Violent Crime and the Economy

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Abstract

This thesis examines how the state of the economy in Michigan relates to the violent crime rate in the state. The state of the economy is represented by the independent variables of income and unemployment. An econometric model is created in order to find the ceteris paribus effect of these economic variables on the amount of crime committed in the state in a given year. Data is used from the years 1976-2016. The results of the model show a significant positive relationship between both income and the violent crime rate and unemployment and the violent crime rate. The results were obtained after subjecting the model to specification error testing. The result for unemployment is in-line with much of the literature. The effect of income was unusual, though not unheard of, given past research.

Introduction

Crime is something that human societies have had to deal with since the dawn of time. Anybody can be impacted by it at any time and the experience is a very displeasing. Because it is so widely accepted that crime is a negative occurrence in society and that it is worthwhile to combat it, there would seem to be a benefit to be had from acquiring tools to predict changes in the crime rate. With this capability, better solutions for combating crime can be developed.

One likely driving factor of crime is the performance of the economy. In a thriving economy, individuals are able to gain lawful employment, purchase goods and services they want, and possess a high standard of living that could lead them to become less likely to commit crimes against others.

Crime in general can be separated into two different categories, violent crime and property crime. It is entirely possible that the two crime categories could be driven by different factors and to varying degrees by the same factors. For this reason, only one should be observed at a time to obtain meaningful insights. For the current paper, the violent crime rate will be the topic of interest.

When examining the economy, it seems there are two very strong indicators of any given individual's current well-being, and therefore two possible drivers of individuals' propensity to commit violent crimes due to economic conditions. These factors are the income people are receiving for the work they perform and the unemployment rate that reveals what percentage of the labor force is not able to receive any legal income at all from an occupation.

If income increases for individuals, they will be able to obtain more goods and services, increasing their standard of living. This could have the effect of increasing their opportunity cost for committing violent crimes because they may end up going to prison and not having access to

their valuables while they are there. They will also miss out on the wages they would otherwise be earning at their place of employment (and potentially lose their job entirely) during their time in prison. Alternatively, increasing income also has the potential to increase the motivation for some individuals to commit property crimes because of the increased bounty of things to steal. If property crime increased due to higher incomes, associated violent crimes may rise as well.

When the unemployment rate increases, some individuals will lose their jobs and their primary income stream. These people will then have a lower opportunity cost of committing violent crimes and will be more susceptible to commit such crimes, possibly leading to a rise in the violent crime rate. An increase in the unemployment rate may also increase the need for individuals to commit property crimes in order to obtain the goods and services they believe are required for them to live comfortably. This might lead to a knock on effect of increasing the violent crime rate.

In order to formally look at the relationship between the performance of the economy and the violent crime rate, data will be collected for the state of Michigan across a 41 year time span from 1976-2016. This data will be used to construct a time series econometric model to form precise estimates of the relationship between the independent variables and the dependent variable. In order to gain insight on how similar projects have been carried out in the past and what variables might be relevant for such an analysis, a review of previous literature will be carried out.

Literature Review

Studies were examined concerning the economy and crime across a variety of countries over a wide time span. Each study will be summarized and the insights obtained from them will be detailed. The model that will be created will build off of this previous research.

Gould, E., Weinberg, B., & Mustard, D. performed a study in 2002 that examined the effects of wages and unemployment on crime. The study utilized data from the United States over the period 1979-1997 using young men as the population of interest. Both property crime and violent crime were looked at. The study found that the wage level had a significant negative relationship with crime rates. It also found that unemployment had a significant positive relationship with crime rates. Of the two variables, wages had the larger effect.

Similarly, Cantor, D., & Land, K. in 1985 published a study that used data from the U.S. from 1946-1982 that examined the relationship between unemployment and crime. The results showed that there seemed to be a significant, yet small, relationship between crime and unemployment. There were two influences on crime rates identified. The first was a negative opportunity effect that happened at the same time as an increase in unemployment. The second was a positive motivational effect that occurred the period after an increase in unemployment. The overall effect of unemployment on crime was negative because the opportunity effect was larger than the motivational effect. The motivational effect was not observed for violent crimes without a property factor involved.

Cantor and Land's model was put to further scrutiny by Martin A. Andresen (2013) when he applied it to 10 Canadian provinces over the period 1981-2009. The model he generated shows an insignificant effect of income on property crime, but a highly significant positive relationship between income and violent crime. It also shows a significant negative relationship

between unemployment and property crime in both the short and long run and unemployment and violent crime in the short run, but a significant positive relationship between unemployment and violent crime in the long run. Andresen notes that the sings of variables switch when different amounts of variables representing the state of the economy are included, implying there is omitted variable bias when not all relevant economic variables are in the model. He also suggests that future work should be conducted applying a model of multiple economic variables on crime at the U.S. state level.

A study conducted by R Rosenfeld, R., & Messner, S. F. in 2009 looked into how the state of the economy along with imprisonment rates impact the crime rate. The study used data from the U.S. and nine European nations from 1993-2006. Consumer confidence was found to have a significant negative relationship with burglary rates. Additionally, incarceration was found to have a negative relationship with burglary rates but this relationship was usually found only after an unordinary change in prison policies. Unemployment was found to be insignificant.

Merlo, A. in 2003 conducted a study that examined the effect on property crime of income distribution and police expenditures. The study utilized data from all 50 states in the U.S. for the year 1990. The study explains one methodology for examining crime and the variables that may cause it.

Theodore Chiricos in 1987 conducted a meta-analysis of studies examining the relationship between crime and unemployment. This meta-analysis included 63 studies and his conclusion was that there was often a positive and significant relationship between the crime rate and the unemployment rate, especially for property crimes post 1970. He does mention, however, that this field still has a high degree of uncertainty surrounding it and that no clear relationship has been agreed upon yet.

In 1986, Robert Nash Parker and Allan V. Horwitz examined the relationship of unemployment and crime as well as unemployment and imprisonment. The study used panel data looking at all 50 states across a six year period from 1974-1979. At first glance, the results of the study seem to support the existence of a relationship between unemployment and both property and violent crime. After controlling for trends and lagged effects however, the relationship evaporates and there is no clear interaction between crime and unemployment.

Stephen Machin and Costas Meghir (2004) examined the relationship between economic incentives, particularly wages, on the property crime rate in England and Wales between 1975 and 1996. What they found is that wages of low wage earners had a significant negative relationship with the property crime rate. From the results of their model, they suggest that wages may play a larger role in determining crime rates than the unemployment rate does because many crimes are committed by those with jobs and the wage level therefore is a better representation than the unemployment level of the relative incentives for committing crimes.

Richard Rosenfeld conducted a study in 2009 that examines the effect of changes in the economy on the homicide rate indirectly through changes in acquisitive crimes (robbery, burglary, motor vehicle theft). The study used regional data from the U.S. over the period 1970-2006. Through his analysis, Rosenfeld established a significant correlation between changes in the perception of the economy and acquisitive crimes. He additionally finds a significant correlation between changes in acquisitive crimes and homicide. Through the transitive property, a link is established between changes in the perceived state of the economy and the homicide rate. This link is explained because as the economy weakens, more people partake in property crimes and become engrossed in a lifestyle that makes them more prone to violence.

Pablo Fajnzylber, Daniel Lederman, and Norman Loayza (2002) have examined how economic conditions, including income inequality, impact the violent crime rates of homicide and robbery. The researchers utilized panel data from various developed and developing countries from 1970-1994. The results showed a robustly significant negative relationship between GDP growth and the violent crime rates. They also showed a significant positive relationship between income inequality and the violent crime rates.

Ted Enamorado, Luis F. López-Calva, Carlos Rodríguez-Castelán, and Hernán Winkler (2016) examined the impact of income inequality on violent crime rates in Mexico in the context of Mexico's drug war. Data was collected from 2438 municipalities over the period 1990-2010, constituting a diversified data set to represent the entire nation. The results showed a concrete relationship between income inequality and the homicide rate. As inequality increased, so did the homicide rate.

Douglas L. Yearwood and Gerry Koinis (2011) examined the effectiveness of using unemployment in econometric models relating the economy to crime and suggested other useful variables for this purpose. The researchers found that unemployment was not a useful predictor of most of the different types of crimes they examined, but other variables that could be useful were average wage and salary disbursements, supplemental security income receipts, the consumer price index, and per capita personal income.

The review of the literature has revealed that there is no broad consensus regarding the relationship between crime and unemployment. Some studies, such as those by Cantor & Land and Andresen, suggest the relationship is negative while others, such as those by Gould, E., Weinberg, B., & Mustard, D and Chiricos, show a positive relationship between the two variables. Even more studies, such as those by Parker & Horwitz, Rosenfeld & Messner, and

Yearwood & Koinis, have found unemployment to have no relation to crime. I will therefore include unemployment in my model as a measure of the state of the economy in order to see the results for Michigan regarding this variable.

Andresen noted in his study the need to include all relevant economic variables to avoid introducing omitted variable bias into the model. So, in order to avoid this problem, per capita income will be included as another testing variable. It was suggested by Yearwood & Koinis that this variable will aid in establishing a relationship between the performance of the economy and the crime rate and was found to be significantly related to income in previous studies by Andresen; Gould, Weinberg, & Mustard; and Machin & Meghir.

In addition to the two testing variables, additional control variables will be utilized to further limit omitted variable bias. The incarceration rate was signaled as being potentially important by Rosenfeld & Messner, so it will be one of these control variables. Income inequality as well seems like a likely candidate for inclusion as a control variable as it was found to impact crime rates by Fajnzylber, Lederman, & Loayza and Enamorado, López-Calva, Rodríguez-Castelán, & Hernán Winkler. Other control variables will be added as data availability allows.

The Model

Based on the previous review of the literature, the model that will be analyzed is:

$VioCrime = B_0 + B_1PersIncome + B_2Unem + B_3IncTopEarn + B_4NumChil + B_5Mort + B_6PropCrime + B_7EdRev + B_8Inc + B_9Dum + U.$

U in this model is the disturbance term. The disturbance term includes all factors that affect the rate of violent crime that are not included as independent variables in the model. The errors produced by the disturbance term should be normally distributed, have a zero mean, have an equal variance regardless of the value(s) of x, not be correlated with any of the x, and not be correlated with each other.

The dependent variable is the violent crime per capita of Michigan. This is defined as the number of violent crimes committed in Michigan per 100,000 people in the state. Violent crimes include murder, non-negligent manslaughter, rape, robbery, and aggravated assault. Since the violent crime rate is being used instead of the number of violent crimes, changes in the population of the state are controlled for and population does not have to be its own variable.

There are two independent testing variables in the model. Testing variables are the independent variables representing the components of the item of interest. Since the state of the economy is the item whose impact on the violent crime rate we are trying to determine, the components of it are the testing variables for the model. Therefore, the independent testing variables are the personal income per capita and the unemployment rate.

The personal income per capita of Michigan is defined as the total personal income in Michigan divided by the state's population. This variable will likely have a negative sign. This is because as people earn more money they have a greater standard of living and a higher

opportunity cost when committing violent crimes that could result in them going to prison or paying fines and losing their property.

The unemployment rate is defined as the percentage of people unemployed divided by the total labor force. This variable will likely have a positive sign. This is because as the percentage of people that are out of work increases a greater share of the population will have a relatively smaller opportunity cost of committing violent crime since they will not have a job to lose by doing so. People will also be more likely to have to resort to property crimes to obtain goods and this could have an indirect impact on the number of violent crimes committed because they are often committed together.

There are six independent control variables in the model. Control variables are all independent variables other than testing variables that could have an impact on determining the violent crime rate. By including these variables in the model, we can control for their effects on the dependent variable by holding them constant and get the ceteris paribus effects of the testing variables. The independent control variables in the model are the income of top earners, average number of children involved in a divorce, the mortality rate, the property crime rate, the total operating revenue for local schools, and the incarceration rate.

The income of top earners is a measure of income inequality within Michigan. It is defined as the percentage of total income in Michigan that goes to the top 10% of earners. This variable will most likely possess a positive sign. This is because it is likely that as income inequality increases within the state, more social unrest will arise and more violent crime will be a result of this increase in tensions between individuals in society.

The average number of children involved in a divorce is defined as the estimated average number of children per divorce decree reported on an annual basis by the Michigan Department

of Health and Human Services. This variable will likely have a positive sign. This is because as more children are involved in each divorce, divorces are more disruptive to the average family unit going through a divorce process in Michigan and it is possible more children will have to grow up in a split family that could lead them to be less likely to develop good moral values and social skills. Children may become more prone to commit violent crimes as they age because of this.

The mortality rate is defined as the number of deaths in a year per 1,000 people in Michigan as reported by the Michigan Department of Health and Human Services. This variable will likely have a positive sign. This is because when people are expected to live longer, they will have a greater incentive to live more ethically sound lives since they will be around to bear the fruit of their decisions for a longer time, resulting in them having a greater opportunity cost for committing a violent crime.

The property crime rate is defined as the number of property crimes per 100,000 people in the state of Michigan. Property crimes include burglary, larceny-theft, and motor vehicle theft. This variable will likely have a positive sign. This is because violent crimes and property crimes are often committed by the same people and often even in the same incident. When the population is more prone to committing property crimes, violent crimes are expected to increase just for this reason alone.

The total operating revenue for local schools is defined as the total revenue for local schools in Michigan as reported by the Michigan State Senate. The parameter for this variable will likely have a negative sign. This is because as more money is spent on education within the state, it is likely that students will obtain a better appreciation for the law and will more likely

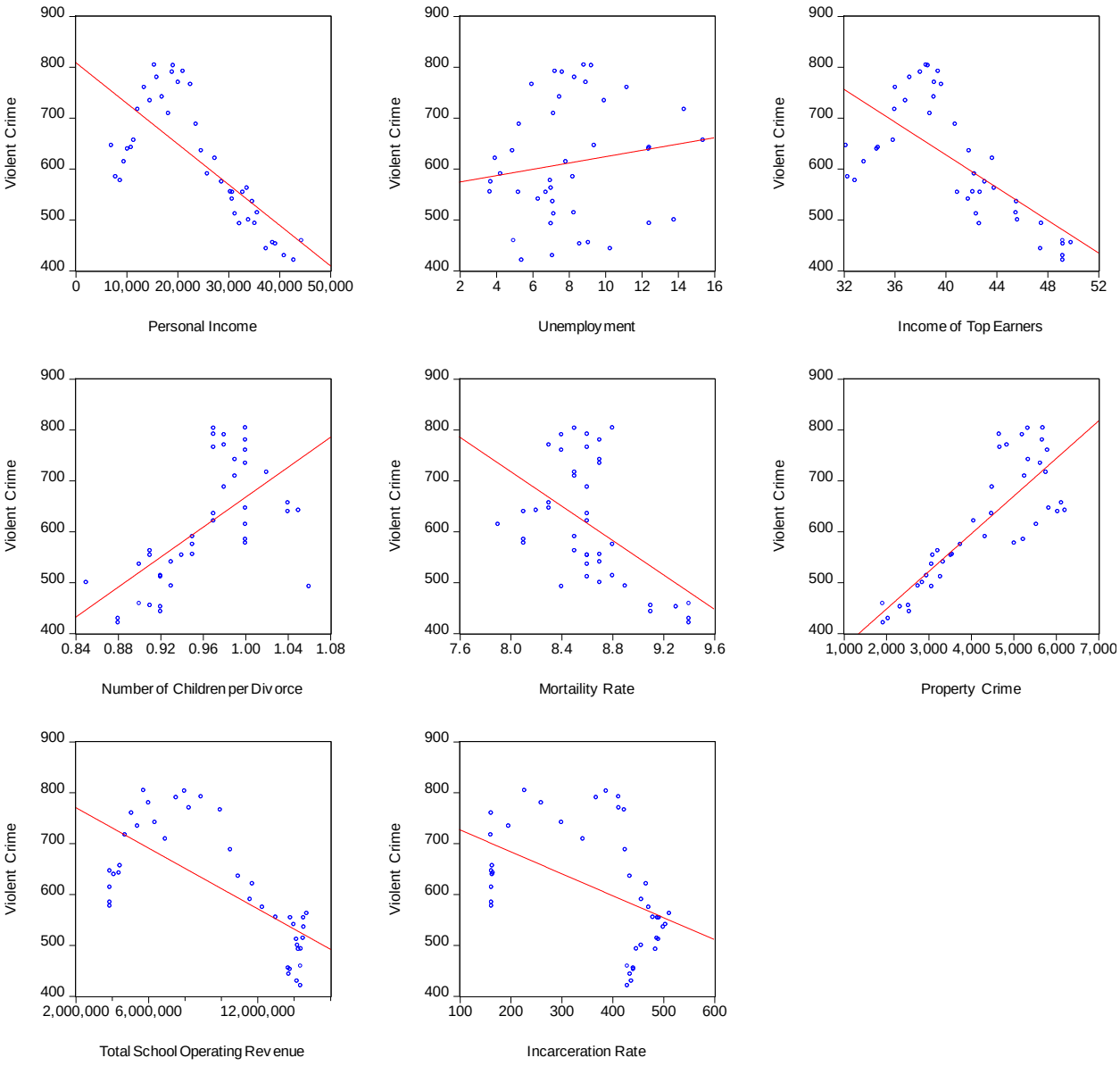
avoid committing violent crime in the future. They will also be more qualified for various employment opportunities and have a greater opportunity cost of committing violent crimes.

The incarceration rate is defined as the number of inmates in Michigan prisons per 100,000 people living in the state. This variable will likely have a negative value. This is because as a greater percentage of the state's population is in prison, some of the people most likely to commit a violent crime will no longer have the capacity to do so.

The dummy variable for missing data is a dummy variable with 1 for years in which data was missing for one or more variables and 0 for all other years. Data was missing for four years for the number of children involved in a divorce, one year for the mortality rate, four years for the income of top earners, four years for total school operating revenue, three years for the incarceration rate, and two years for the Fall pupil count which is a measure of the number of students in Michigan delivered by the Michigan Student Data System and used as an instrumental variable during the error testing section of the paper. The dummy variable will likely be different from 0. This is because it is unlikely that the values inserted for missing data will be exact matches with the actual values for these entries.

As a first step, it is important to visually evaluate the univariate relationship between the independent variables and the dependent variables to obtain an idea of how an independent variable could possibly affect the dependent variable. In order to accomplish this, a scatter plot was made for each independent variable showing its correlation with the dependent variable. This is presented in Figure 1 below. Initially, our predictions regarding the independent variables were as follows with each independent variable appearing in abbreviated form and its expected sign in parenthesis: PI(-), U(+), ITE(+), ANCID(+), M(+), PC(+), TORLS(-), I(-), DVMD(+/-).

Figure 1



The only variables that would appear to possess a different sign than originally thought are the income of top earners and the mortality rate. It was predicted that both of these variables would have a positive sign, but the graphs show a negative relationship. These relationships most likely exist because the effects of these variables on the dependent variable are much smaller than the effects of other variables and the resulting graphs are a creature of circumstance rather

than showing any sort of causal relationship. It is relevant to note that the model that will be created will show the multivariate relationships between the independent variables and the dependent variable, and the signs of their correlations may change as a result. With the predictions established for each variable, initial estimation and hypothesis testing of the model can be conducted.

Initial Estimation and Hypothesis Testing

The initial estimation of the model will help reveal the relationship between the performance of the economy and the violent crime rate prevalent in the state. Using the statistical program Eviews, OLS is used to give each variable a coefficient to show its ceteris paribus relationship to the dependent variable. These coefficients also have standard errors which can be used to compute T-statistics that are used to determine whether the variable is significant. The results of the initial estimation can be found in Appendix B.1. and are also shown in Table 1 below.

Table 1

Variable Name	Expected Sign	Estimate	Standard Error	T-Statistic
Intercept	+	-521.69	489.77	-1.07
Personal Income	-	.0097	.0068	1.43
Unemployment	+	4.95	3.42	1.45*
Income of Top Earners	+	-13.18	8.19	-1.61
Number of Children Per Divorce	+	-249.8	252.54	-.99
Mortality	+	129.87	53.18	2.44***
Property Crime	+	.1117	.0308	3.63***

Total School Operating Revenue	-	.0000397	.0000135	-2.94***
Incarceration Rate	-	1.21	.24	5.04
Dummy for Missing Data	+/-	-6.65	28.36	-.23
R^2=.9068	Adjusted R^2=.8798	F-Stat = 1.82	SE = 41.02	*=T-stat significant at 10% **=T-stat significant at 5% ***=T-stat significant at 1%

The table above was created using data output from EViews which can be found in Appendix B.1. Data was also used from calculations performed in Appendix C.1-C.10. The results for each variable will only be briefly discussed for now because specification error testing still needs to be conducted and the model could change materially as a result of that testing.

Intercept –

This test can be found in Appendix C.1. Initial estimation and testing has suggested that the intercept is not very significant. Violent crime in the absence of our variables would not be materially different from zero according to the t-statistic associated with the intercept parameter. This seems unrealistic but is not especially interesting for the question at hand.

Personal Income –

This test can be found in Appendix C.2. Personal income did not appear to have a significant negative correlation with the violent crime rate. Interestingly, if it had been predicted that income would have a positive sign attached to it, the variable would have been significant at

the 10% significance level. This suggests there might be a positive correlation between income and violent crime. This variable will be looked at again after specification error testing.

Unemployment –

This test can be found in Appendix C.3. Unemployment was found to be significant at the 10% significance level. This suggests that unemployment may have a positive correlation with violent crime. As more people become unemployed, their opportunity cost of committing violent crime may be reduced.

Income of Top Earners –

This test can be found in Appendix C.4. Income of top earners, or income inequality, did not appear to have a significant positive relationship with violent crime. Like personal income however, if we had predicted the opposite sign for the variable, the result would have been that the variable was significant at the 10% level. This variable will also be interesting to examine after performing error testing.

Number of children per divorce –

This test can be found in Appendix C.5. The number of children per divorce was not found to be statistically significant at any level. This suggests the variable may have only a small, or even nonexistent, influence on the violent crime rate.

Mortality –

This test can be found in Appendix C.6. The mortality rate was extremely significant at the 1% significance level. This would suggest a strong relationship between the mortality rate and the violent crime rate. This could be because of the lower perceived opportunity cost of committing a violent crime when the chances of passing away in any given year are higher.

Property Crime –

This test can be found in Appendix C.7. Property crime was found to be very significant at the 1% level. This is as expected. Criminals committing property crimes will be likely to also commit violent crimes during the same incidents. After checking for specification error, we can examine if this relationship is still this strong.

Total School Operating Revenue –

This test can be found in Appendix C.8. Total school operating revenue was found to be extremely significant at the 1% level. It would appear that as schools are better funded, children may be better educated and have less of a motivation to commit violent crimes as they grow older.

Incarceration rate –

This test can be found in Appendix C.9. The incarceration rate did not appear to be significant. Like personal income and the income of top earners however, if the opposite sign had been predicted, then this variable would have been significant. In fact, it would have been extremely significant at the 1% level. It's possible that the incarceration rate and the violent crime rate move together because of more people being locked in jail is a result of more violent crimes being committed. Often, the question is asked of whether severe punishment deters crime? There are multiple factors that go into crime deterrence. There is the probability of getting caught, the probability of being convicted, and the severity of the sentence. If any of these three factors is weak, the deterrence to crime is going to be weak, if existent at all. The estimate for the incarceration rate here would appear to agree with this reasoning, as higher incarceration rates do not seem to have a negative impact on the violent crime rate.

Dummy for missing data –

This test can be found in Appendix C.10.The dummy variable for missing data was not found to be significant. This suggests that perhaps the data used in place of missing data was not very different from the real values for those entries.

Wald test –

A Wald test was performed in addition to the individual t-tests on the variables. The purpose of this test is to answer the question being asked of whether the state of the economy in Michigan impacts the violent crime rate by testing the joint significance of the testing variables. To conduct this test, a regression was run on violent crime of all the variables with the exception of the two testing variables, personal income and unemployment. This restricted model can be found in Appendix B.2. The Wald test itself can be found in Appendix C.11. The calculated F statistic was 1.82. This is insignificant and would indicate that the testing variables are jointly insignificant, meaning the state of the economy does not affect the violent crime rate. Another Wald test will be conducted after error testing and the result could be drastically different.

Now that the initial estimation and hypothesis testing has been carried out, specification error testing can be done to improve the model and obtain more accurate estimates. The results of our final model could vary drastically from the initial results depending on what is found during the error testing process.

Specification Error Testing

The error tests that will be utilized are tests for endogeneity, non-zero mean, autocorrelation, and normality. These tests will check for violations of the assumptions that were made about the error term in the model. If any of the assumptions are violated, there could be severe consequences for the desirable traits of the estimates produced. Through these four tests, we can identify misspecification of the model and adapt it to better reflect the true nature of the

relationships between the dependent variable and independent variables by mitigating the negative effects of error assumption violations.

Endogeneity –

It is suspected that total school operating revenue may be endogenous because of its relationship with the fall pupil count for Michigan schools. If an endogeneity problem exists here, the model will need to be corrected to obtain better estimates. A Hausman test was performed to test for endogeneity. To carry out the Hasuman test, a regression was done with the fall pupil count replacing total school operating revenue in the model. This output can be seen in Appendix B.3. Then, the residuals were saved as RESID01 and these were included in the original model to produce another set of output seen in Appendix B.4. A t-test was performed on RESID01, seen in Appendix C.12., and the result showed there was endogeneity present. To correct for endogeneity, two stage least squares was used within Eviews to produce the current model which is shown in Appendix B.5. Without this change, the model would possess no desirable properties. The change reduces the effect of endogeneity on the model and strengthened the desirable traits of the estimates, giving them stronger asymptotic properties.

Non-Zero Mean –

A Ramsey RESET test was performed to test for misspecification of the model. This will determine whether the error term has an expected mean of zero. Output from the test can be seen in Appendix B.6. A hypothesis test can be seen in Appendix C.13. The results of the hypothesis test would suggest that the model is specified correctly because the Pvalue was significantly higher than the alpha term. No correction is needed here.

Autocorrelation –

A correlogram was used to search for potential autocorrelation in the error term. This correlogram can be found in Appendix B.7. The correlogram suggested there were multiple orders of autocorrelation present, so a formal Breusch-Godfrey serial correlation test was performed. The output from this test is located in Appendix B.8. and a hypothesis test using this data is found in Appendix C.14. The test showed that there was likely autocorrelation present. To correct for this, the Cochrane-Orcutt procedure was applied in EViews. First, an AR(1) term was added to the model to see if the autocorrelation was still likely present. The resulting correlogram and Breusch-Godfrey test suggested the problem was not yet resolved, so an AR(2) term was used instead. The resulting correlogram and Breusch-Godfrey test with the AR(2) term still suggested autocorrelation was likely present. Finally, an AR(3) term was added to the model and the resulting correlogram, shown in Appendix B.9., and Bresuch-Godfrey test, shown in Appendix B.10., displayed output that seems to show the problem has been corrected for. A Bresuch-Godfrey hypothesis test can be seen in Appendix C.15. and the resulting p value of .0476 is sufficiently high enough to conclude that the autocorrelation issue has been properly mitigated. By adding an AR(3) term to the model then, the model will possess more desirable properties.

Normality –

Normality of the errors was examined using a histogram and the Jarque-Bera statistic shown in Appendix B.11. A hypothesis test was conducted in Appendix C.16. and the errors were found to be normally distributed with a high degree of certainty. This suggests the estimates produced by the model should be highly efficient.

Final Estimation and Hypothesis Testing

Output for the final estimation of the model can be seen in Appendix B.12. These are the final estimates for each variable and the analysis for each will aid us in answering the question of how the performance of the economy in Michigan impact the rate violent crime is committed at. The results of the model are duplicated in Table 2 below.

Table 2

Variable Name	**Expected Sign**	**Estimate**	**Standard Error**	**T-Statistic**
Intercept	+	-957.58	468.39	-2.04
Personal Income	-	.0188	.0076	2.47
Unemployment	+	9.36	3.32	2.82***
Income of Top Earners	+	-13.81	7.49	-1.84
Number of Children Per Divorce	+	-129.83	230.90	-.56
Mortality	+	106.46	53.34	2.00**
Property Crime	+	.1740	.0362	4.81***
Total School Operating Revenue	-	.0000412	.0000121	-3.4***
Incarceration Rate	-	1.30	.21	6.19
Dummy for Missing Data	+/-	9.38	31.73	.3
AR(3)	+/-	-.5037	.1583	-3.18***
R^2=.9257	Adjusted R^2=.8982	F-Stat = 3.74**	SE = 39.14	*=T-stat significant at 10% **=T-stat significant at 5% ***=T-stat significant at 1%

The results show some fairly strong relationships between multiple independent variables and the dependent variable. Each will be discussed and the reasoning that is believed for each will be elaborated on. After a review of the individual variables, another Wald test will be performed to see if the testing variables are jointly significant.

Intercept –

This test can be found in Appendix C.17. Like the initial view of the intercept estimate, it remains to be somewhat illogical and not particularly interesting. The result would indicate a negative violent crime rate given a zero value for all variables in the model.

Personal Income –

This test can be found in Appendix C.18. Personal income remains to be very interesting because while it was found to be insignificant when predicting a negative value for it, the variable becomes extremely significant at the 1% level when predicting a positive value for it. This could make sense if we view higher incomes for individuals as implying there's a greater amount of wealth stored in both currency and valuables to be stolen. Instead of possessing a higher opportunity cost for committing a violent crime because of higher incomes in the legal labor market, would be criminals might gain a motivational incentive to commit more property crimes with more goods to steal and additional violent crimes may occur as a byproduct of this activity.

Unemployment –

This test can be found in Appendix C.19. Unemployment was found to be very significant at the 1% significance level. This is what was originally believed to be the case and would lead us to believe that when people become unemployed they have less to lose by

committing violent crimes (and property crimes associated with them) and the violent crime rate increases as a result.

Income of Top Earners –

This test can be found in Appendix C.20. Income of top earners, the measure of income inequality being used, still does not possess a statistically significant positive relationship. If we predict the opposite sign for it, the relationship would be found to be significant at the 5% level. It is possible that this relationship is observed because of the measure of income inequality used. The measure used signals wealth accumulation of high income individuals and this can happen as the economy expands and unemployment concurrently decreases, leading to a lowering of the violent crime rate. Thus, it could be the multicollinearity between the income of top earners and unemployment that creates this apparent relationship between income inequality and the violent crime rate. Another measure of income inequality may provide different results.

Number of children per divorce –

This test can be found in Appendix C.21. The number of children per divorce was once again found to not be significant. The average number of children involved in a divorce within the state would not appear to affect the rate at which violent crimes are committed. This suggests that children may not be any better or worse off in their odds of being raised with good moral values as they are raised when their parents have a divorce.

Mortality –

This test can be found in Appendix C.22. The mortality rate is still significant but is now only significant at the 5% level instead of the 1% level. It still seems likely there is an association between the violent crime rate and the mortality rate. The reasoning remains unchanged. As people have a higher chance of passing away in any given year, they see their

potential opportunity costs of committing violent crimes as lessening and are more willing to partake in these crimes once the perceived benefits outweigh these costs.

Property Crime –

This test can be found in Appendix C.23. Property crime was once again found to be very significant at the 1% level. What can be concluded is that it is very likely that those committing property crimes will partake in violent crimes as well, either in the same incident or in a string of incidents. Once someone breaks a crime, the psychological factors that were present causing them to restrain themselves from committing crime in the past are weakened and the next crime that they commit will be done so with less caution.

Total School Operating Revenue –

This test can be found in Appendix C.24. Total school operating revenue was again found very significant at the 1% level. It seems as the education given to children within the state is increased, they most likely have a declining tendency to commit violent crimes and the skeptical view of the benefits of crime instilled in them stays with them as they age.

Incarceration rate –

This test can be found in Appendix C.25. The incarceration rate remained insignificant. Similar to the initial hypothesis testing, if the sign for the incarceration rate had been predicted to be positive, the variable would have been immensely significant at the 1% level. This strongly suggests that as violent crime rates increase, police are able to arrest many of the individuals committing them and the prison population of the state accordingly adjusts upwards, though the overall effectiveness of the criminal justice system doesn't appear to be deterring the crime from occurring in the first place.

Dummy for missing data –

This test can be found in Appendix C.26. The dummy variable for missing data was still not found to be significant. This bodes well for the unbiasedness of the estimates produced from the model because it suggests that the data input for missing data was not materially different from the actual values.

AR(3) –

This test can be found in Appendix C.27. The AR(3) term that was added to remove autocorrelation from the errors was statistically significant at the 1% level. This would imply that autocorrelation was properly controlled for.

Wald test –

Another Wald test was performed to see if the testing variables were jointly significant after the model was modified. The result of the test will help determine if the violent crime rate changes as the testing variables change, holding all other variables constant. If it does, then the state of the economy has an impact on the violent crime rate. This test was performed identically to the previous one with a regression ran on violent crime of all the variables with the exception of the two testing variables: personal income and unemployment. The resulting restricted model can be found in Appendix B.13. The Wald test can be found in Appendix C.28. The calculated F statistic was 3.74. This result is now significant at the 5% significance level, unlike the previous Wald statistic that wasn't even significant at the 10% level. It can now be stated that the testing variables are jointly significant and the state of the economy does appear to affect the violent crime rate.

With the final estimation and hypothesis testing complete, all that needs to be done before making concluding remarks is stability testing to see if the model is the same across all years observed.

Testing for Stability

After the tech bubble of the early 2000s and the terrorist attack of 2001, the U.S. economy transformed in significant ways and security measures across the country tightened. To see if these changes affect the accuracy of the model created, an interaction term was introduced and a new model was created, as can be seen in Appendix B.14. A Chow test was performed using this data, with the results shown in Appendix C.29. The null hypothesis was not rejected and it can be concluded that the model did not materially change as a result of a changing economy and security measures. The model created should work just as well for predicting violent crime rates post-2001 as it does for predicting them pre-2001.

Conclusion

Now that the economy-crime model has been generated, what are the conclusions that can be made from the estimates produced? It would appear that the state of the economy does have a significant impact on the amount of violent crime committed. Both income and unemployment were found to have significant t-values, though the sign for income differed from what was originally predicted, and a Wald test of the two variables was significant at the 5% level. Income appears to have a positive relationship with the violent crime rate at the 1% significance level. Unemployment also appears to have a positive relationship with the violent crime rate at the 1% significance level.

The finding concerning unemployment falls in line with much of the past research done. Gould, E., Weinberg, B., & Mustard, D and Chiricos all found there to be a positive relationship between unemployment and crime. We can hypothesize that this could be because of a decrease in the opportunity cost of committing violent crime when a lower percentage of the workforce is employed. We can also attribute it to a rise in acquisitive crimes because of a lack of goods

among those now unemployed, and a rise in violent crime rates through the transitive property described by Rosenfeld.

The finding concerning income, however, is somewhat more puzzling. While Andresen found a positive relationship between income and violent crime, income and crime were found to be negatively related by Gould, Weinberg, & Mustard and Machin & Meghir. It can be hypothesized that income could be positively related to violent crimes because as the amount of wealth in society is increased, this wealth will be stored in many goods capable of being stolen and the available market for criminals will therefore increase, leading to a higher motivational incentive for them to commit crime. The environment will then become more conducive for individuals to not only partake in property crimes, but violent crimes as well.

The results of this study can be used to estimate changes in the future violent crime rate with known or predicted changes in personal income per capita or the unemployment rate. These estimates can be refined in future work by altering the variables in the model to obtain a more coherent picture of the state of the economy as more data becomes available. Other states can have a similar model applied to them to see if the relationships between violent crime, unemployment, and income are similar across state lines.

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Appendix A

Dates	Violent Crime	Personal Income	Unemployment	Income of Top Earners	Number of Children per Divorce	Mortaility Rate	Property Crime	Total School Operating Revenue	Incarceration Rate	Dummy for missing data	Fall Pupil Count	Prior to 2001
1976	646.0	7020	9.38	32.2	1.00	8.3	5832.2	3881766	162.4	1	2023944	1
1977	584.7	7861	8.21	32.3	1.00	8.1	5227.3	3881766	162.4	1	2023944	1
1978	577.2	8722	6.98	32.9	1.00	8.1	5016.9	3881766	162.4	1	1965685	1
1979	614.2	9511	7.83	33.6	1.00	7.9	5532.8	3881766	162.2	0	1910385	1
1980	639.5	10171	12.39	34.6	1.04	8.1	6036.4	4100127	163.4	0	1859934	1
1981	641.9	10934	12.42	34.7	1.05	8.2	6212.2	4385015	164.6	0	1792331	1
1982	656.6	11403	15.37	35.9	1.04	8.3	6128.0	4437708	163.6	0	1742831	1
1983	716.7	12207	14.34	36.0	1.02	8.5	5760.8	4713808	160.4	1	1712103	1
1984	760.1	13497	11.19	36.0	1.00	8.4	5795.9	5068303	161.4	0	1678458	1
1985	734.1	14599	9.95	36.8	1.00	8.7	5632.2	5408512	195.6	0	1666281	1
1986	803.9	15455	8.83	38.5	1.00	8.8	5687.6	5736500	227.2	0	1657423	1
1987	780.1	15968	8.30	37.2	1.00	8.7	5676.7	6011350	259.9	0	1657844	1
1988	741.7	16982	7.48	39.1	0.99	8.7	5342.7	6364184	299.5	0	1640294	1
1989	709.2	18223	7.16	38.8	0.99	8.5	5259.2	6938228	341.9	0	1637592	1
1990	790.4	18949	7.63	38.0	0.98	8.4	5204.4	7516289	368.0	0	1651502	1
1991	803.1	19165	9.24	38.6	0.97	8.5	5335.0	7986383	387.5	0	1673020	1
1992	770.1	20167	8.93	39.1	0.98	8.3	4840.5	8230869	412.6	0	1675465	1
1993	791.5	21106	7.23	39.4	0.97	8.6	4661.0	8892948	412.1	0	1667041	1
1994	766.1	22559	5.96	39.7	0.97	8.6	4679.1	9950188	423.3	0	1653949	1

1995	687.8	23664	5.26	40.7	0.98	8.6	4495.0	10515351	424.9	0	1673879	1
1996	635.3	24696	4.89	41.8	0.97	8.6	4482.2	10927496	434.0	0	1680693	1
1997	590.0	25874	4.23	42.2	0.95	8.5	4326.9	11584829	456.4	0	1694320	1
1998	620.8	27348	3.95	43.7	0.97	8.6	4062.1	11711725	465.9	0	1710365	1
1999	574.9	28640	3.69	43.1	0.95	8.8	3750.0	12261215	471.0	0	1714815	1
2000	555.0	30391	3.66	42.1	0.95	8.7	3554.9	13007656	479.3	0	1720335	1
2001	553.9	30786	5.22	40.9	0.94	8.6	3521.3	13810215	488.2	0	1731151	0
2002	540.7	30729	6.30	41.8	0.93	8.7	3336.2	13994004	504.0	0	1750631	0
2003	511.3	31306	7.17	42.4	0.92	8.6	3278.6	14140785	490.3	0	1734019	0
2004	492.2	32167	7.02	42.6	1.06	8.4	3066.1	14245833	484.5	0	1723087	0
2005	553.8	32813	6.73	42.7	0.91	8.6	3097.7	14539991	491.0	0	1712133	0
2006	562.4	33638	7.01	43.8	0.91	8.5	3212.8	14696664	511.6	0	1693436	0
2007	536.0	34691	7.11	45.6	0.90	8.6	3065.7	14542408	499.8	0	1661414	0
2008	513.7	35644	8.28	45.5	0.92	8.8	2946.0	14503911	487.3	0	1628628	0
2009	499.8	33966	13.78	45.6	0.85	8.7	2848.8	14198914	456.2	0	1605951	0
2010	493.0	35204	12.42	47.5	0.93	8.9	2748.8	14394718	446.6	0	1577606	0
2011	442.8	37400	10.28	47.5	0.92	9.1	2544.6	13720622	434.2	0	1559847	0
2012	455.0	38699	9.07	49.9	0.91	9.1	2522.1	13681933	440.8	0	1542691	0
2013	452.2	39214	8.59	49.2	0.92	9.3	2325.0	13785997	441.2	0	1530457	0
2014	429.1	40942	7.09	49.2	0.88	9.4	2044.0	14160049	437.0	1	1520074	0
2015	420.6	42833	5.39	49.2	0.88	9.4	1927.8	14364686	429.0	1	1507743	0
2016	459.0	44347	4.95	49.2	0.90	9.4	1909.9	14364686	429.0	1	1507743	0
Source	FBI UCR	FRED	BLS	EPI	MDHHS	MDHHS	FBI UCR	Michigan Senate	BJS		MSDS	

Appendix B

Initial Estimation –

Figure B.1. –

Dependent Variable: VIOLENT_CRIME
Method: Least Squares
Date: 02/10/18 Time: 15:11
Sample: 1976 2016
Included observations: 41

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-521.6932	489.7687	-1.065183	0.2950
PERSONAL_INCOME	0.009684	0.006833	1.417186	0.1664
UNEMPLOYMENT	4.947218	3.420020	1.446547	0.1581
INCOME_OF_TOP_EARNERS	-13.18484	8.185243	-1.610807	0.1174
NUMBER_OF_CHILDREN_PER_D	-249.8000	252.5445	-0.989133	0.3303
MORTAILITY_RATE	129.8659	53.18018	2.441998	0.0205
PROPERTY_CRIME	0.111706	0.030755	3.632155	0.0010
TOTAL_SCHOOL_OPERATING_R	-3.97E-05	1.35E-05	-2.937315	0.0062
INCARCERATION_RATE	1.206500	0.241084	5.004489	0.0000
DUMMY_FOR_MISSING_DATA	-6.652877	28.36116	-0.234577	0.8161

R-squared	0.906839	Mean dependent var	612.3512
Adjusted R-squared	0.879792	S.D. dependent var	118.3205
S.E. of regression	41.02287	Akaike info criterion	10.47436
Sum squared resid	52169.14	Schwarz criterion	10.89230
Log likelihood	-204.7243	Hannan-Quinn criter.	10.62655
F-statistic	33.52862	Durbin-Watson stat	1.150245
Prob(F-statistic)	0.000000		

Figure B.2. –

Dependent Variable: VIOLENT_CRIME
Method: Least Squares
Date: 02/10/18 Time: 16:15
Sample: 1976 2016
Included observations: 41

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-730.7902	430.7279	-1.696640	0.0992
INCOME_OF_TOP_EARNERS	-3.234458	6.329619	-0.511004	0.6128
NUMBER_OF_CHILDREN_PER_D	-279.8977	254.5850	-1.099427	0.2795
MORTAILITY_RATE	138.5601	48.13052	2.878840	0.0070
PROPERTY_CRIME	0.103688	0.027558	3.762536	0.0007
TOTAL_SCHOOL_OPERATING_R	-2.40E-05	1.08E-05	-2.219552	0.0334
INCARCERATION_RATE	0.968516	0.190275	5.090083	0.0000
DUMMY_FOR_MISSING_DATA	-11.97402	28.91013	-0.414181	0.6814

R-squared	0.895451	Mean dependent var	612.3512
Adjusted R-squared	0.873274	S.D. dependent var	118.3205
S.E. of regression	42.12051	Akaike info criterion	10.49213
Sum squared resid	58546.53	Schwarz criterion	10.82648
Log likelihood	-207.0886	Hannan-Quinn criter.	10.61388
F-statistic	40.37722	Durbin-Watson stat	0.938650
Prob(F-statistic)	0.000000		

Endogeneity –

Figure B.3. –

Dependent Variable: VIOLENT_CRIME
Method: Least Squares
Date: 02/10/18 Time: 17:34
Sample: 1976 2016
Included observations: 41

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2228.510	700.5149	3.181246	0.0033
PERSONAL_INCOME	-0.011406	0.004842	-2.355905	0.0250
UNEMPLOYMENT	-2.012711	2.684055	-0.749877	0.4590
INCOME_OF_TOP_EARNERS	-16.23345	6.437717	-2.521616	0.0170
NUMBER_OF_CHILDREN_PER_D	-240.4860	201.8674	-1.191307	0.2426
MORTAILITY_RATE	48.89149	46.11959	1.060102	0.2973
PROPERTY_CRIME	0.040504	0.029396	1.377889	0.1781
INCARCERATION_RATE	0.694969	0.137517	5.053685	0.0000
DUMMY_FOR_MISSING_DATA	18.06146	22.27752	0.810749	0.4237
FALL_PUPIL_COUNT	-0.000751	0.000135	-5.570168	0.0000

R-squared	0.940481	Mean dependent var	612.3512
Adjusted R-squared	0.923201	S.D. dependent var	118.3205
S.E. of regression	32.78963	Akaike info criterion	10.02632
Sum squared resid	33329.95	Schwarz criterion	10.44427
Log likelihood	-195.5396	Hannan-Quinn criter.	10.17851
F-statistic	54.42702	Durbin-Watson stat	1.515546
Prob(F-statistic)	0.000000		

Figure B.4. –

Dependent Variable: VIOLENT_CRIME
Method: Least Squares
Date: 02/10/18 Time: 17:36
Sample: 1976 2016
Included observations: 41

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-612.9097	330.3033	-1.855597	0.0734
PERSONAL_INCOME	0.008017	0.004612	1.738359	0.0924
UNEMPLOYMENT	4.482572	2.305410	1.944371	0.0613
INCOME_OF_TOP_EARNERS	-11.84755	5.518915	-2.146717	0.0400
NUMBER_OF_CHILDREN_PER_D	-251.7841	170.1483	-1.479791	0.1494
MORTAILITY_RATE	133.7665	35.83488	3.732859	0.0008
PROPERTY_CRIME	0.115879	0.020731	5.589519	0.0000
TOTAL_SCHOOL_OPERATING_R	-3.38E-05	9.15E-06	-3.697249	0.0009
INCARCERATION_RATE	1.133367	0.162856	6.959326	0.0000
DUMMY_FOR_MISSING_DATA	-4.239898	19.11187	-0.221846	0.8259
RESID01	0.941875	0.152204	6.188230	0.0000

R-squared	0.959077	Mean dependent var	612.3512
Adjusted R-squared	0.945436	S.D. dependent var	118.3205
S.E. of regression	27.63853	Akaike info criterion	9.700509
Sum squared resid	22916.65	Schwarz criterion	10.16025
Log likelihood	-187.8604	Hannan-Quinn criter.	9.867921
F-statistic	70.30778	Durbin-Watson stat	1.096233
Prob(F-statistic)	0.000000		

Figure B.5. –

Dependent Variable: VIOLENT CRIME
Method: Two-Stage Least Squares
Date: 02/10/18 Time: 17:38
Sample: 1976 2016
Included observations: 41
Instrument specification: VIOLENT CRIME C PERSONAL INCOME UNEMPLOYMENT INCOME OF TOP EARNERS NUMBER OF CHIL DREN PER D MORTAILITY RATE PROPERTY CRIME INCARCERATION RATE DUMMY FOR MISSING DATA FALL PUPIL COUNT

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	791.2182	867.4685	0.912100	0.3688
PERSONAL INCOME	0.033682	0.013269	2.538400	0.0164
UNEMPLOYMENT	11.63502	5.643871	2.061532	0.0477
INCOME OF TOP EARNERS	-32.43297	14.01866	-2.313557	0.0275
NUMBER_OF_CHILDREN_PER_D	-221.2432	379.1766	-0.583483	0.5638
MORTAILITY RATE	73.72194	82.21233	0.896726	0.3768
PROPERTY CRIME	0.051640	0.050742	1.017694	0.3167
TOTAL SCHOOL OPERATING R	-0.000124	3.58E-05	-3.457675	0.0016
INCARCERATION RATE	2.259139	0.517007	4.369648	0.0001
DUMMY FOR MISSING DATA	-41.38371	44.27665	-0.934662	0.3572

R-squared	0.790136	Mean dependent var	612.3512
Adjusted R-squared	0.729208	S.D. dependent var	118.3205
S.E. of regression	61.57123	Sum squared resid	117521.5
F-statistic	15.78657	Durbin-Watson stat	0.950125
Prob(F-statistic)	0.000000	Second-Stage SSR	21365.13
J-statistic	5.635725	Instrument rank	11
Prob(J-statistic)	0.017598		

Non-Zero Mean –

Figure B.6. –

Ramsey RESET Test
Equation: UNTITLED
Specification: VIOLENT_CRIME C PERSONAL_INCOME
UNEMPLOYMENT INCOME_OF_TOP_EARNERS NUMBER_OF_CHIL
DREN_PER_D MORTAILITY_RATE PROPERTY_CRIME
TOTAL SCHOOL OPERATING R INCARCERATION RATE
DUMMY FOR MISSING DATA
Instrument specification: VIOLENT CRIME C PERSONAL INCOME
UNEMPLOYMENT INCOME_OF_TOP_EARNERS NUMBER_OF_CHIL
DREN_PER_D MORTAILITY_RATE PROPERTY_CRIME
INCARCERATION_RATE DUMMY_FOR_MISSING_DATA
FALL_PUPIL_COUNT
Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	0.611256	30	0.5456
F-statistic	0.373633	(1, 30)	0.5456
Difference in J-stats	5.635725	0	NA

F-test summary:

	Sum of Sq.	df	Mean Squares
Test 2SSR	21365.13	1	21365.13
Restricted 2SSR	21365.13	31	689.1977
Unrestricted 2SSR	-2.06E-05	30	-6.87E-07
Unrestricted SSR	1715462.	30	57182.08

J-statistic summary:

	Value
Restricted J-statistic	5.635725
Unrestricted J-statistic	0.000000

Unrestricted Test Equation:
Dependent Variable: VIOLENT_CRIME
Method: Two-Stage Least Squares
Date: 02/10/18 Time: 17:52
Sample: 1976 2016
Included observations: 41
Instrument specification: VIOLENT_CRIME C PERSONAL_INCOME
UNEMPLOYMENT INCOME_OF_TOP_EARNERS NUMBER_OF_CHIL
DREN_PER_D MORTAILITY_RATE PROPERTY_CRIME
INCARCERATION RATE DUMMY FOR MISSING DATA
FALL PUPIL COUNT

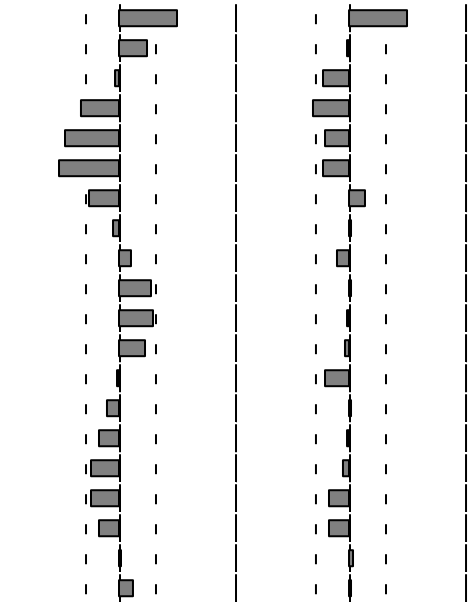
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-16701.43	28815.20	-0.579605	0.5665
PERSONAL_INCOME	-1.033221	1.746189	-0.591700	0.5585
UNEMPLOYMENT	-411.3007	692.2603	-0.594142	0.5569
INCOME_OF_TOP_EARNERS	939.9789	1591.775	0.590522	0.5593
NUMBER_OF_CHILDREN_PER_D	4365.665	7647.209	0.570883	0.5723
MORTAILITY_RATE	-1573.573	2713.786	-0.579844	0.5663
PROPERTY CRIME	-1.033518	1.786197	-0.578613	0.5672
TOTAL SCHOOL OPERATING R	0.003838	0.006483	0.592018	0.5583
INCARCERATION RATE	-69.69807	117.7375	-0.591979	0.5583
DUMMY_FOR_MISSING_DATA	1014.732	1736.318	0.584416	0.5633
FITTED^2	0.021460	0.035108	0.611256	0.5456

R-squared	-2.063382	Mean dependent var	612.3512
Adjusted R-squared	-3.084510	S.D. dependent var	118.3205
S.E. of regression	239.1277	Sum squared resid	1715462.
F-statistic	0.979310	Durbin-Watson stat	1.935982
Prob(F-statistic)	0.481283	Second-Stage SSR	-2.06E-05
J-statistic	0.000000	Instrument rank	11

Autocorrelation –

Figure B.7. –

Date: 02/10/18 Time: 18:05
Sample: 1976 2016
Included observations: 41



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	0.520	0.520	11.926	0.001
		2	0.260	-0.014	14.993	0.001
		3	-0.046	-0.242	15.092	0.002
		4	-0.348	-0.332	20.874	0.000
		5	-0.485	-0.218	32.410	0.000
		6	-0.540	-0.239	47.098	0.000
		7	-0.266	0.144	50.773	0.000
		8	-0.057	0.016	50.945	0.000
		9	0.101	-0.108	51.511	0.000
		10	0.292	0.018	56.370	0.000
		11	0.311	-0.018	62.065	0.000
		12	0.241	-0.041	65.609	0.000
		13	-0.013	-0.206	65.620	0.000
		14	-0.105	0.015	66.338	0.000
		15	-0.187	-0.013	68.717	0.000
		16	-0.256	-0.052	73.324	0.000
		17	-0.247	-0.173	77.821	0.000
		18	-0.186	-0.180	80.459	0.000
		19	0.022	0.027	80.499	0.000
		20	0.117	0.020	81.647	0.000

*Probabilities may not be valid for this equation specification.

Figure B.8. –

Breusch-Godfrey Serial Correlation LM Test:

Obs*R-squared	24.21410	Prob. Chi-Square(6)	0.0005

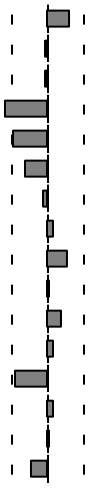
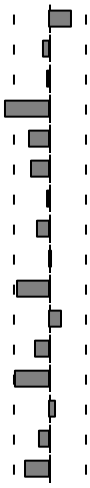
Test Equation:
Dependent Variable: RESID
Method: Two-Stage Least Squares
Date: 02/10/18 Time: 18:09
Sample: 1976 2016
Included observations: 41
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	367.5984	654.5577	0.561598	0.5794
PERSONAL INCOME	0.012336	0.011269	1.094633	0.2841
UNEMPLOYMENT	11.69542	4.837992	2.417412	0.0233
INCOME OF TOP EARNERS	-15.41361	12.49018	-1.234058	0.2287
NUMBER OF CHILDREN PER D	211.5896	281.8627	0.750683	0.4599
MORTAILITY RATE	-11.66930	60.51167	-0.192844	0.8486
PROPERTY_CRIME	-0.031530	0.037915	-0.831596	0.4135
TOTAL SCHOOL OPERATING R	-3.61E-05	2.87E-05	-1.257412	0.2202
INCARCERATION RATE	0.699079	0.416365	1.679005	0.1056
DUMMY FOR MISSING DATA	22.14959	36.06991	0.614074	0.5447
RESID(-1)	0.242591	0.196773	1.232845	0.2291
RESID(-2)	0.158156	0.186814	0.846592	0.4053
RESID(-3)	0.089507	0.184749	0.484478	0.6323
RESID(-4)	-0.255066	0.176871	-1.442103	0.1617
RESID(-5)	-0.162128	0.182334	-0.889181	0.3824
RESID(-6)	-0.481117	0.219674	-2.190142	0.0381

R-squared	0.590588	Mean dependent var	-5.59E-13
Adjusted R-squared	0.344941	S.D. dependent var	54.20367
S.E. of regression	43.87014	Akaike info criterion	10.68614
Sum squared resid	48114.73	Schwarz criterion	11.35485
Log likelihood	-203.0658	Hannan-Quinn criter.	10.92964
F-statistic	2.404211	Durbin-Watson stat	2.275716
Prob(F-statistic)	0.025361		

Figure B.9. –

Date: 02/10/18 Time: 18:55
Sample: 1976 2016
Included observations: 38
Q-statistic probabilities adjusted for 1 ARMA term

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	0.203	0.203	1.7007	
		2	-0.012	-0.056	1.7072	0.191
		3	-0.023	-0.009	1.7303	0.421
		4	-0.376	-0.387	8.0602	0.045
		5	-0.309	-0.187	12.459	0.014
		6	-0.189	-0.171	14.155	0.015
		7	-0.042	-0.011	14.243	0.027
		8	0.052	-0.111	14.381	0.045
		9	0.176	0.014	16.010	0.042
		10	-0.006	-0.280	16.012	0.067
		11	0.130	0.104	16.960	0.075
		12	0.048	-0.118	17.098	0.105
		13	-0.288	-0.300	22.152	0.036
		14	0.061	0.058	22.386	0.050
		15	-0.005	-0.087	22.388	0.071
		16	-0.154	-0.228	24.017	0.065

*Probabilities may not be valid for this equation specification.

Figure B.10. –

Breusch-Godfrey Serial Correlation LM Test:

Obs*R-squared	9.604757	Prob. Chi-Square(4)	0.0476

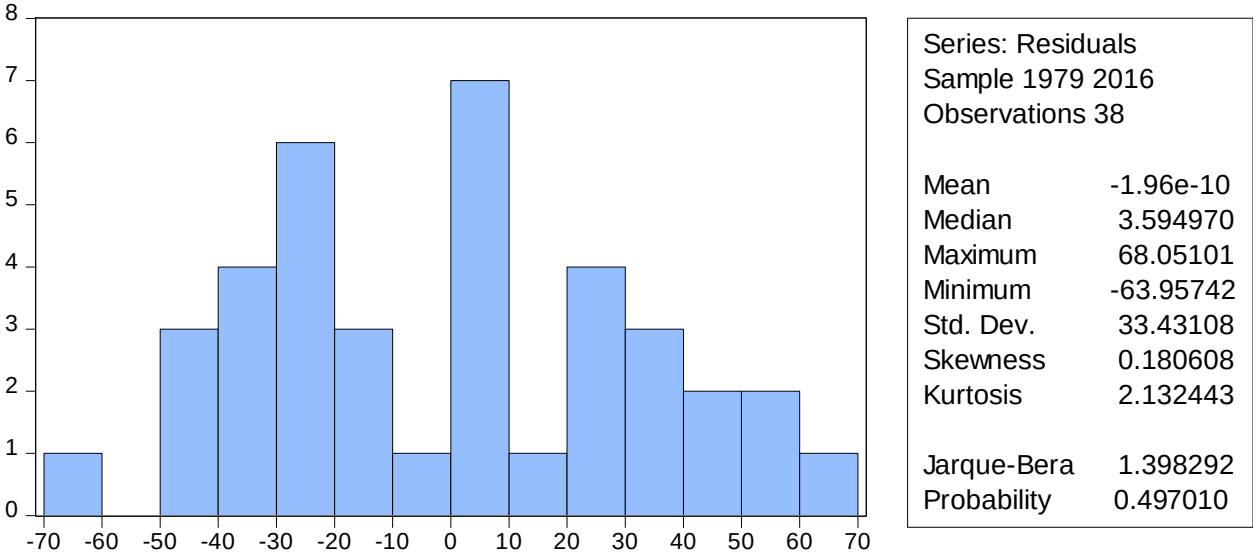
Test Equation:
Dependent Variable: RESID
Method: Two-Stage Least Squares
Date: 02/10/18 Time: 18:55
Sample: 1979 2016
Included observations: 38
Coefficient covariance computed using outer product of gradients
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-22.84190	440.9742	-0.051799	0.9591
PERSONAL_INCOME	-0.005238	0.007348	-0.712780	0.4832
UNEMPLOYMENT	1.005185	3.266278	0.307746	0.7610
INCOME OF TOP EARNERS	5.151507	8.748998	0.588811	0.5617
NUMBER OF CHILDREN PER D	-82.25763	232.1916	-0.354266	0.7264
MORTAILITY_RATE	-4.721001	60.41589	-0.078142	0.9384
PROPERTY CRIME	-0.004039	0.035864	-0.112608	0.9113
TOTAL SCHOOL OPERATING R	3.49E-06	1.12E-05	0.312666	0.7574
INCARCERATION RATE	0.085435	0.197477	0.432630	0.6693
DUMMY_FOR_MISSING_DATA	30.81542	32.37021	0.951968	0.3510
AR(3)	-0.163395	0.318698	-0.512694	0.6131
RESID(-1)	0.293561	0.212150	1.383741	0.1797
RESID(-2)	-0.104709	0.268384	-0.390145	0.7000
RESID(-3)	0.272393	0.430326	0.632993	0.5330
RESID(-4)	-0.515977	0.210927	-2.446233	0.0225

R-squared	0.252757	Mean dependent var	-1.96E-10
Adjusted R-squared	-0.202087	S.D. dependent var	33.43108
S.E. of regression	36.65374	Akaike info criterion	10.32829
Sum squared resid	30900.42	Schwarz criterion	10.97471
Log likelihood	-181.2375	Hannan-Quinn criter.	10.55828
F-statistic	0.555700	Durbin-Watson stat	2.253254
Prob(F-statistic)	0.871673		

Normality –

Figure B.11. –



Final Estimation –

Figure B.12. –

Dependent Variable: VIOLENT_CRIME
Method: Two-Stage Least Squares
Date: 02/10/18 Time: 21:15
Sample (adjusted): 1979 2016
Included observations: 38 after adjustments
Convergence achieved after 50 iterations
Instrument specification: VIOLENT_CRIME C PERSONAL_INCOME UNEMPLOYMENT INCOME_OF_TOP_EARNERS NUMBER_OF_CHIL DREN_PER_D MORTAILITY_RATE PROPERTY_CRIME INCARCERATION_RATE DUMMY_FOR_MISSING_DATA FALL_PUPIL_COUNT
Lagged dependent variable & regressors added to instrument list

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-957.5789	468.3916	-2.044398	0.0508
PERSONAL_INCOME	0.018817	0.007578	2.483236	0.0195
UNEMPLOYMENT	9.357722	3.318440	2.819916	0.0089
INCOME_OF_TOP_EARNERS	-13.81451	7.486634	-1.845223	0.0760
NUMBER_OF_CHILDREN_PER_D	-129.8302	230.9008	-0.562277	0.5786
MORTAILITY_RATE	106.4563	53.33851	1.995863	0.0561
PROPERTY_CRIME	0.173960	0.036169	4.809705	0.0001
TOTAL_SCHOOL_OPERATING_R	-4.12E-05	1.21E-05	-3.417998	0.0020
INCARCERATION_RATE	1.302737	0.207460	6.279455	0.0000
DUMMY_FOR_MISSING_DATA	9.379286	31.72952	0.295601	0.7698
AR(3)	-0.503664	0.158330	-3.181101	0.0037

R-squared	0.925736	Mean dependent var	613.1184
Adjusted R-squared	0.898231	S.D. dependent var	122.6768
S.E. of regression	39.13536	Sum squared resid	41352.56
Durbin-Watson stat	1.504318	J-statistic	25.77414
Instrument rank	21	Prob(J-statistic)	0.004056

Inverted AR Roots	.40+.69i	.40-.69i	-.80

Figure B.13 –

Dependent Variable: VIOLENT_CRIME
Method: Two-Stage Least Squares
Date: 02/10/18 Time: 22:17
Sample (adjusted): 1979 2016
Included observations: 38 after adjustments
Convergence achieved after 20 iterations
Instrument specification: VIOLENT CRIME C PERSONAL INCOME UNEMPLOYMENT INCOME OF TOP EARNERS NUMBER OF CHIL DREN PER D MORTAILITY RATE PROPERTY CRIME INCARCERATION RATE DUMMY FOR MISSING DATA FALL PUPIL COUNT
Lagged dependent variable & regressors added to instrument list

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	254.3566	611.4791	0.415969	0.6805
INCOME OF TOP EARNERS	-12.43440	6.754328	-1.840952	0.0759
NUMBER OF CHILDREN PER D	-332.8542	244.3620	-1.362135	0.1836
MORTAILITY RATE	113.8556	53.14889	2.142200	0.0407
PROPERTY CRIME	0.048734	0.032595	1.495158	0.1457
TOTAL SCHOOL OPERATING R	-3.54E-05	1.30E-05	-2.723150	0.0108
INCARCERATION_RATE	0.998657	0.275334	3.627081	0.0011
DUMMY FOR MISSING DATA	11.16428	28.27285	0.394876	0.6958
AR(3)	0.285287	0.212684	1.341366	0.1902

R-squared	0.907201	Mean dependent var	613.1184
Adjusted R-squared	0.881602	S.D. dependent var	122.6768
S.E. of regression	42.21190	Sum squared resid	51673.50
Durbin-Watson stat	1.115663	J-statistic	27.98095
Instrument rank	19	Prob(J-statistic)	0.001818

Inverted AR Roots	.66	-.33+.57i	-.33-.57i

Stability –

Figure B.14. –

Dependent Variable: VIOLENT_CRIME
Method: Two-Stage Least Squares
Date: 02/11/18 Time: 15:42
Sample (adjusted): 1979 2016
Included observations: 38 after adjustments
Convergence achieved after 38 iterations
Instrument specification: VIOLENT_CRIME C PERSONAL_INCOME UNEMPLOYMENT INCOME_OF_TOP_EARNERS NUMBER_OF_CHIL DREN_PER_D MORTAILITY_RATE PROPERTY_CRIME INCARCERATION_RATE DUMMY_FOR_MISSING_DATA FALL_PUPIL_COUNT
Lagged dependent variable & regressors added to instrument list

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1245.731	2543.669	0.489738	0.6306
PERSONAL_INCOME	0.017674	0.025006	0.706793	0.4893
UNEMPLOYMENT	0.774242	14.22524	0.054427	0.9572
INCOME_OF_TOP_EARNERS	-7.381167	20.60167	-0.358280	0.7245
NUMBER_OF_CHILDREN_PER_D	-263.1800	371.0920	-0.709204	0.4878
MORTAILITY_RATE	-125.0989	177.0389	-0.706618	0.4894
PROPERTY_CRIME	0.104199	0.162821	0.639960	0.5307
TOTAL_SCHOOL_OPERATING_R	8.92E-07	8.01E-05	0.011148	0.9912
INCARCERATION_RATE	-0.002414	1.796207	-0.001344	0.9989
DUMMY_FOR_MISSING_DATA	-12.58705	87.27951	-0.144215	0.8870
PRIOR_TO_2001	111.4678	2861.434	0.038955	0.9694
PRIOR_TO_2001*PERSONAL_INCOME	-0.053669	0.040379	-1.329133	0.2014
PRIOR_TO_2001*UNEMPLOYMENT	13.27556	15.92312	0.833728	0.4160
PRIOR_TO_2001*INCOME_OF_TOP_EA...	-7.193139	29.67234	-0.242419	0.8114
PRIOR_TO_2001*NUMBER_OF_CHILD...	-2082.759	1080.166	-1.928184	0.0707
PRIOR_TO_2001*MORTAILITY_RATE	412.3196	218.5545	1.886575	0.0764
PRIOR_TO_2001*PROPERTY_CRIME	-0.116101	0.186323	-0.623115	0.5415
PRIOR_TO_2001*TOTAL_SCHOOL_OP...	5.13E-06	8.94E-05	0.057368	0.9549
PRIOR_TO_2001*INCARCERATION_RATE	1.167605	1.912741	0.610435	0.5496
PRIOR_TO_2001*DUMMY_FOR_MISSIN...	-53.85560	105.1270	-0.512291	0.6150
AR(3)	0.301543	0.270940	1.112948	0.2812

R-squared	0.951553	Mean dependent var	613.1184
Adjusted R-squared	0.894556	S.D. dependent var	122.6768
S.E. of regression	39.83572	Sum squared resid	26977.03
Durbin-Watson stat	2.944127	J-statistic	10.40112
Instrument rank	30	Prob(J-statistic)	0.318998

Inverted AR Roots	.67	-.34+.58i	-.34-.58i

Appendix C

Initial Hypothesis Testing –

C.1. –

H_0: $B_0 \leq 0$

H_1: $B_0 > 0$

D.F. 40

a = .01 a = .05 a = .1

tcrit = 2.42 tcrit = 1.68 tcrit = 1.30

tstat = -521.69/489.77 = -1.07

tstat<tcrit so do not reject H_0

C.2. –

H_0: $B_1 \geq 0$

H_1: $B_1 < 0$

D.F. 40

a = .01 a = .05 a = .1

tcrit = -2.42 tcrit = -1.68 tcrit = -1.30

tstat = .0097/.0068 = 1.43

tstat>tcrit so do not reject H_0

C.3. –

H_0: $B_2 \leq 0$

H_1: $B_2 > 0$

D.F. 40

a = .01 a = .05 a = .1

tcrit = 2.42 tcrit = 1.68 tcrit = 1.30

tstat = 4.95/3.42 = 1.45

tstat>tcrit at a=.1 so reject H_0 at a=.1

C.4. –

H_0: $B_3 \leq 0$

H_1: $B_3 > 0$

D.F. 40

a = .01 a = .05 a = .1

tcrit = 2.42 tcrit = 1.68 tcrit = 1.30

tstat = -13.18/8.19 = -1.61

tstat<tcrit so do not reject H_0

C.5. –

H_0: $B_4 \leq 0$

H_1: $B_4 > 0$

D.F. 40

a = .01 a = .05 a = .1

tcrit = 2.42 tcrit = 1.68 tcrit = 1.30

tstat = -249.8/252.54 = -.99

tstat<tcrit so do not reject H_0

C.6. –

H_0: $B_5 \leq 0$

H_1: $B_5 > 0$

D.F. 40

a = .01 a = .05 a = .1

tcrit = 2.42 tcrit = 1.68 tcrit = 1.30

tstat = 129.87/53.18 = 2.44

tstat>tcrit at a=.01 so reject H_0 at a=.01

C.7. –

H_0: $B_6 \leq 0$

H_1: $B_6 > 0$

D.F. 40

a = .01 a = .05 a = .1

tcrit = 2.42 tcrit = 1.68 tcrit = 1.30

tstat = .1117/.0308 = 3.63

tstat>tcrit at a=.01 so reject H_0 at a=.01

C.8. –

H_0: $B_7 \geq 0$

H_1: $B_7 < 0$

D.F. 40

a = .01 a = .05 a = .1

tcrit = -2.42 tcrit = -1.68 tcrit = -1.30

tstat = -.0000397/.0000135 = -2.94

tstat<tcrit at a=.01 so reject H_0 at a=.01

C.9. –

H_0: $B_8 \geq 0$

H_1: $B_8 < 0$

D.F. 40

a = .01 a = .05 a = .1

tcrit = -2.42 tcrit = -1.68 tcrit = -1.30

tstat = 1.21/.24 = 5.04

tstat>tcrit so do not reject H_0

C.10. –

H_0: $B_9=0$

H_1: $B_9\neq0$

D.F. 40

a = .01 a = .05 a = .1

tcrit = +/-2.70 tcrit = +/-2.02 tcrit = +/-1.68

tstat = -6.65/28.36 = -.23

tcrit<tstat<tcrit so do not reject H_0

C.11. –

H_0: $B_1=0$, $B_2=0$

H_1: Otherwise

SSR_r = 58546.53

SSR_{ur} = 52196.14

D.F.N = 2

D.F.D = 31

a = .01 a=.05 a=.1

Fcrit = 5.36 Fcrit = 3.30 Fcrit = 2.48

Ftest = ((58546.53-52196.14)/2)/(52196.14/(41-9-1)) = 1.82

Ftest<Fcrit so do not reject H_0

Endogeneity –

C.12. –

H_0: No endogeneity (RESID01 = 0)

H_1: Endogeneity (RESID01 ≠ 0)

a = .01

tcrit = +/- 2.70

tstat = .94/.15 = 6.27

tstat > tcrit so reject H_0

Non-Zero Mean –

C.13. –

H_0: Original model is correctly specified

H_1: Misspecification is present

a=.01

Fstat = .37

Pvalue = .55

Pvalue>a so do not reject H_0

Autocorrelation –

C.14. –

H_0: No serial correlation present

H_1: Serial correlation present

a=.01

NR^2 = 24.21

Pvalue = .0005

Pvalue<a so reject H_0

C.15. –

H_0: No serial correlation present

H_1: Serial correlation present

a=.01

NR^2 = 9.60

Pvalue = .048

Pvalue>a so do not reject H_0

Normality –

C.16. –

H_0: Normality is present

H_1: Errors are not distributed normally

a=.01

Jarque-Bera = 1.40

Pvalue = .50

Pvalue>a so do not reject null hypothesis

Final Hypothesis Testing –

C.17. –

H_0: $B_0 \leq 0$

H_1: $B_0 > 0$

D.F. 40

a = .01 a = .05 a = .1

tcrit = 2.42 tcrit = 1.68 tcrit = 1.30

tstat = -957.58/468.39 = -2.04

tstat<tcrit so do not reject H_0

C.18. –

H_0: $B_1 \geq 0$

H_1: $B_1 < 0$

D.F. 40

a = .01 a = .05 a = .1

tcrit = -2.42 tcrit = -1.68 tcrit = -1.30

tstat = .0188/.0076 = 2.47

tstat>tcrit so do not reject H_0

C.19. –

H_0: $B_2 \leq 0$

H_1: $B_2>0$

D.F. 40

a = .01 a = .05 a = .1

tcrit = 2.42 tcrit = 1.68 tcrit = 1.30

tstat = 9.36/3.32 = 2.82

tstat>tcrit at a=.01 so reject H_0 at a=.01

C.20. –

H_0: $B_3\leq0$

H_1: $B_3>0$

D.F. 40

a = .01 a = .05 a = .1

tcrit = 2.42 tcrit = 1.68 tcrit = 1.30

tstat = -13.81/7.49 = -1.84

tstat<tcrit so do not reject H_0

C.21. –

H_0: $B_4\leq0$

H_1: $B_4>0$

D.F. 40

a = .01 a = .05 a = .1

tcrit = 2.42 tcrit = 1.68 tcrit = 1.30

tstat = -129.83/230.90 = -.56

tstat<tcrit so do not reject H_0

C.22. –

H_0: $B_5\leq0$

H_1: $B_5>0$

D.F. 40

a = .01 a = .05 a = .1

tcrit = 2.42 tcrit = 1.68 tcrit = 1.30

tstat = 106.46/53.34 = 2.00

tstat>tcrit at a=.05 so reject H_0 at a=.05

C.23. –

H_0: $B_6 \leq 0$

H_1: $B_6 > 0$

D.F. 40

a = .01 a = .05 a = .1

tcrit = 2.42 tcrit = 1.68 tcrit = 1.30

tstat = .1740/.0362 = 4.81

tstat>tcrit at a=.01 so reject H_0 at a=.01

C.24. –

H_0: $B_7 \geq 0$

H_1: $B_7 < 0$

D.F. 40

a = .01 a = .05 a = .1

tcrit = -2.42 tcrit = -1.68 tcrit = -1.30

tstat = -.0000412/.0000121 = -3.40

tstat<tcrit at a=.01 so reject H_0 at a=.01

C.25. –

H_0: $B_8 \geq 0$

H_1: $B_8 < 0$

D.F. 40

a = .01 a = .05 a = .1

tcrit = -2.42 tcrit = -1.68 tcrit = -1.30

tstat = 1.30/.21 = 6.19

tstat>tcrit so do not reject H_0

C.26. –

H_0: $B_9=0$

H_1: $B_9\neq0$

D.F. 40

a = .01 a = .05 a = .1

tcrit = +/-2.70 tcrit = +/-2.02 tcrit = +/-1.68

tstat = 9.38/31.73 = .30

tcrit<tstat<tcrit so do not reject H_0

C.27. –

H_0: $B_{10}=0$

H_1: $B_{10}\neq0$

D.F. 40

a = .01 a = .05 a = .1

tcrit = +/-2.70 tcrit = +/-2.02 tcrit = +/-1.68

tstat = -.5037/.1583 = -3.18

tstat<tcrit at a=.01 so reject H_0 at a=.01

Wald Test –

C.28. –

H_0: $B_1=0$, $B_2=0$

H_1: Otherwise

SSR_r = 51673.5

SSR_{ur} = 41352.56

D.F.N = 2

D.F.D = 30

a = .01 a=.05 a=.1

Fcrit = 5.39 Fcrit = 3.32 Fcrit = 2.49

Ftest = (51673.5-41352.56)/2)/(41352.56/(41-10-1)) = 3.74

Ftest<Fcrit at a=.05 so reject H_0 at a=.05

Chow test –

C.29. –

H_0: Prior to 2001 = 0

H_1: Prior to 2001 ≠ 0

SSR_r = 41352.56

SSR_{ur} = 26977.03

a=.01

D.F.N = 21

D.F.D = 10

Fcrit = 4.38

Fcalc = ((41352.56-26977.03)/26977.03) * ((41-2*(9+1))/(9+1)) = 1.12

Fcalc<Fcrit so do not reject H_0