*GASOLINE DEMAND IN THE OECD*

A REPLICATION OF “AN APPLICATION OF POOLING AND TESTING PROCEDURES”, BY BADI H. BALTAGI AND JAMES M. GRIFFIN (1982)

REPLICATION REPORT

by

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1. INTRODUCTION

Gasoline is a very important resource and thus the demand for it is substantial. As there is at least some availability of data in regards to gasoline consumption, price, efficiency and the like, one can analyze the market for gasoline, in order to understand how volatile the price of gasoline is, how the consumers react to the changes in prices (i.e., elasticity of demand), whether countries rely on gasoline more or less than the past and whether countries are using gasoline more efficiently than the past.

On the other hand, another aim of the paper is to investigate whether pooling is useful in the sense that standard errors of the coefficient estimates are lower than individual-country time-series models. To do this, the authors have to pick the right estimation techniques and apply the necessary tests.

To conduct their work on, the authors utilize the dataset of 18 OECD countries and their corresponding gasoline demand for the period 1960 to 1978. Thereby, the authors have two main tasks: 1) Understand the pros and cons of pooling, 2) Understand gasoline demand in the OECD countries.

Our dependent variable is gasoline consumption per car. Our independent variables are per capita income, price of gasoline, number of cars per capita. Additionally, the dynamic models include the lagged dependent variable as an independent variable. The expected relationship is that when per capita income goes up, gasoline consumption per car increases. On the other hand, if either price of gasoline or number of cars per capita goes up (or both), gasoline consumption per car goes down. The reasoning for the former is obvious. For the second, authors explain that when number of cars per capita go up in a family, the family members will not rely on one single car to take themselves to places but on more cars. As a result, the gasoline consumption per car will very likely go down. The lagged dependent variable may be expected to have a positive relationship with the dependent variable; the amount of gasoline consumption per capita today will be similar to that of the past. The implicit assumption is that the efficiency of gasoline consumption is adapted very slowly, hence gasoline consumption per miles driven does not go down so much due to this low adaption rate of a change in gasoline efficiency (especially in the short run, which we can observe from the short run price elasticities of gasoline demand.). Thus, gasoline efficiency is considered constant.

The stylized fact is that countries still relied on gasoline for the period 1960 to 2000 as most studies reported low price elasticities between -0.04 and -0.24. These low elasticity results imply that the demand for gasoline is roughly stable albeit significant price fluctuations. I also think this represents the reality of the given period, as not only few alternative fuels were invented at this period, but also those fuels were not intensively used, since fuels such as gasoline were mainly utilized for the time’s vehicles.

1. LITERATURE REVIEW

As mentioned, most econometric studies found low price elasticities of gasoline demand as in Houthakker, Verleger and Sheehan (1974); Chamberlain (1973); and also Mehta, Narasimham and Swamy (1978). However, there are studies (see Sweeney, 1978) which conversely reported a long-run price elasticity of -0.73. In fact, another important aim of this paper is to observe whether the reports of a pooled inter-country data would be parallel to the findings of Sweeney.

The authors also view gasoline consumption as Sweeney (1978) and Griffin (1979) do. They separate it into three determinants which are gasoline efficiency, utilization and stock of cars. They believe this approach is advantageous because one gets to distinguish the short term and the long term effects. Note that efficiency requires long periods whereas stock of cars and auto utilization may even change substantially in the short run (Baltagi and Griffin, 119).

On the other hand, literature of theoretical econometrics is not clear on when a researcher should pool the data which they are to analyze and what estimation technique they should use. For that, authors seek to understand the consequences of pooling the dataset that they possess and observe the estimations of the estimation techniques that will be described in the Empirical Results of this report. These estimation techniques will be checked whether they are biased, inconsistent and whether we can claim one is better than another for certain datasets, models, error structures (e.g., one-way or two-way) and/or potential correlations existing in a model.

1. DATA

Despite the feasibility of the approach above in the past studies, due to lack of international data limitations, efficiency and utilization are (must be) combined in this study. Utilization (i.e., miles driven per car) divided by efficiency (i.e., miles per unit of gasoline or 1/gasoline consumption per mile) gives total gasoline consumption per auto.

The data is a pooled sample of 18 OECD countries for 1960-1978. One upside of this sample is that income per capita differs significantly among OECD countries and over time. The similar variation can be observed in the relative gasoline prices and number of cars per capita.

Another upside is that there are 5 data points for every country after the 1973 oil crisis which realized as a result of the imposition of embargo by Arab members OPEC. The price fluctuations during that time are worth to be observed.

Bear also in mind that there are significant differences in tax rates imposed on gasoline. See appendix of the original paper for more descriptions and specifications of the data.

The dataset consists of 3 independent variables: 1) Income per capita, 2) Price of gasoline, 3) Number of cars per capita. The natural logarithm is taken of these independent variables and the dependent variable so that one can interpret the coefficients of these independent variables as constant elasticities. In other words, a 1% change in one of the independent variables will induce approximately b% change in the dependent variable.

Countries included are Austria, Belgium, Canada, Denmark, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, Norway, Spain, Sweden, Switzerland, Turkey, U.K., U.S.A.

To prevent confusion, bear in mind that there is no conversion/notation in terms of the numerical values of the independent variables and the dependent variable. Their values are used as they are (i.e., 100,000 = 100K, but the authors directly use the numbers as the left hand side of this equation.).

The sources of the data are given in the appendix of the paper. *OECD’s Energy Statistics* reports total consumption of motor gasoline. OECD’s *National Accounts* reports real per capita income (Y/N). The conversion of gasoline prices denoted with different currencies was not simply an exchange rate conversion. Rather, the authors utilized the purchasing power parities as adjustment factors so as to have a “real” comparison of the costs of gasoline among different countries. The data for the purchasing power parities were taken from by United Nations-Pennsylvania International Comparison Project. Prices of motor gasoline in every country were taken from United Nations-Department of Energy.

1. EMPIRICAL RESULTS

We are trying to explain gasoline consumption per car and our explanatory variables are 1) Income per capita, 2) Price of gasoline, 3) Number of cars per capita.

We have two different models on which we will apply our estimation techniques. The first one is the static model:

The second one is the dynamic model in the form of the Koyck distributed lag model. This model additionally has a lagged dependent variable:

Where a = Constant, GAS = Gasoline consumption, CAR = Number of cars, Y = Income, N = Population, PMG = Price of motor gasoline, PGDP = Price of other goods. On the other hand; each one of b1, b2, b3 and is the coefficient/constant elasticity of the independent variable it is multiplied with. The expected signs of these coefficients are +, -, -, +, respectively.

The estimator techniques are pooled OLS, Within Regression, Between Regression and 5 2-Staged Generalized Least Squares (2SGLS). I only exclude the ‘Wallace and Hussain’, ‘Nerlove’ and ‘MINQUE’ 2SGLS techniques. Further Between Regression is only for Model I and not for Model II. The coefficients of nearly all the explanatory variables turned out to be very significant (\*\*\* in Stata table output) in every estimation technique.

We conduct three tests for further analysis: Roy-Zellner Test (both on MODEL I and MODEL II), Breusch-Pagan Test (both on MODEL I and MODEL II) and Hausman Test (only on MODEL I; because in MODEL II there is a lagged dependent variable which is very likely to be correlated with the unobservable individual country effects.).

Roy-Zellner test is to check the stability of regressions (time-series regressions and cross-sectional regressions). If both of these models are not rejected to be stable, then the data is poolable. Note that the authors carry out this test instead of Chow test because the error term is heteroskedastic. Therefore, type I error may realize, as Chow test on average rejects poolability when it is known that the data is poolable. To conduct a Roy-Zellner test, one should possess unpooled data by interacting regressors with individual dummies. Then, one needs to run a random effect model on the unpooled data. Lastly, one should compare the individual coefficients of both models and test for their equality. Even though poolability is rejected in Roy-Zellner test, the authors pool due to “a priori economic grounds”. They believe that any deemed error structure in the pooled model tends to yield a significant amount of simplification to the actual error structure. Therefore, the tests are not very reliable and hence the authors proceed to pool using the error-component model.

Is the error-component one-way or two-way? In other words, do we have both the individual-country and the time-period effects? For this query, the authors conduct the Breusch-Pagan Lagrange Multiplier test (B-P LM test).

In fact, B-P LM test tests whether there are random effects in the model. In other words, whether random effects model is appropriate to regress or not. The null hypothesis is that there are no random effects. The alternative hypothesis is that there are random effects. We reject the null hypothesis if the p-value is less than 0.05. Otherwise, we cannot reject the null hypothesis as we do not have sufficient evidence to reject it. Note that the chibar2 value (the statistic in the Stata output) in the BP LM test table is the test statistic that should be compared to a chi-squared distribution to obtain the p-value. In our case, the p-value was less than even 0.01. Thus, we reject the null hypothesis as random effect model is an appropriate model. Note that this test does not say anything about the fixed effect model. For that, we will conduct the Hausman Specification test.

The other B-P LM test conducted by the authors has the null hypothesis that the error components model is a one-way model and the error term is homoscedastic. The alternative hypothesis is that the error components model is a two-way model and the error term is heteroscedastic. The alternative hypothesis means that there exist both individual-country and time-period effects in the error components model. The results support the authors’ prior belief that solely country effects are significant hence one-way error components model is the way to go.

Last but not least, Hausman Specification test (Durbin-Wu-Hausman test) was applied to MODEL I. The question to get an answer for was whether there is correlation between the unobservable individual-country effects and the exogenous variables. Given the variation in the price elasticity estimates of static model that ranges from -0.32 (Within) to -0.89 (OLS), this test is considered important. The expected result of the test is that there is correlation. Thus, the null hypothesis is that there is no correlation between the unobservable individual-country effects and the exogenous variables in the static model. The reasoning is that in the countries where there is a “nudge” to use small cars, bicycles, public transportation and the like, there are also unobservable factors such as the compactness of the cities, the narrowness of the streets, the few numbers of multi-lane highways and high numbers of quality cycle routes which also reinforce the decline of gasoline consumption, apart from the fact that these countries have relatively higher gasoline prices. In fact, the expected result of the test becomes reality, as the null hypothesis is rejected. We conduct this test for both random effect estimation techniques Amemiya and Swamy&Arora separately. As per the results of the test, we prefer the fixed effect model over these random effect models.

One should also note that there is a dramatic increase in R2 and Adjusted R2, after Model I becomes Model II when the lagged dependent variable is included (from 0.85s to 0.98s in both measures). Thus, focusing on Model II may be appropriate. Given the regression results, the highest adjusted R2 values for Model I are observed in OLS and Between regressions. In our dynamic model which is Model II, again the highest adjusted R2 is in OLS.

1. CONCLUSION

There were 3 methodological questions raised at the beginning of the paper. The first one was about the consequences of pooling. This paper suggests that pooling is indeed very beneficial individual-country time-series datasets. The reason is the coefficient estimates differ dramatically among countries, thereby, the standard errors are large. Without pooling, one may even conclude that significant explanatory variables such as price of gasoline and income per capita are insignificant. By the virtue of pooling the sample, we attain reasonable income and price elasticities with much lower standard errors.

The second question is about which pooling technique is appropriate, particularly for the given dataset. Given that we observe that the coefficients of the estimators are substantially affected by whether they are intercountry or intra-country data, we needed understand the error structure of the model since there may be individual-country and/or time-period effects. Further, by conducting the B-P LM test, we concluded that the model is a one-way error-components model with only country effects being significant.

The third question is about the how the tests conducted on the pooled models should be interpreted. Several tests are conducted to understand which model is biased and/or inconsistent and/or worse than some other model, etc. For instance, Hausman Specification Test was conducted to compare the models at hand. One rule of thumb is if OLS and GLS estimators are similar, then one can simply prefer GLS over OLS. If dissimilar, the country-specific effects are very likely to be correlated with at least one of the independent variables. If the correlation is systematic, OLS is more appropriate. If the correlation is temporary and spurious then GLS can be still the preferred estimator.

Additionally, one other important discussion is on the price elasticity of gasoline demand. The authors compare their results with those of Sweeney (1978), as Sweeney’s results created a conflict on whether the price elasticity of gasoline demand is low or high. Wherefore, the authors particularly were interested in whether their result would support Sweeney’s findings or other authors’ findings. After pooling, the intercountry sample advocated that the long run price elasticity is in between -0.6 and -0.9. This implies that the adaptation rate is indeed slow.

A possible policy implication of the results is that the slow adoption rate of gasoline efficiency should be improved given the fact that gasoline is still a fundamental resource of the society. Owing to this, oil would be consumed more efficiently and thus demanded less. This would be economically very beneficial for gasoline net-importers. They also would be less damaged in oil supply shocks (as transpired in Oil Crisis of 1973) since they would rely on less gasoline. More fundamentally, investment in alternative fuels has an utmost significance so as to not be ‘addicted’ to gasoline. Price elasticity results of this paper and those of Sweeney (1978) go hand in hand and indicate how the OECD countries can be disrupted due to gasoline price fluctuations as per the analysis conducted. In other words, the price elasticity of gasoline demand is high in absolute terms and needless to say, negative. This can be interpreted as the following: The OECD countries do rely on gasoline yet when its price increases citizens of those countries find alternative ways to carry on with their lives. One interesting topic to investigate would be how the volume of public transportation usage changes when gasoline prices fluctuate. Is the change sufficiently significant to conclude that people would opt for public transportation when gasoline price increases and private transportation when gasoline price decreases? Would this alternation have any negative and/or positive externalities? Can one conclude one means of transportation is better than the other according to their main objective (e.g., long term economic growth of their country)?

**REFERENCES**

Baltagi, B. H., & Griffin, J. M. (1983, July). Gasoline demand in the OECD. *European Economic Review*, *22*(2), 117–137. <https://doi.org/10.1016/0014-2921(83)90077-6>