Price Elasticity of Hard Drugs
Practical Assignment for
Advanced Methods for Applied Economic Reasoning

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Introduction

Since the beginning of time, mankind has sought out and experimented with various types of narcotics. From ancient and China to Egypt, alcohol and cannabis were widely used [1]. Opiates however have a different history, primarily laying in the ancient Greece and Roman empire, where it's usage was popular, to the Arabians who quickly integrated the usage of opiates in the 8th century into their culture. The Arabs then set up a (very profitable) network of distribution, causing opium to become well-known over the whole old world:

"*Among the remedies which it has pleased Almighty God to give to man to relieve his sufferings, none is so universal and so efficacious as opium.*" - Thomas Sydenham, 17th century English pioneer in medicine

In our current society, much has changed. Narcotics are seen as the opposite of what they were 300 years ago: harmful, addictive and a bane to society. This is most vividly seen in the “War on Drugs”, the American no-nonsense battle against narcotics, raging on for years and costing billions of dollars while ruining thousands of lives. [3]

On the other side of the fence, governments of certain states and countries have been looking for a more fitting solution. The Dutch have a system of 'gedogen', decriminalization, where marijuana usage is permitted. On a small scale experiments with legalized distribution of methadone and hard drugs have been conducted in the Netherlands and similar experiments have taken place in Spain, Germany and Switzerland. States in Canada have been discussing the decriminalization of marijuana [3], and the topic has been a hot issue in the United States for years.

Why would these administrations be experimenting with the legalized distribution of drugs? The main reason is that many of the negative effects commonly associated with drug usage appears to be related to only the prohibition of drugs, contrary to popular belief. The economic costs of battling drug usage in a society that has known it's usage for years is also another factor: it's like trying to bail a sinking ship:

[...] many of the harms typically attributed to drug use are instead due to drug prohibition. This is not to deny that drugs can have powerful effects on the user, nor to deny that drugs differ in some respects from other commodities. But a wide range of outcomes typically thought to result from drug use is far more accurately attributed to the current legal treatment of drugs - **The economics of drug prohibition and drug legalization** [6]

The goal of this paper is to examine the price-elasticity of hard drugs. The main problem regarding the legalization of hard drugs (and drugs in general) is the fear of increased usage and addiction due to lower prices and a higher quality of influencing substances, both effects of legalization. Decriminalization of soft drugs has proved to be working in the Netherlands [5], however the effects of legalization of hard drugs is largely unknown. Society views hard drugs as more dangerous than soft drugs like marijuana, so when prices fall consumption should only see a limited increase due to new users. Consumption of hard drugs should thus theoretically be mostly insensitive to price fluctuations, but how does this work in practice?

In order to examine the relationship between the price of hard drugs, the amount of usage and the number of users, data is required for calculating the effects of (price) fluctuations upon a community. For this reliable data is necessary over a longer period of time.

Coincidently, opium (a hard drug to our current standards) was not always forbidden in the 20th century: in the first half of the previous century the selling of opium was licensed and controlled in the Dutch East Indies. Because of this, and the fact that the Dutch rulers kept a detailed administration of all proceedings, this data is useful for finding the relationship between the price of opium and it's usage. The data used in this paper is from the period 1923-1938, the time of the Dutch 'opiumregie'.

Theoretical background

There has been quite a lot of debate on the topic of legalization of narcotics and other addictive products, there has also been quite a lot of economic research on the topic. Becker and Grossman [8] argue in 'The economic theory of illegal goods' that legalization will primarily affect the upper and middle-class incomes; high 'sin' taxes have less effect if the consumer can afford it, while the lower incomes will still have the same difficulties and illegal trade, as they can't afford the legal, but more costly, narcotics.

In earlier research [9] they also found substantial evidence for rational addiction behaviour with cigarette addiction. A 10% increase in price caused a 7.5% reduction of consumption in the long run, while temporary increases in price do so much less.

The opiumregie began as an experiment in the late 1890's, in an effort to control the import, distribution and selling of opium throughout the Dutch East Indies. Effectively a state monopoly, it took until 1914 until it was introduced throughout the region.

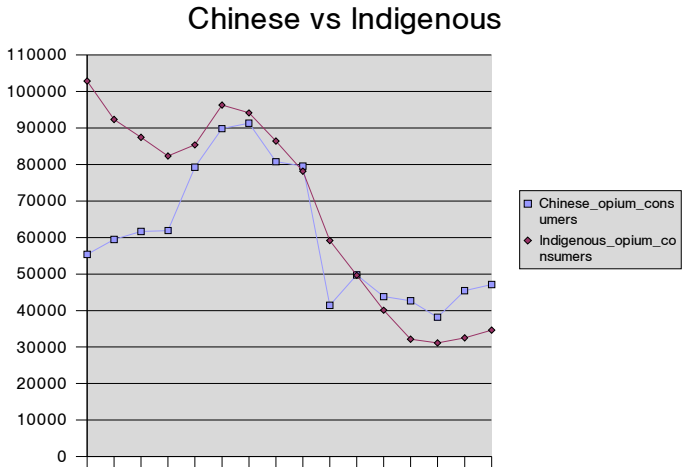
In the data, there is a distinction between the Chinese and Indigenous population's consumption, rightfully so as there is a major difference in opium usage between the two. Van Ours [7] explains that the Chinese immigrants, merely 2% of the population, were primarily active in middle-class industry and trade occupations, giving them a larger income and bringing them more in contact with others, while the Indigenous population mostly kept to themselves and worked mainly in the agriculture sector. The Chinese were effectively a buffer between the Dutch and the Indigenous population, thus the Chinese were in a better position to obtain the necessary licenses for selling opium. In the densely-populated urban areas, the amount of Chinese was high as was the amount of interaction, all reasons why the consumption of opium was as high as it was.

The price of opium was held artificially high and stable to discourage (new) customers. Only in the latter years of the opiumregie was the price reduced substantially, Van Ours [7] states that this probably was because of increased amounts of illegal trafficking, but this doesn't seem very likely seeing the low amounts of opium confiscated. On the other hand, there likely wasn't an active reinforcement considering the amounts involved.

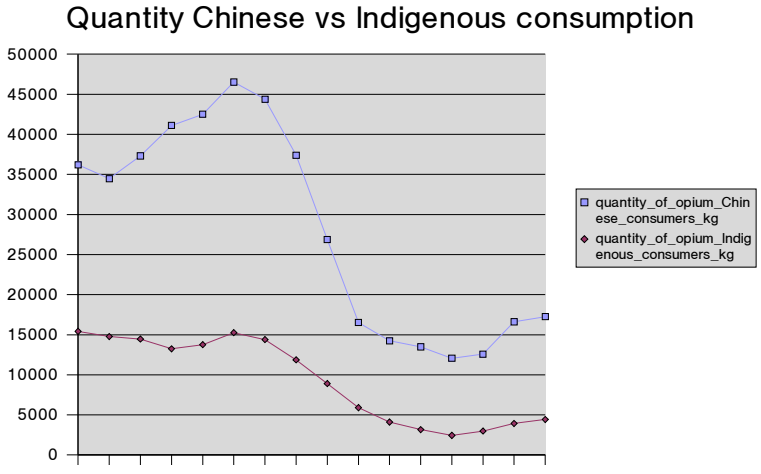
Empirical Analysis

Data Analysis

The data from the opiumregie contains information on the amount of consumption and consumers of both the Chinese and Indigenous population. It also contains price data for the period described. An overview of the population that consumed opium:

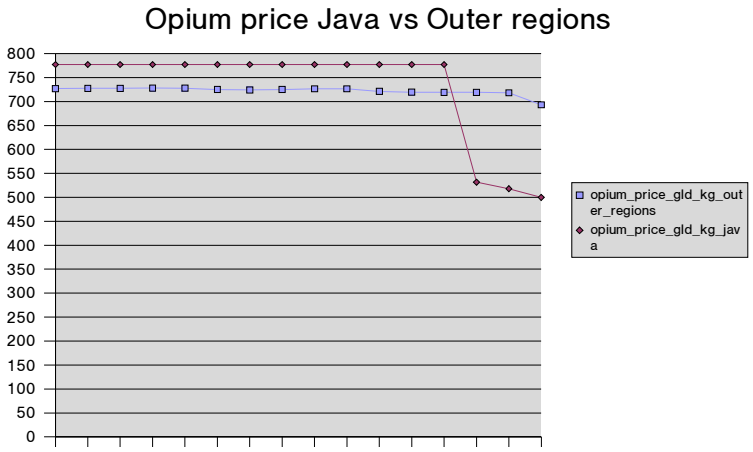


Thus despite only being 2% of the population, the amount of opium users under the Chinese is nearly as much as that of the Indigenous population. The total amount of opium consumed by both groups:



As is clear, consumption of opium by the Chinese immigrant population was a multitude of that of the Indigenous population.

The following graph shows the price fluctuations of opium per year per kilogram:



As you can see, the price doesn't fluctuate very much until the last few years. This drop in price occurs after the drop in both consumption and number of consumers.
For tables containing information about the data see Appendix 1.

Modeling the data

In determining the relationship between consumption and price, a simple linear regression gives us the following details:

$\log(\text{consumption}_{i,t}) = B_0 + B_1 \log(\text{prices}_{i,t}) + U_{i,t}$

$B_0 = 9.179$
$B_1 = -1.453$
$R^2 = 0.1915$

It is clear from R squared that this model has a very poor fit, see the plot in Appendix 2 for a graphical comparison. The price elasticity is high: with this model a price increase means a sharp drop in consumption.

With addictions, naturally a previous periods consumption has a large influence on the current consumption. For this to work the first period has to be dropped from the sample, as it doesn't have a previous period:

$B_0 = 0.5986$
$B_1 = -0.1859$
$B_2 = 0.9550$

$R^2 = 0.9740$

With this inclusion the model has greatly improved compared to the simple linear regression. R squared has jumped close to the 1 (perfect fit) and the residual differences are greatly reduced.

When including a dummy regressor for the region (if the data is from the Java region or from the outer regions), R squared improves slightly (to 0.9742), however assuming that there isn't any interaction between the regions isn't possible. With only a 0.0002 increase in R squared, this is an assumption that isn't worthwhile.

When including the regressors of the income, amount of illegal opium confiscated, autocorrelation can be found using the Breusch-Godfrey test. A policy change happened in 1927, when licensing was made significantly easier, this can be modeled by adding a dummy regressor that is 1 after 1926, and 0 otherwise. When including regressors on the year and policy change this autocorrelation is resolved. The full models are again in Appendix 2. With the inclusion of these regressors R squared increases to 0.9822, a significant improvement of the previous model.

After these improvements, a different step is possible: by taking the first difference of every variable. The model then ends up as:

$\Delta\log(\text{consumption}_{i,t}) = B_1\,\Delta\log(\text{prices}_{i,t}) + B_2\Delta\log(\text{consumption}_{i,t-1}) + B_3\,\Delta\log(\text{incomse}_{i,t}) + B_4\,\Delta\log(\text{illegal opium}_{i,t}) + B_5 + B_6\,D_t + \Delta U_{i,t}$

The trend regressor, being the year of the data, always is one more than that of the year before, and hence is always 1 (and isn't shown next to B_5). D_t is the dummy regressor from the policy change: it is only 1 during data from 1927, and is 0 otherwise, as this delta only is one when the policy change takes place (in all other cases before 1927, the result is $0 - 0 = 0$, in cases after 1927 this becomes $1 - 1 = 0$). The dummy regressor for the various regions would be removed (if used): the value doesn't change, and thus the delta is always 0.

With the above model, there is however a violation of the conditional mean zero assumption: the left-hand side result $\Delta\log(\text{consumption}_{i,t})$ contains $\log(\text{consumption}_{i,t-1})$, which is also on the right-hand side. Thus there is a correlation where there shouldn't be. This can be resolved by using 2SLS (see Appendix 2). This in turn gives us an estimate of the price elasticity: B of the delta of the log of the price becomes -0.5935, which is the relationship between consumption and the price of opium. Thus, for every increase in price, the consumption decreases by a factor of 0.5935.

In order to get an idea of the relation between consumption and the amount and type of consumers, regression is applied against the Chinese data. This gives the following details: (see Appendix 2 for the plot and models)

B_0 = -0.5135
B_1 = 0.2818
B_2 = 1.0750
R^2 = 0.9158

This is then compared to that of the Indigenous population:

B_0 = 1.8957
B_1 = -0.07341
B_2 = 1.0183
R^2 = 0.8977

Using this information, it seems that there is a stronger relation between price and consumption with the Chinese population than that of the Indigenous population.

Conclusions

From the results of the analysis, a number of conclusions can be drawn. The price elasticity of -0.6 is conform a rational addiction, price fluctuations very much influence the consumption rate. A licensing shift caused for a decrease in price, however consumption was decreasing before this period, the downward trend appears to be reduced by the lower prices.

Chinese and Indigenous consumption drop, however the Chinese, with only 2% of the population in 1930, have a very large portion of the consumption. This isn't strange, as hinted before: the Chinese population had a larger income and were living closer together: certainly the acceptance of opium in such a group would have had a considerable effect as seen above. This also strengthens the results of the data that price fluctuations effect Chinese consumption more than that of the Indigenous population.

Naturally, it isn't possible to map these results onto the current Western society. However, as addiction appears to be rational with price fluctuations effecting the amount of consumption in a legalized market, legalization of hard drugs wouldn't be a wise choice. Better prevention, treatment, small-scale distribution to registered addicts and education are methods of reducing the problems around illegal hard drugs, and although societies negative view of opium would reduce the amount of new addicts, there is a relation between opium price and consumption.

References

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http://opiates.net

[3] Drug War Facts
http://www.drugwarfacts.org

[4] Drug Policy Alliance
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[5] Drug Policy Alliance – the Netherlands
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[6] The economics of drug prohibition and drug legalization
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[7] The Price Elasticity of Hard Drugs: The Case of Opium in the Dutch East Indies, 1923-1938
The Journal of Political Economy, Volume 103, Issue 2, Jan C. van Ours

[8] The Economic Theory of Illegal Goods: The Case of Drugs
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[9] An Empirical Analysis of Cigarette Addiction
1990, Becker, Grossman and Murphy for the National Bureau of Economic Research

Appendix 1 – Overview of used data

Opium consumed vs total number of consumers from 1923 to 1938:

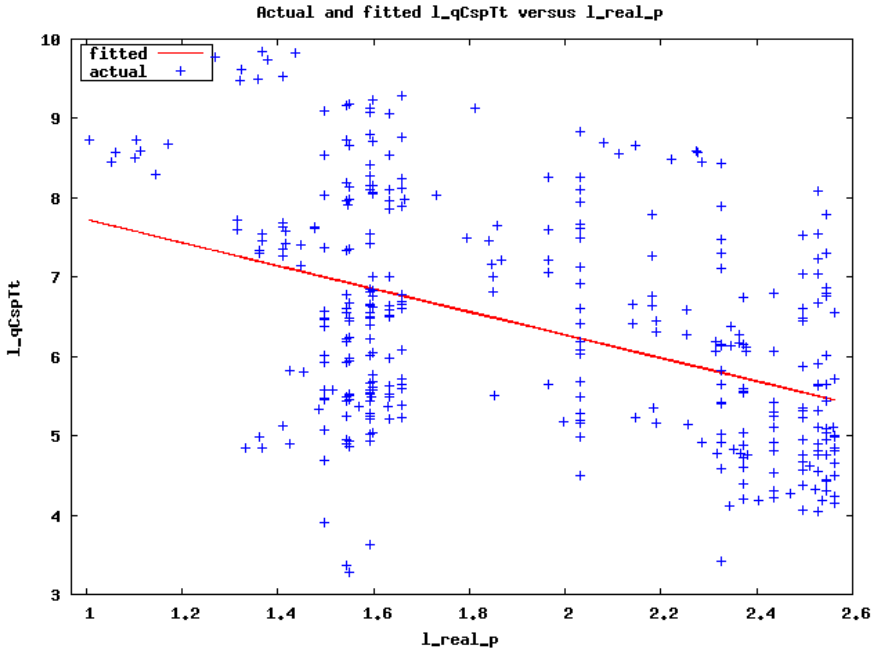
	Total Opium Consumption	Total Opium Consumers	Average Price
1923	51614.6	158220	752.13
1924	49250.5	151786	752.34
1925	51777.6	149091	752.32
1926	54364.5	144268	752.64
1927	56291.7	164620	752.62
1928	61793.4	186114	751.2
1929	58801.6	185413	750.69
1930	49275.5	167200	751.18
1931	35785.3	157699	751.86
1932	22434.1	100540	751.88
1933	18353.8	99365	749.23
1934	16648.3	83861	748.41
1935	14512.3	74833	748.2
1936	15576	69304	625.48
1937	20548.9	77957	618.24
1938	21691.7	81734	596.64
Totals:	37419.99	128250.31	

Amount of illegal opium retrieved during the period. As is clear the amount of illegal opium is minute compared to the total amount of opium consumed:

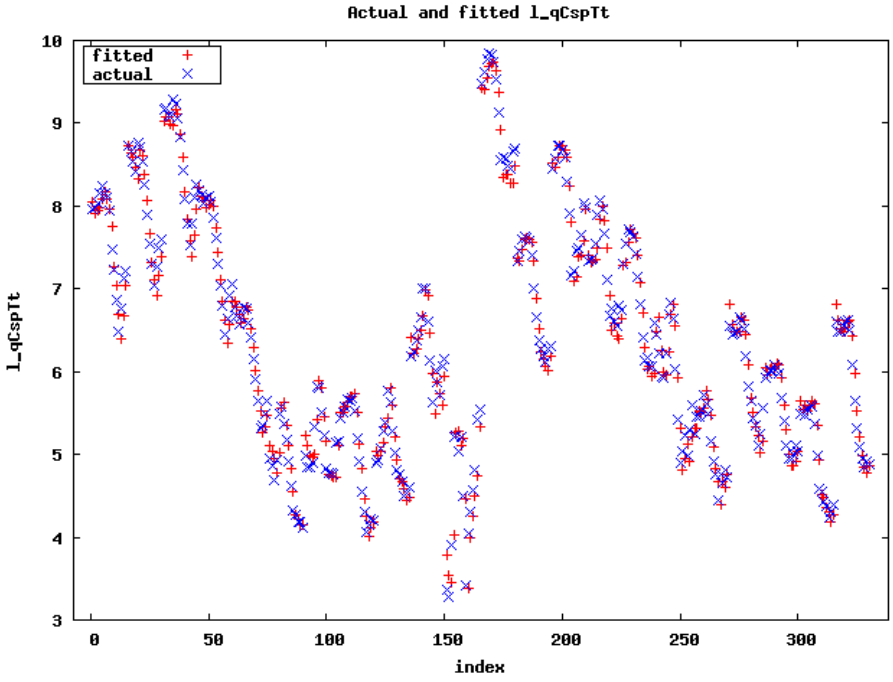
	illegal opium intercepted in kg
1923	447.6
1924	819.6
1925	1291.8
1926	1791.2
1927	1836
1928	826.2
1929	417.6
1930	583.2
1931	242.6
1932	1244.7
1933	504.4
1934	1044.4
1935	1105.6
1936	566.5
1937	340.2
1938	190.6
Average	828.26

Appendix 2 – technical details of analysis

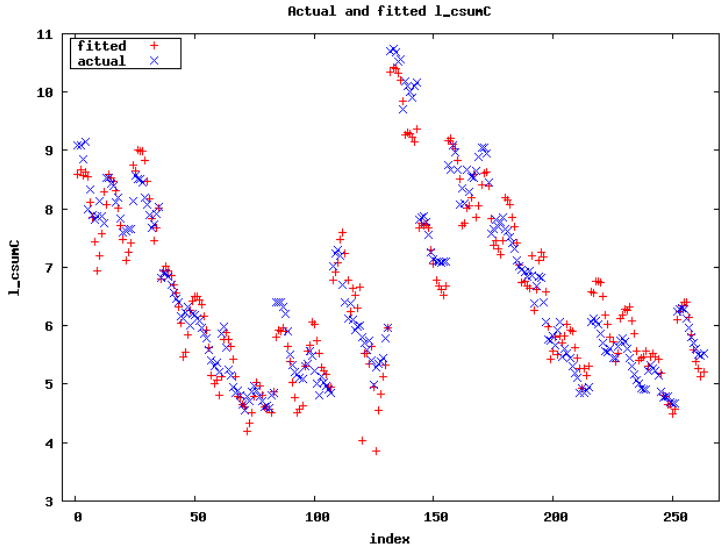
simple linear regression:



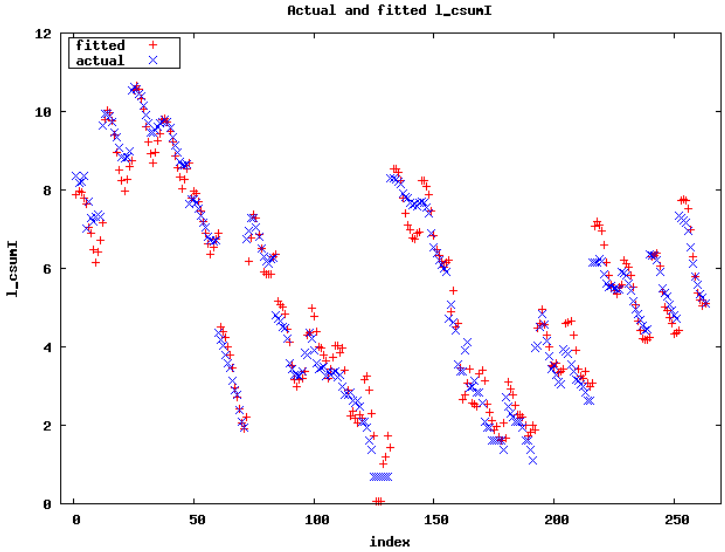
regression using panel data (previous period's consumption):



regression using panel data (previous period consumption with Chinese)



regression using panel data (previous period consumption with Chinese)



Model using panel data of previous years:

$\log(\text{consumption}_{i,t}) = B_0 + B_1 \log(\text{prices}_{i,t}) + B_2 \log(\text{consumption}_{i,t-1}) + U_{i,t}$

Model with income and illegal opium regressors:

$\log(\text{consumption}_{i,t}) = B_0 + B_1 \log(\text{prices}_{i,t}) + B_2 \log(\text{consumption}_{i,t-1}) + B_3 \log(\text{income}_{i,t}) + B_4 \log(\text{illegal opium}_{i,t}) + U_{i,t}$

Model with dummy regressors against autocorrelation:

$\log(\text{consumption}_{i,t}) = B_0 + B_1 \log(\text{prices}_{i,t}) + B_2 \log(\text{consumption}_{i,t-1}) + B_3 \log(\text{income}_{i,t}) + B_4 \log(\text{illegal opium}_{i,t}) + B_5 \log(\text{trend}_{i,t}) + B_6 \log(\text{policy change}_{i,t}) + U_{i,t}$

Model using the first difference of the data:

$\Delta\log(\text{consumption}_{i,t}) = B_1 \Delta\log(\text{prices}_{i,t}) + B_2 \Delta\log(\text{consumption}_{i,t-1}) + B_3 \Delta\log(\text{incomse}_{i,t}) + B_4 \Delta\log(\text{illegal opium}_{i,t}) + B_5 + B_6 D_t + \Delta U_{i,t}$

With:

$\Delta\log(\text{consumption}_{i,t-1}) = y_1 \Delta\log(\text{prices}_{i,t-1}) + y_2 \Delta\log(\text{income}_{i,t-1}) + y_3 \Delta\log(\text{illegal opium}_{i,t-1}) + e_{i,t-1}$

Model with Chinese consumers vs. consumption amount:

$\log(\text{consumption}_{i,t}) = B_0 + B_1 \log(\text{prices}_{i,t}) + B_2 \log(\text{consumptionChinese}_{i,t-1}) + U_{i,t}$

Model with Indigenous consumers vs. consumption amount:

$\log(\text{consumption}_{i,t}) = B_0 + B_1 \log(\text{prices}_{i,t}) + B_2 \log(\text{consumptionIndigenous}_{i,t-1}) + U_{i,t}$