figure 3.3.

For respondents under the age of 25, gamers were generally less likely than non-gamers to be working full-time and more likely to be working part-time. Of students, heavy-gamers, but not moderate-gamers, were much less likely to have jobs. Moderate-gaming students, by contrast, were much more likely than non-gamers and heavy-gamers to have a job. For respondents of age 25 and over, gamers were less likely than non-gamers to be working full-time and moderate-gamers were more likely than non-gamers to be working part-time while heavy-gamers were less likely to be working part-time. In general, gamers were much more likely than non-gamers to be unemployed. Heavy gamers were found to have worked about the same number of hours in the previous week as non-gamers, on average, but moderate-gamers were found to have worked about three hours less.







<u>The Choice of Instrumental Variables and Testing the Endogeneity of Video Games</u>

Ultimately, as will be discussed in greater detail in section IV, the model this paper hopes to estimate is as follows.

$$Ln(Income)_i = \beta_0 + \beta_1 * VideoGames_i + \beta_2 * Female_i + \beta_3 * VideoGames_i * Female_i + \beta_4 * Married_i + \beta_5 * Separated_i + \beta_6 * Age_i + \beta_7 * Age_i^2 + E * \beta_{EduVec} + u_i$$

$$VideoGames_i = \delta_0 + \delta_1 * Ln(Income)_i + \delta_2 * Female_i + \delta_3 * Married_i + \delta_4 * Separated_i + \delta_5 * Age_i + \delta_6 * Age_i^2 + \delta_7 * Weekday_i + \delta_8 * ChildTime_i + \delta_9 * NoTimeForFun_i + E * \delta_{EduVec} + v_i$$

In order for the particular coefficients of interest, β_1 and β_3, to be estimated without bias, the income equation must be identified by 'shifters' or instrumental variables, which appear in the structural video games equation but not in the income equation. For the purposes of this paper, three instrumental variables were identified and tested for exogeneity in the income equation[2], namely 'Weekday', 'ChildTime' and 'NoTimeForFun'. Ideally, these variables should be correlated with the amount of video games the respondents reported playing but not with the error term in the income equation so that it can be used to properly discern the effect playing video games has on a person's income without confusing that with the effect a person's income has on the amount of video games they play (Wooldridge 2006). 'Weekday', an indicator variable equal to one if the respondent's diary day was a weekday, was assumed to be exogenous. It seems a fair assumption that the day of the week that a responded was asked to fill out their diary should have no correlation with their income or the error term in that equation. However, whether the respondent filled out their diary on a weekday or weekend should make a difference to the opportunity cost of their time and so should be correlated with the amount of video games they reported playing on that day. 'NoTimeForFun' is an indicator equal to one if the respondent answered yes to the question "Do you feel that you just don't have time for fun anymore?" This seems likely to be correlated with the amount of video games a person would

[2] The tests used for this purpose require a single LHS variable rather than the interval data reported on income. Thus, for the purposes of these tests, the natural logarithm of the median value of the reported income interval was used. The results from these tests for exogenteity are assumed to be valid for the interval data as well.

play on their diary day for obvious reasons. Finally, 'ChildTime' is a variable which measured to total time in minutes between when the respondent's first child under the age of 15 woke up on the diary day and when the last child went to sleep. This was equal to zero if the respondent did not have children, their children did not live at home or if their children were over the age of 15. This variable would capture another opportunity cost of time factor which should be correlated with the amount of video games a person plays. While the number of children a person has could be correlated with income, it seems unlikely that their sleeping patterns would be correlated with their parents income.

The three instruments were tested for exogeneity using a Sargan test for exogeneity (for details see Sargan 1958 and Wooldridge 2006, chapter 15). This involved running the full income equation using two stage least squares, then regressing the residuals from that regression on all of the explanatory variables and instruments. The R2 for this regression was then multiplied by the number of observations, producing a statistic that is distributed chi2. The Sargan statistic produced was chi2(2) = 2.825, failing to reject the null hypothesis that the instruments are exogenous. Moreover, the F statistic testing the joint significance of the first stage of the above mentioned two stage least squares regression was F(18, 14105) = 10308.88 suggesting the instruments are, as hoped, strongly correlated with the amount of video games played.

To add some evidence to suspicions that the amount of video games played and the respondent's income are determined simultaneously, a Hausman test for endogeneity was conducted on the continuous video games variable using the income equation discussed above. The test regresses the video games variables on all exogenous variables and instruments, then runs the income equation without the instruments and includes the residuals from the first regression. The coefficient on the residuals is then tested for statistical significance. Under the null hypothesis that the coefficient is zero, we would be unable to reject the idea that the amount of video games played is exogenous in the income equation (for a full treatment of this test and its intuition see Hausman 1978 and Wooldridge 2006, chapter 15). The t-statistic resulting from this test was 8.16 with a corresponding p-value of 0.000, easily rejecting the null hypothesis of exogeneity. Thus, it is concluded that the amount of video games played and the respondent's income are simultaneously determined.

IV. Model

The model to be estimated in this paper is shown below.

$$\text{Ln(Income)}_i = \beta_0 + \beta_1\text{*VideoGames}_i + \beta_2\text{*Female}_i + \beta_3\text{*VideoGames}_i\text{*Female}_i + \beta_4\text{*Married}_i + \beta_5\text{*Separated}_i + \beta_6\text{*Age}_i + \beta_7\text{*Age}_i^2 + E\text{*}\,\beta_{EduVec} + u_i$$

The amount of video games played by the respondent is measured as a continuous variable, 'VideoGames' which is equal to the reported minutes of video games played on the diary day. In this case, the coefficient on VideoGames, β_1, will measure the predicted change in log income as a result of reporting playing an additional minute of video games on the diary day. This would suggest that each additional minute of video games played has a constant effect on log income. An interaction term of video games and female was included to see if the effects of playing video games on log income was dependent on gender (as noted in section II, some of the psychological and physiological effects playing video games can have are felt more in males than in females). Numerous control variables are included as well. First are three indicator variables, female, married and separated, each equal to one if the respondent is (obviously) female, married (or common law) and separated (or divorced, widowed), respectively. The coefficients of these variables represent the change in log income as a result of being female (as opposed to male) and being married or separated (as opposed to the base category of being single). E is a vector containing dummy variables representing educational attainment of the respondent. Each dummy is equal to one if the respondent reported the respective degree or partial degree as the highest they had successfully completed. These included dummy variables for Ph.D./graduate school, undergraduate school, college, trade school, some university completed, some college/CEGEP/nursing completed, some trade school completed, high school and some high school completed. The coefficients on these variables represent the predicted change in log income as a result of belonging to one of these categories, as opposed to belonging to the base category – completing elementary school or less.

Four different models were run to investigate the effect playing video games may have on income. First, a standard OLS model was run as a first pass at the investigation. Second, an interval regression (Int Reg) was run to account for the interval nature of the available income data and as a first pass at investigating the effect playing video games may have on income. This model did not, however, control for the potential endogeneity of video gaming. Next a two stage least squares regression (2SLS) was run using the midpoint of the reported income interval as an attempt at controlling for the simultaneous determination of income and video games played. Finally, a two equation interval regression model (2EIR) was estimated using maximum likelihood methods. This model can be thought of as a sort of hybrid of the other two. The details of all three models are elaborated on below. It should be noted that the OLS and 2SLS estimates should be observed with caution as they do not use the data on income interval endpoints available but rather a linear transformation of those to produce a dependant variable these models could use. The variation in the income data with this transformed variable (the logarithm of the midpoint of the reported income interval) still moves in the same direction as that of the original but it may do so in different proportions. As such, estimated coefficients for these models may not be entirely accurate in magnitude, though they should be the same in sign. These models are simply being used as a first pass at the investigation and to give an idea of what to expect from the other models.

In the two interval regression models, there are two dependent variables used in the interval regression, the left and right end points of the income interval the respondent reported belonging to (with the right end point for respondents who reported earning $100,000+ being a missing observation), with the actual income of the respondent being an unobserved, latent variable. If the respondent reported having no income, then the two dependent variables are both equal to zero. However, taking the log of income causes problems for respondents who reported having no income since the log of zero is undefined. For this reason, one has been added to the endpoints of each interval. Thus, the formulas by which the latent variable is transformed into the observed dependent variables are given by the following.

$$y_{1i} = \ln\,[1[y_i^* = 0] * 1 + 1[0 < y_i^* \leq 4{,}999] * 1 + 1[5{,}000 < y_i^* \leq 9{,}999] * 5001 + \cdots + 1[80{,}000 < y_i^* \leq 99{,}999] * 80{,}001 + 1[y_i^* \geq 100{,}000] * 100{,}001]$$

$$y_{2i} = \ln\,[1[y_i^* = 0] * 1 + 1[0 < y_i^* \leq 4{,}999] * 5{,}000 + 1[5{,}000 < y_i^* \leq 9{,}999] * 10{,}000 + \cdots + 1[80{,}000 < y_i^* \leq 99{,}999] * 100{,}000 + 1[y_i^* \geq 100{,}000] * \text{'.'}]$$

Where y_{1i}, y_{2i} and y_i^* are the left end points, right end points and the latent variable, respectively and 1[.] is an indicator function equal to one if the event contained within the braces is true and equal to zero otherwise.

OLS:

This will simply be a straightforward OLS regression on the income equation shown above. Due to the interval nature of the income data, the natural logarithm of the midpoint of the reported income category was used as the dependant variable in this case, rather than the endpoints of the interval used in the interval regression model.

Interval Regression:

The regression will be estimated by maximum likelihood estimation. This model assumes normally distributed errors so that the contribution of each observation to the likelihood function is equal to the probability that the u_i fell into the corresponding interval for all income reported as such and simply the probability that u_i was equal to its given value in the case of income being reported equal to zero. This gives the following likelihood function to be maximized.

$$\ln L = -\frac{1}{2}\sum_{i\in C}\left\{\left(\frac{y_i - x\beta}{\sigma}\right) + \log 2\pi\sigma^2\right\} + \sum_{i\in I} log\left\{\varphi\left(\frac{y_{2i} - x\beta}{\sigma}\right) - \varphi\left(\frac{y_{1i} - x\beta}{\sigma}\right)\right\} + \sum_{i\in R} log\left\{1 - \varphi\left(\frac{100{,}000 - x\beta}{\sigma}\right)\right\}$$

Where C is the set of point observations (for which reported income was \$0), I is the set of observations for which income fell into an interval, R is the set of right-censored observations (for which income was reported to be \$100,000+), $\varphi(\,)$ is the standard cumulative normal, y_{2i} and y_{1i} are the right and left end points of each interval, x is a vector of independent variables for observation i, and β is the vector of parameters to be maximized (StataCorp LP 2005). While the dependant variables used in the regression are the endpoints of the interval the respondent reported belonging to, the predicted dependant variable will be the natural logarithm of the continuous variable, income. Thus, the estimated coefficients on each variable can be interpreted as in a normal OLS regression, as the change predicted in the natural logarithm of income resulting from a one unit change in the respective regressor.

Two Stage Least Squares:

The model to be estimated by two stage least squares is the same as that to be estimated by the interval regression except that in this case, the instrumental variables discussed in section III will be used to hopefully remove any estimation bias that might be present in the coefficient on video games as a result of potential endogeneity. This is a standard two stage least squares regression, the details of which can be found in Wooldridge 2006, chapter 15. Due to the interval nature of the income data, the natural logarithm of the midpoint of the reported income category was used as the dependant variable in this case, rather than the endpoints of the interval used in the interval regression model.

Two Equation Interval Regression:

This model assumes that the respondent's income and time spent playing video games on the diary day are determined simultaneously in a two equation model as shown below.

$$\text{Ln(Income)}_i = \beta_0 + \beta_1 * \text{VideoGames}_i + \beta_2 * \text{Female}_i + \beta_3 * \text{VideoGames}_i * \text{Female}_i + \beta_4 * \text{Married}_i + \beta_5 * \text{Separated}_i + \beta_6 * \text{Age}_i + \beta_7 * \text{Age}_i^2 + E * \beta_{EduVec} + u_i$$

$$\text{VideoGames}_i = \delta_0 + \delta_1 * \text{Ln(Income)}_i + \delta_2 * \text{Female}_i + \delta_3 * \text{Married}_i + \delta_4 * \text{Separated}_i + \delta_5 * \text{Age}_i + \delta_6 * \text{Age}_i^2 + \delta_7 * \text{Weekday}_i + \delta_8 * \text{ChildTime}_i + \delta_9 * \text{NoTimeForFun}_i + E * \delta_{EduVec} + v_i$$

Weekday, ChildTime and NoTimeForFun are the instrumental variables or 'shifters' that allow for the proper identification of the income equation in this model. The rest of the variables are the same as discussed above. The error terms, u_i and v_i are assumed to be independent and distributed bivariate normal with a resulting covariance matrix of

$$\omega = \begin{bmatrix} \sigma_u^2 & 0 \\ 0 & \sigma_v^2 \end{bmatrix}$$

And joint p.d.f. $\phi(u,v)$. The assumption of independence of the errors terms is a useful simplifying assumption and seems reasonable as it simply assumes that there is no correlation between unobserved factors that influence a person's decision to play video games (such as personal preferences) and unobserved labour market opportunities. It seems unlikely that there would be any significant correlation between these.

The model will be estimated by maximum likelihood estimation with the contribution to the likelihood function of each observation being the two equation analogous version of the likelihood contributions of each observation in the one equation interval regression model discussed above. Thus, the likelihood function is as follows

$$L = \prod_{\forall y_{2i}=0} \phi(-X\beta, y_{2i} - S\delta) * \prod_{y_{1i}\in(a,b)} \int_{a-X\beta}^{b-X\beta} \int_{y_{2i}-\delta_1 b-S\delta}^{y_{2i}-\delta_1 a-S\delta} \phi(u,v)\,dv\,du * \prod_{y_{1i}\in(100\,000,\infty)} \lim_{t\to\infty} \int_{100\,000-X\beta}^{t} \int_{-t}^{y_{2i}-100\,000\,\delta_1-S\delta} \phi(u,v)\,dv\,du$$

Where y_{1i} is the unobserved, latent value of the respondent's income, y_{2i} is a short hand for VideoGamesi, $X\beta$ is a matrix equal to the product of the vector or regressors from the income equation and the corresponding vector of coefficients, $S\delta$ is the analogous matrix for the video games equation with the exclusion of the income variable and it's coefficient, and a and b are respectively the upper and lower bounds of the reported income interval. With the assumption of independence of the error terms the likelihood function simplifies to

$$L = \prod_{\forall y_{1t}=0} \phi_u(-X\beta)\phi_v(y_{2t} - S\delta) * \prod_{y_{1t}\in(a,b)} [\Phi_u(b - X\beta) - \Phi_u(a - X\beta)][\Phi_v(y_{2t} - \delta_1 a - S\delta) - \Phi_v(y_{2t} - \delta_1 b - S\delta)] * \prod_{y_{1t}\in(100\,000,\infty)} [1 - \Phi_u(100\,000 - X\beta)][\Phi_v(y_{2t} - 100\,000\delta_1 - S\delta)]$$

Where ϕ_u and ϕ_v are the marginal (normal) p.d.f.'s for u and v and Φ_u and Φ_v are the c.d.f's for u and v.

V. Estimation and Results

OLS Regression Results:

The OLS regression results are summarized in table 5.1. The regression involved 14,329 observations and yielded an F statistic of F(16, 14312) = 146.42, easily supporting the joint significance of the model.

The estimated coefficient on Video Games predicts a roughly 0.4% decrease in income as a result of having reported playing an additional minute of video games on the diary day. For the average reported gamer in the survey (128.3 minutes played) this would correspond to a 51.32% income penalty. The estimated coefficient on the interaction term between Video Games and the female indicator seems to exactly negate the effect for females. A joint significance test on Video Games and it's interaction with Female yields an F statistic of

F(2, 14312) = 7.94 with a corresponding p-value of 0.0004, easily rejecting the null hypothesis that video games had no significant effect on income at all.

Table 5.1 - OLS Regression Results				
Regressor	Coefficient	Robust Std. Err.	t	P>t
Constant	6.010	0.202	29.790	0.000
Video Games	-0.004	0.001	-3.980	0.000
Female	-1.260	0.047	-26.990	0.000
Married	-0.242	0.051	-4.720	0.000
Separated	0.581	0.056	10.410	0.000
Ph.D./Grad	2.076	0.162	12.840	0.000
Undergrad	1.890	0.154	12.240	0.000
College	1.618	0.157	10.300	0.000
Trade	1.393	0.154	9.020	0.000
Some University	1.150	0.171	6.720	0.000
Some College	1.340	0.174	7.680	0.000
Some Trade	1.056	0.181	5.830	0.000
High School	0.745	0.158	4.700	0.000
Some High School	-0.222	0.159	-1.390	0.164
Age	0.754	0.037	20.380	0.000
Age^2	-0.039	0.002	-18.260	0.000
Video Games*Female	0.004	0.002	2.210	0.027

All of the control variables except Some High School are found to have statistically significant effects on income and with the exception of Married, which is predicted to decrease income by roughly 24%, all behave as would typically be expected. Female respondents are predicted to receive lower income than male counterparts, each additional level of education attained is found to yield positive returns over the last and age is found to positive but diminishing returns, reaching its peak in the 55-64 range.

Interval Regression Results:

Table 5.2 - Interval Regression Results				
Regressor	**Coefficient**	**Robust Std. Err.**	**z**	**P>z**
Constant	5.233	0.209	24.990	0.000
Video Games	-0.004	0.001	-3.940	0.000
Female	-1.394	0.050	-27.990	0.000
Married	-0.191	0.054	-3.520	0.000
Separated	0.662	0.060	10.940	0.000
Ph.D./Grad	2.384	0.170	14.000	0.000
Undergrad	2.076	0.158	13.150	0.000
College	1.720	0.160	10.750	0.000
Trade	1.453	0.158	9.220	0.000
Some University	1.206	0.176	6.860	0.000
Some College	1.399	0.179	7.830	0.000
Some Trade	1.113	0.185	6.010	0.000
High School	0.798	0.161	4.950	0.000
Some High School	-0.380	0.163	-2.340	0.019
Age	0.932	0.039	23.670	0.000
Age^2	-0.048	0.002	-21.370	0.000
Video Games*Female	0.004	0.002	2.350	0.019

The results of the interval regression are shown in table 5.2. The regression involved 14, 329 observations and a joint significance test on all regressors yielded a chi2 statistic of chi2(16) = 2602.88, supporting the joint significance of the model. It should be noted that the results of this model and the OLS results, as will be seen, are very similar.

The estimated coefficient on Video Games is economically quite significant. It can be interpreted as predicting a roughly 0.4% decrease in income for each additional minute of video games reported having been played on the diary day. To put this into perspective, of respondents who reported playing any video games at all during the diary day, the mean number of minutes played was 128.3, which would be predicted to correspond to a 51.32% decrease in income against respondents that did not report playing video games. This effect is found to be statistically significant at the even the 1% significance level.

However, the estimated coefficient on the interaction term between Video Games and Female suggest that the above effect is only observed in males, as it is found that females who play video games earn roughly 0.4% more per minutes of video games played than their male counterparts, exactly counteracting the original effect. This effect was found to be statistically significant at a 2% significance level. In other words, there is no evidence to suggest that playing video games has any effect on income in females.

Testing whether video games had a significant effect on income over all by running a joint significance test on Video Games and it's interaction with Female yielded a chi2 statistic of chi2(2) = 15.55 with a corresponding p-value of 0.0004, easily rejecting the null hypothesis that each additional reported minute of playing video games on the diary day has no effect on the respondent's income.

Almost all estimated coefficients on the control variables follow the usual expectations (with the exception of Married) and all are found to be statistically significant. Female respondents are found to earn roughly 139.4% less than their male counterparts (perhaps a bit unrealistic). Married and separated respondents are found to earn 19.1% less and 66.2% more than respondents who reported being single. With the exception of respondents who reported only completing some high school, education is found to yield positive returns, increasing in value as the number of years required to achieve the respective level increases. Finally, there is found to be positive but decreasing returns to age with a peak around the 55-59, 60-64 age groups.

Two Stage Least Squares Results:

Table 5.3 - Two Stage Least Squares Regression Results				
Regressor	Coefficient	Robust Std. Err.	z	P>z
Constant	10.373	1.335	7.770	0.000
Video Games	-0.184	0.051	-3.590	0.000
Female	-2.724	0.405	-6.720	0.000
Married	-0.710	0.171	-4.160	0.000
Separated	0.472	0.135	3.500	0.000
Ph.D./Grad	2.132	0.249	8.560	0.000
Undergrad	2.056	0.232	8.850	0.000
College	1.895	0.244	7.750	0.000
Trade	1.707	0.257	6.650	0.000
Some University	1.336	0.288	4.640	0.000
Some College	2.004	0.415	4.830	0.000
Some Trade	1.637	0.357	4.580	0.000
High School	1.402	0.344	4.080	0.000
Some High School	0.400	0.300	1.330	0.183
Age	-0.004	0.252	-0.020	0.986
Age^2	0.001	0.014	0.090	0.929
Video Games*Female	0.183	0.051	3.590	0.000

The results of the two stage least squares regression are shown in table 5.3. The regression involved 14,124 observations and a joint significance test on all the regressors yielded an F statistic of $F(16, 14107) = 51.01$, rejecting the null hypothesis that the regression explained none of the variation in the dependent variable.

The estimated coefficient on Video Games is found to be statistically significant at the 1% significance level and predicts that for each additional minute reported spent playing video games on the diary day leads to a roughly 18.4% decrease in income (perhaps unrealistic). For reported gamers at the mean (128.3 minutes of video games reported) this corresponds to a 2,360.72% decrease in income (also a bit unrealistic). As in the regressions above, the estimated coefficient on the interaction between Video Games and Female is found to be statistically significant and to almost exactly counteract the original effect, leading to the conclusion that playing video games did not have any effect on the income of female respondents. A joint significance test on Video Games and it's interaction with Female yields an F statistic of chi2(2) = 12.98 and a corresponding p-value of 0.0015, rejecting the null hypothesis that reporting having played video games on the diary day had no effect on the respondent's income.

Estimated coefficients on the control variables are found to be statistically significant with the exception of the indicator for respondents who reported only having completed some high school and age. Female respondents are predicted to earn 272.4% less than male respondents. Married respondents are found to earn 71.0% less and separated respondents are found to earn 47.2% more than single respondents. Education is found to yield positive returns, increasing with the number of years required to complete the respective education category. Finally, age is found to yield the opposite effect as would normally be expected, with income decreasing with age to some minimum and then increasing again past that point, though this effect is not statistically significant.

Multivariate Interval Regression Results:

The results of the two equation interval regression are shown in table 5.3 below. The regression involved 13,528 observations and a joint hypothesis test on all the regressors yielded a chi2 statistic of chi2(16) = 2214.66, easily rejecting the null hypothesis that the system explained none of the variation in the dependant variables.

In the income equation, the estimated coefficient on Video Games is found to be statistically significant at the 1% significance level and predicts that for each additional minute reported spent playing video games on the diary day leads to a roughly 0.4% decrease in income. For reported gamers at the mean (128.3 minutes of video games reported) this corresponds to a 51.32% decrease in income. As in both regressions above, the estimated coefficient on the interaction between Video Games and Female is found to be statistically significant and to exactly counteract the original effect, reinforcing the conclusion that playing video games did not have any effect on the income of female respondents. The control variables all behave as would normally be expected with the exception of Married which was found to yield a statistically significant negative effect on income. It should be noted that the results of this equation are all very similar to the straight interval regression results reported above. This could suggest two things. First, perhaps the amount of video games played is not simultaneously determined with income as hypothesized or perhaps the instruments chosen were not sufficient to remove the bias created by this endogeneity. Second, in contrast to the first option, it would seem that while the variables are simultaneously determined, the effect income has on video games is simply fairly small and so doesn't add an economically significant amount of bias to the estimates that do not control for endogeneity. This seems more likely the case as the estimated coefficient on income in the video game equation (discussed below) is fairly small.

In the video games equation, a one percent increase of income is predicted to have caused the respondent to have reported playing roughly .47 more minutes of video games on the diary day Perhaps unexpectedly, being female as opposed to male and being married as opposed to single was predicted to translate into roughly 53 and 13 more minutes of video games being played on the diary day, respectively. Being separated was predicted to result in 26 fewer minutes of video games being played on the diary day. Increasing levels of education were found to reduce the amount of video games played on the diary day. Increasing age is found to result in less time spent playing video games hitting a minimum around age 60-64, suggesting that retirees may play more video games than their still working counterparts. Finally, the instruments all behaved as expected although the effect of the diary day having been a weekday on the amount of video games played was not found to be statistically significant.

Table 5.3 -Multivariate Interval Regression Results				
Regressor	Coefficient	Robust Std. Err.	z	P>z
Income Equation				
Constant	5.315	0.211	25.170	0.000
Video Games	-0.004	0.001	-3.620	0.000
Female	-1.238	0.049	-25.090	0.000
Married	-0.279	0.055	-5.090	0.000
Separated	0.620	0.060	10.410	0.000
Ph.D./Grad	1.895	0.171	11.060	0.000
Undergrad	1.934	0.159	12.140	0.000
College	1.742	0.161	10.800	0.000
Trade	1.466	0.159	9.230	0.000
Some University	1.181	0.177	6.650	0.000
Some College	1.426	0.180	7.910	0.000
Some Trade	1.158	0.186	6.220	0.000
High School	0.808	0.163	4.970	0.000
Some High School	-0.399	0.164	-2.430	0.015
Age	0.872	0.040	22.050	0.000
Age^2	-0.045	0.002	-19.660	0.000
Video Games*Female	0.004	0.002	2.170	0.030
Video Games Equation				
Constant	-215.565	12.959	-16.630	0.000
Income	47.089	1.464	32.170	0.000
Female	53.065	2.437	21.770	0.000
Married	13.718	2.822	4.860	0.000
Separated	-26.383	3.018	-8.740	0.000
Ph.D./Grad	-91.717	8.707	-10.530	0.000
Undergrad	-92.622	8.169	-11.340	0.000
College	-80.941	8.124	-9.960	0.000
Trade	-66.565	7.909	-8.420	0.000
Some University	-55.573	8.787	-6.320	0.000
Some College	-64.504	8.994	-7.170	0.000
Some Trade	-51.013	9.211	-5.540	0.000
High School	-34.817	7.918	-4.400	0.000
Some High School	23.245	8.128	2.860	0.004
Age	-44.309	2.286	-19.390	0.000
Age^2	2.194	0.126	17.420	0.000
Weekday	-0.473	2.592	-0.180	0.855
Child Time	-0.008	0.004	-2.000	0.046
No Time for Fun	-23.606	2.692	-8.770	0.000

VI. Summary and Conclusions

As stated at the outset of this paper, the goal of this investigation was to determine whether or not playing video games had an effect on an individual's income and if so, to gain some kind of understanding of what exactly that effect was. This investigation included an analysis of the effect playing video games had on the logarithm of income directly, as well as whether this effect was different for women than for men. Of the four models run, all four find that the reported number of minutes spent playing video games on the respondent's diary day had a statistically and economically significant, negative effect on their reported income. While the estimated effect in the two stage least squares model were quite unrealistic, it was noted at the outset that due to the linear transformation applied to the income data to use this model, it was not expected that these results should be accurate in magnitude. However, all the models agree in the sign and statistical significance of the effect playing video games can have on income. Of particular note is the near identical results yielded by the single and two equation interval regressions. This seems to suggest that while a respondent's income and the amount of video games played are simultaneously determined, the effect of their total income on the amount of video games played is small, though statistically significant. Also of particular note, this 'gaming' effect on income is found in all four models to be prevalent only in males. In other words, the ultimate findings of this paper are that playing video games can have a negative effect on the income of males but not on females.

This was however, only an initial investigation into the effects of playing video games on income. While this paper provides evidence for a negative effect exhibited on income by playing video games, it does not suggest what mechanisms this effect works through. Limitations in the data available did not allow this investigation to determine whether playing video games actually result in a person earning a lower wage per hour worked or if playing video games simply caused the respondent to work fewer hours. It was also not possible, due to the lack of wage data, to estimate separate income and substitution effects on the amount of video games played, though it appears we can say the income effect dominates the substitution effect in this sample. It should also be noted that the data set used for this investigation contained less information on the respondent's video game playing habits than could be desired for a full investigation of video games effects on income. It would be preferable to have information on the individual's gaming history to more accurately assess whether the effect video games have on income is a short- or long-term effect. As well, such data would be better suited to investigating the possibility that playing video games has an effect on the returns to education as it would include data on video games played during the respondent's time receiving their education. Also, as noted by Dr. Sax, the majority of best selling games are violent video games and not the educational games discussed by Professor Williamson and Dr. Saw or the pro-social, non-violent games studied in Gentile, et al. 2009 and Greitemeyer and Osswalk 2009. A full investigation into the effects that playing video games could have on an individuals would ideally control for the different types of game being played by the respondents in order to properly identify if the effects found in this paper are caused by all video games or simply by certain types.

Thus, while this paper finds some interesting results which suggest an income penalty to men, this is ultimately a subject which requires much further investigation before we can really understand the effects video games may have on income.

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