

# Econometrics B Assignment

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## A Contribution to the Understanding of Problem Behaviour



University of Warwick

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## Table of Contents

CLEAR  
STRUCTURE

Introduction .....	3
Literature Review .....	4
Explanatory Variables Used.....	6
The Model .....	8
Methodology and Results.....	9
Diagnostic Tests.....	13
Conclusions.....	16
Limitations.....	17
References.....	18

To the point!

# Introduction

In this assignment, a **logit model** is used to try to understand more about the effects of unemployment, income and education on problem behaviour. Data from **the Panel Study of Income Dynamics (PSID)** are used. This is a survey conducted every year since 1968 on thousands of families across the USA.

## Defining Problem Behaviour

The variable 'problem behaviour' must be qualified. In the year 1995, participants in the survey were asked the following question:

*"For a variety of reasons, many young people come into contact with the police or with the court system. Sometimes, these contacts with the police are very serious. Other times, the reason may be a minor problem or misunderstanding. Not counting minor traffic offenses, have you ever been booked or charged for breaking a law?"*

STRAIGHT FORWARD DETAILED DEFINITION

Only clear yes and no answers have been included in this assignment. Other answers such as 'don't know' or refusals were omitted from the sample, reducing it from 29,884 observations to 17,363.

At this point a qualification of the term 'problem behaviour' is necessary - it is an umbrella term for many illegal activities, such as theft and burglary, vandalism, or more serious crimes like homicide and rape. Also, it may include 'white-collar' crimes such as fraud and tax evasion. In this study we are looking at crime in its widest sense: all activities that qualify as 'breaking the law'.

The data from this survey show that 8.43% of Americans have engaged in problem behaviour at least once in their lives.

M27 EVER BOOKED/CHARGED BREAKING LAW 95	Freq.	Percent	Cum.
0	15,899	91.57	91.57
1	1,464	8.43	100.00
Total	17,363	100.00	

SHOWS VARIATION IN DEPENDENT

NOT FLASHY BUT

STRUCTURE IS GOOD

Figure 1 - Problem Behaviour

# Literature Review

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Much of the economic literature on crime treats criminal activity just like any other economic activity, i.e. a criminal act will be carried out if its expected value outweighs the expected costs that it involves for the individual in question. Seminal work by Becker (1968) presents the following model for crime:

$$E[U] = PU(Y - f) + (1 - P)U(Y),$$

Where  $U(\cdot)$  is a person's von-Neumann utility function,  $P$  the subjective probability of being caught,  $Y$  the benefits from the crime committed (monetary and psychic) and  $f$  the monetary equivalent of punishment.

Thus in Becker's model, the level of crime in society will depend largely on the probability of getting caught, which is highly related to factors such as policing and severity of punishments.

Later models have built on this to include initial income as a reference point, such as that by Brown and Reynolds (1973). The model becomes:

$$E[U] = PU(W - f) + (1 - P)U(W + g),$$

Where  $w$  is income and  $g$  is gains from crime.

Thus when expressed this way, an individual's wage income and whether that person is employed or not become significant variables worth studying.

Yet as argued by Levitt (2001), income is a variable that would most likely affect crimes such as burglary and theft, but not crimes such as violence, murder or rape.

In a comprehensive survey, Chiceros (1987) demonstrates that in most of the studies done on the subject, unemployment seems to lead to an increase in crime. From 68 studies published in major journals, he finds that 31% of the estimates were positive and significant, whilst only 2% were negative and significant (Eide, Rubin and Shepherd 2006).

As for income, much in the literature seems to suggest that there exists a negative relationship between incidence of crime and wage income. Using a panel dataset of North Carolina, Cornwell and Trumbull (1994) find that high wages in legal activities are associated with low crime rates. Machin and Meghir (2000), using different wage measures in a time-series study of England and Wales, find that decreases in wages of unskilled workers lead to increases in crime.

A general review on some of the existing literature on crime by Eide, Rubin and Shepherd (2006) argues that although a generally negative relationship does exist, it is not so clear cut. They point out that many proxies for the variable 'income' have been applied, (median family income, labor income to manufacturing workers, mean income per tax unit, etc).

They claim that “no systematic relationship appears between the income measures applied and the estimates obtained”. They argue that there is ambiguity because although most studies do not reject the hypothesis that an increase in legal income opportunities decreases crime, there are other studies which do not reject the inverse hypothesis that an increase in legal income opportunities would increase crime.

Unemployment and Income are naturally not the only variables considered to have an effect on crime. For example, Chapman (1976) finds that the female participation rate, (a proxy for unguarded homes), has a positive significant effect. In this study, burglary is being analysed specifically, not ‘crime’ in general.

Levitt (2001) focuses on a particular decade and seeks to disprove commonly cited reasons as to why crime fell during that period. He argues that from 10 reasons commonly mentioned by the media only 4 actually did cause the fall in crime. These four are: the increase in the number of police, the rising prison population, the decline in the crack cocaine industry and the legalization of abortion.

Levitt claims that from the existing literature, “a typical estimate would be that a one percentage point increase in the unemployment rate is associated with a one percent increase in property crime.” This assignment finds a stronger effect of unemployment on crime, but note that here, total crime and not just property crime is being analysed.

LIT REVIEW HAS BASIC  
THEORY FOR MOTIVATION  
+ PRECISE REVIEW  
OF OTHER ESTIMATES

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5

VERY PLAIN BUT STRUCTURE  
IS GOOD

## Explanatory Variables Employed

### Unemployment

One explanatory variable chosen was whether the individual was employed or unemployed.

'Temporarily laid off' and 'student' were included in the employed category. 'Retired' 'permanently disabled' 'housewife' 'other' and 'don't know' were excluded from the sample. The sample was thus reduced from 29,884 to 3,603. The resulting variable is thus a discrete one: 0 if employed, 1 if unemployed. There are 3,197 employed and 406 unemployed (11.3%).

EMPLOYMENT STATUS		Freq.	Percent	Cum.
95				
0		3,197	88.73	88.73
1		406	11.27	100.00
Total		3,603	100.00	

Figure 2 - Employment Status

### Education

Another variable included was years of education received. 1-16 reflects the number of years spent at school. An answer of 17 implies "at least some post graduate work". Answers of 'don't know' or n/a were omitted from the sample.

Table 2 overleaf shows the observations.

CLEAR DEFINITIONS  
BASED ON LITERATURE

**Table 1 - Years of Education**

Years of Education	Frequency	Percent	Cumulative
1	47	0.24	0.24
2	70	0.36	0.59
3	174	0.88	1.48
4	125	0.64	2.11
5	163	0.83	2.94
6	446	2.27	5.21
7	234	1.19	6.4
8	580	2.95	9.34
9	817	4.15	13.49
10	1,318	6.7	20.19
11	1,502	7.63	27.82
12	7,300	37.09	64.91
13	1,533	7.79	72.7
14	1,831	9.3	82
15	679	3.45	85.45
16	1,770	8.99	94.44
17	1,094	5.56	100
Total	19,683	100	

## **Labour Income**

Another continuous variable included was that of labour income. The idea is that the higher one's income, the less reason there is to turn to crime. The variable was converted to log form.

Arguably, a more pertinent income variable to such a question would be something like 'lifetime income till now'. The income variable used in this assignment is 'labour income in 1993' (the year closest to 1995 for which income data were available- see 'limitations' section on page 17)

# The Model

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The model used in this assignment is a logit model of the form

$$p_i = \Pr[y_i = 1 | x_i] = \frac{\exp(\beta_1 + \beta_2 x_i)}{1 + \exp(\beta_1 + \beta_2 x_i)}$$

We are seeking to establish the effects of unemployment, income and education on the likelihood that an individual has ever broken the law. In the above case,  $y_i = 1$  represents the fact that a person has broken the law once in her life (0 if not).  $x_i$  are the explanatory variables – income, education and unemployment.



# Methodology and Results

## The Logit Model for all three Variables

When the logit model is run for all three explanatory variables, the following results are obtained:

Crime	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
Unemp	1.153913	.2627472	4.39	0.000	.638938	1.668888
Educ	-.1947443	.0528263	-3.69	0.000	-.2982819	-.0912066
lnY	.0461821	.0686938	0.67	0.501	-.0884554	.1808195
_cons	-.6611391	.7859566	-0.84	0.400	-2.201586	.8793075

Figure 3 - Logit Model

### Income and its insignificance

INTERPRETATION

The interpretation of the coefficient on lnY is that a 1% increase in income will lead to a 0.00046% increase in the likelihood of committing a crime. The positive sign is contradictory to what most of the literature review says about the correlation between income and crime.

Yet it must be noted that it is statistically insignificant at the 5% interval. This means that it must be treated with caution. It is thus not surprising that the sign is not what we would expect.

Thus although the literature on the subject of crime indicated that income is an important variable, the data in this study do not find a statistically significant correlation between income and crime.

One reason for this is that in this study crime is an umbrella term. In other studies, the effects of income were looked at on specific crimes. Levitt (2001) points out that income has an effect on burglary and theft but not rape and murder. So while in some studies income has been shown to have an effect on *some* crimes, it needn't have an effect on *all* crimes.

One must also note that there may be a problem of endogeneity. If a person has broken the law once, then he is likely to have gone to prison – which will most likely have a negative effect on his future wage income (going to prison means one will struggle to find high paying jobs). Thus the dependent variable (crime) which we are trying to explain is affecting the explanatory variable, income!

### Education and the odds ratio

TECHNICAL KNOWLEDGE

The coefficient of education of -0.1947 can be interpreted in terms of odds. To find the effect of an additional year of education on the *odds* of ever having broken the law, we use the following equation<sup>1</sup>:

$$100*(1-\exp(-0.1947)) = 17.69\%.$$

<sup>1</sup> How did we move from an odds ratio to a percentage increase? The odds ratio tells us that when we increase years of education by 1, we get new predicted odds that are  $e^{\beta}$  times our initial predicted odds (where  $\beta = -0.1947$ ). If  $\beta$  is negative  $e^{\beta}$  is less than 1 so we can express the change as a decrease of  $100*(1-e^{\beta})$  percent.

## The Effect of Being Unemployed on Having Ever Committed a Crime

We instruct STATA to run a logit model for the 2 variables. The results are shown below:

Crime	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]
Unemp	1.042632	.1522777	6.85	0.000	.7441729 1.34109
_cons	-2.6279	.0721457	-36.42	0.000	-2.769303 -2.486497

Figure 4 - Logit: Unemployment on Crime

$$\Pr(\text{crime}=1 \mid \text{unemployed}) = \frac{\exp(-2.629 + \exp(1.0426(1)))}{1 + \exp(-2.629 + \exp(1.0426(1)))} = 0.1701$$

$$\Pr(\text{crime}=1 \mid \text{employed}) = \frac{\exp(-2.629 + \exp(1.0426(0)))}{1 + \exp(-2.629 + \exp(1.0426(0)))} = 0.0674$$

which implies that the probability that a person who is currently unemployed has broken the law at least once is 17.01%, and for those currently employed 6.7%.

Thus being employed (at the time of the survey) increases the probability that that person has ever been involved in crime from 6.7% to 17.01%, i.e. by 10.3 percentage points.

## The Partial Effects

### Marginal Effects and Average Partial Effects

CAREFUL  
TECHNIQUE.

When calculating the marginal effects (ME), a researcher considers the average individual (of the sample) and analyses the marginal effects of this average individual. Such effects are meaningless for this assignment since one of explanatory variables is discrete. There is no such thing as 'a person of average unemployment'.

What is more meaningful is to analyse the average partial effects (APE). In this case, the researcher considers all the marginal effects of each observation, (i.e. the marginal effect of being unemployed on crime, and/or the marginal effect of one more year of education on crime) and finds the average of all said marginal effects.

The APE for the data was calculated using STATA and the following results were obtained:

	Delta-method				
	dy/dx	Std. Err.	z	P> z	[95% Conf. Interval]
Unemp	.0813238	.0189122	4.30	0.000	.0442565 .1183911
Educ	-.0137249	.0037921	-3.62	0.000	-.0211573 -.0062925
lnY	.0032548	.004843	0.67	0.502	-.0062374 .0127469

Figure 5 - margins, dydx(\*)

This implies that on average, the effect of one more year of education makes a person 1.37% less likely to have ever committed a crime. Also, on average, being unemployed at the time of the questionnaire increases the likelihood that a person has ever broken the law by 8.13%.

### Specifying the values of the variables of interest

An interesting hypothesis is that at lower levels of education, every extra year of education should have a greater (negative) effect on tendency for crime. In other words, for a person who has only, say, 5 years of education, one more year should have a larger negative effect on the tendency for crime than for a person who has 15 years of education. Such reasoning is in line with the theory of diminishing returns.

We can specify the values of all the variables at which we are interested in the effect. We instruct STATA to find the APE at 5, 12, and 15 years of education.

	Delta-method				
	dy/dx	Std. Err.	z	P> z	[95% Conf. Interval]
Unemp	.2872731	.0682528	4.21	0.000	.1535001 .4210461
Educ	-.0484827	.0140087	-3.46	0.001	-.0759393 -.0210261
lnY	.0114973	.0171011	0.67	0.501	-.0220204 .0450149

Figure 6 – margins, dydx(\*) at (Unemp=1 Educ=5)

	Delta-method				
	dy/dx	Std. Err.	z	P> z	[95% Conf. Interval]
Unemp	.175325	.0638982	2.74	0.006	.0500869 .3005631
Educ	-.0295894	.0085372	-3.47	0.001	-.0463219 -.0128568
lnY	.0070169	.0105659	0.66	0.507	-.0136919 .0277257

Figure 6 - margins, dydx(\*) at (Unemp=1 Educ=12)

	Delta-method					[95% Conf. Interval]	
	dy/dx	Std. Err.	z	P> z			
Unemp	.1162484	.049979	2.33	0.020	.0182914	.2142055	
Educ	-.0196191	.0042605	-4.60	0.000	-.0279695	-.0112687	
lnY	.0046525	.0070017	0.66	0.506	-.0090705	.0183755	

Figure 7- margins, dydx(\*) at (Unemp=1 Educ=15)

With 5 years of education, an extra year of education decreases likelihood of crime by 4.84%, compared to 2.96% at 12 years and 1.96% at 15 years. Such results are in line with the diminishing marginal returns argument.

### The Effect of Unemployment at Different Levels of Education

We have seen how being unemployed has a positive effect on one's likelihood of having ever been involved in crime. But does unemployment have a different effect on people of different educational levels?

We instruct STATA to work out the average partial of unemployment for people with 5 vs 15 years of education:

		Delta-method				[95% Conf. Interval]	
		dy/dx	Std. Err.	z	P> z		
Unemp	_at						
	1	.2070529	.0537957	3.85	0.000	.1016153	.3124906
	2	.0500434	.0149442	3.35	0.001	.0207534	.0793335

Figure 8 - margins, dydx(Unemp) at(Educ=(5 15))

These results show that unemployment leads to greater increases in crime for less educated people. Unemployment for a person of 5 years education will increase likelihood of engaging in crime by 20.7%, whilst only by 5% for people with 15 years of education.

# Diagnostic Tests

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## Generalized residuals

The generalized residuals were constructed, and are shown in the table below:

Variable	Obs	Mean	Std. Dev.	Min	Max
gres1	1248	-4.48e-11	.2656676	-.5323136	.9671914

The mean is very close to 0 which is good. The correlation between the generalized residuals and the explanatory variables was then computed as is shown below:

	gres1	Unemp	Educ	lnY
gres1	1.0000			
Unemp	0.0000	1.0000		
Educ	0.0000	-0.1192	1.0000	
lnY	-0.0000	-0.0692	0.2321	1.0000

As can be seen, the residuals are orthogonal to the explanatory variables, i.e. they are uncorrelated. This must true by definition.

## Test for omitted variable – Education Squared

In the typical labour economics wage model, income is regressed against education, experience and experience squared. The rationale is that at higher levels of experience, experience becomes more deterministic on wages.

Could the same be true for education in this model? Previous arguments of diminishing returns (on tendency for crime) suggest otherwise. Thus we would expect that including education squared in the model makes no significant difference to our findings and so an LM test for its omission should result in a high p-value.

```
. reg const gres1 g_Educ2 g_Unemp g_Educ g_lnY if sample1, noconst
```

Source	SS	df	MS	Number of obs =	1248
Model	.679784918	5	.135956984	F( 5, 1243) =	0.14
Residual	1247.32022	1243	1.00347564	Prob > F =	0.9842
Total	1248	1248	1	R-squared =	0.0005
				Adj R-squared =	-0.0035
				Root MSE =	1.0017

const	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
gres1	-1.625768	2.125158	-0.77	0.444	-5.795061	2.543525
g_Educ2	-.0124752	.0151571	-0.82	0.411	-.0422115	.0172611
g_Unemp	-.0174205	.2658831	-0.07	0.948	-.5390496	.5042087
g_Educ	.2745137	.3381665	0.81	0.417	-.3889264	.9379538
g_lnY	.021723	.0804368	0.27	0.787	-.1360839	.1795299

```
. display "Test stat = " e(mss) ", p-value = " chi2tail(1, e(mss))
Test stat = .67978492, p-value = .4096608
```

This P-value of 0.409 indicates that when the logit model includes education squared, it still remains very similar to the model without said variable. Thus we cannot reject that they are the same. This means that the omission of this variable is not an issue.

## Goodness of Fit

Classified	True		Total
	D	~D	
+	1	1	2
-	98	1148	1246
Total	99	1149	1248

```
Classified + if predicted Pr(D) >= .5
True D defined as Crime != 0
```

Sensitivity	Pr( +   D)	1.01%
Specificity	Pr( -   ~D)	99.91%
Positive predictive value	Pr( D   +)	50.00%
Negative predictive value	Pr( ~D   -)	92.13%
False + rate for true ~D	Pr( +   ~D)	0.09%
False - rate for true D	Pr( -   D)	98.99%
False + rate for classified +	Pr( ~D   +)	50.00%
False - rate for classified -	Pr( D   -)	7.87%
Correctly classified		92.07%

The goodness of fit test shows that 92.07% of our predicted observations match those actually observed – we are wrong 7.93% of the time.

Recall that in this sample only 8.43% of people have committed a crime. Thus if we simply predict that all respondents have never broken the law, we would get 91.57% of such predicted values correct.

Thus adding unemployment, income and education reduces classification errors from 8.43% to 7.93%, i.e. about half a percent reduction in error.

## Heteroscedasticity Test

A heteroscedasticity test was run on the variable lnY. The results are shown below

```
. regress const gres1 g_Educ g_Unemp g_lnY g_Educ2 ghet, noconst
```

Source	SS	df	MS	Number of obs =	1248
Model	1.11403163	6	.185671938	F( 6, 1242) =	0.18
Residual	1246.88597	1242	1.00393395	Prob > F =	0.9811
Total	1248	1248	1	R-squared =	0.0009
				Adj R-squared =	-0.0039
				Root MSE =	1.002

const	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]
gres1	-.501705	2.727542	-0.18	0.854	-5.852803 4.849393
g_Educ	.1536788	.384922	0.40	0.690	-.6014904 .9088481
g_Unemp	.7910887	1.257769	0.63	0.529	-1.676499 3.258676
g_lnY	-.1421613	.2618514	-0.54	0.587	-.6558812 .3715585
g_Educ2	-.0140893	.0153579	-0.92	0.359	-.0442196 .016041
ghet	-.0884729	.1345224	-0.66	0.511	-.3523892 .1754434

```
. display "Test stat = " e(mss) ", p-value = " chi2tail(1, e(mss))
Test stat = 1.1140316, p-value = .29120724
```

Thus with a (high) p-value of 0.2912, the null hypothesis of homoscedasticity is not rejected.

# Conclusions

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From the findings in the study, it can be said that it is statistically more likely that a person who is unemployed has ever committed a crime than a person who is employed. Also, the more education a person has received, the less likely it is that said person has ever committed a crime. Also, being unemployed is a stronger determinant of whether one has ever committed a crime compared to one more year of education - the effect of one more year of education only has a small negative effect on tendency for crime.

Furthermore, the marginal negative effect of more education on tendency for crime is decreasing, which implies diminishing returns (the 'returns' being less crime).

Another takeaway is that the effect of being unemployed on one's tendency for crime is stronger the less education one has received.

Income does not seem to have any statistically significant effect on whether a person has ever committed a crime or not. From this study, we cannot conclude that people on lower income are more (or less) likely to have ever engaged in criminal activity.

BAD

CONCLUSION

MAIN FINDINGS

NOT CLEAR.



# Limitations

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There are limitations relating to the statistical sophistication of the model, as well as to the data themselves.

With regards the data, issues arise about the questions asked in the survey. For example, respondents are asked whether they are employed or not at that particular point in time. No information about history of un/employment is elicited. Thus a person who is currently employed may have been chronically unemployed prior to the survey.

Additionally, the question regarding 'problem behaviour' is very broad. It asks whether the respondent has ever broken the law. No attempt is made to study the various forms of crime. This becomes a problem especially when we consider the effect of income on crime. Crimes such as theft and burglary are done for financial gain, whilst crimes such as rape and murder have different intentions altogether.

Also, the survey treats a person who has committed a crime once equal to someone who has committed multiple crimes.

Due to time constraints, this assignment does not carry out econometric tests to deal with the potential problem of endogeneity, explained on page 9.

It must be noted that there are many other variables in the literature on crime which have been argued to have (or not to have) an effect on crime. But due to data limitations, these have not been looked into. This may give rise to a problem of missing variable bias. In further study, variables such as cost of fines, police numbers and prison populations may be included.

# References

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