Export Elasticity Estimate
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Power to Ontario.
On Demand.

Estimating the Price Elasticity of Export Demand in the Ontario Electricity Market

This note describes the analytical approach used to derive an elasticity estimate for exports from the Ontario market to the New York market.

Background

The price difference between Ontario and New York determine the export quantities to the New York market. Absent any impediments to trade, the trader buys power in the low priced market and sells power into the high priced market. A negative supply shock to the Ontario market causes the HOEP to increase relative to the New York price. This in turn induces less export from Ontario to New York. Initially and immediately after the supply shock we expect the price gap to deviate from its pre-shock equilibrium level. As the New York market receives less export from Ontario, there is upward pressure on the price in New York. Eventually the price in New York rises to the point where the price gap between Ontario and New York narrows and may, in the long-run, return to its pre-shock equilibrium level. The eventual price change in the New York market depends on the supply elasticity in the New York market. In the long-run fundamental market characteristics determine the equilibrium price gap.

Data

The sample period is January 2003 to October 2006.The monthly average data used are export volume in the market schedule, the HOEP (Hourly Ontario Electricity Price) and the New York (Zone West) price. The Ontario-New York interface was chosen because 80 to 85 per cent of export transactions occur over that interface.

Methodology

The intuitive idea is to find a function that relates export volume to HOEP and the New York price. Economic theory posits an inverse relationship between the quantity of a good and the price of the good[1]. Arbitrage theory indicates that export volume responds to price differences. An individual exporter shows his willingness to buy electricity at different prices through his export bids. An aggregation of all export bid curves yields an aggregated bid curve which is essentially the export demand curve. This export demand curve shows the market quantity of export volume at different HOEP levels while keeping other things equal. The diagram below shows this relationship.

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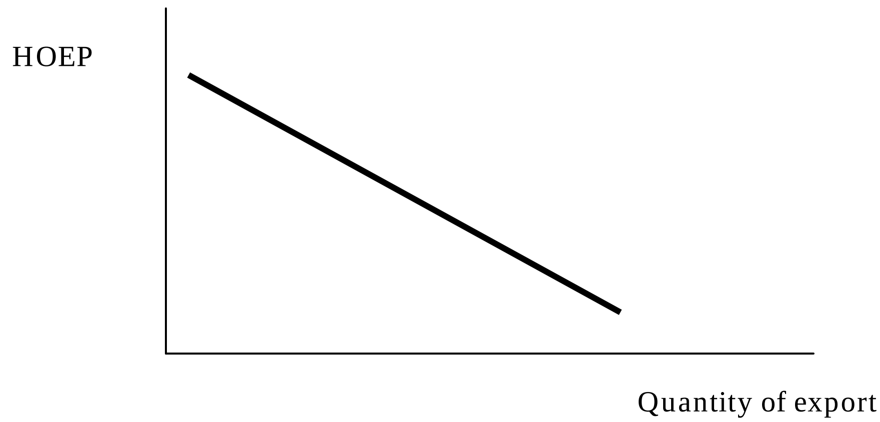
[1] To be precise this relationship holds for what economists refer to as a normal good. A normal good is a good whose demand increases when income increases i.e. a good with a positive elasticity of income.

Figure 1: Relationship Between Export Volume and Price, Other Things Equal



The demand curve shows the relationship between the price (HOEP) and the quantity purchased (export volume) keeping all other variables fixed, including the New York price. This means that the *only* variable that causes the export quantity to move *along* the demand curve is the HOEP. This also suggests that in our analysis we need to find a way to keep all other variables constant. Once we do that we can then identify the marginal impact of a change in HOEP on export volume. This kind of marginal analysis is what econometric analysis offers. In this analysis to keep other things equal, we include variables that control for both supply and demand shifts in the model. For example the Ontario non-dispatchable load is included to control for demand shifts that causes the HOEP to change. The price of natural gas is included to control for supply changes that also cause the HOEP to change. It is critical to control for these shifts because we want to separate these shifts from movements along the demand curve.

Details

Exports are expressed as a function of the HOEP, the New York price, monthly binary variables and a time trend variable. The parameters of the model are estimated using techniques ranging from Ordinary Least Squares (OLS) and Two Stage Least squares (TSLS). The instruments used are Ontario non-dispatchable demand, nuclear generation output, output from self-scheduler generation, the price of natural gas, the New York integrated load and a time trend. The monthly binary variables serve as self-instruments. The idea behind the methodology used is to find instruments that are correlated with the HOEP and the New York price but uncorrelated with the disturbance term in the export equation. In performing this analysis and evaluating the usefulness of the methodology we are interested in finding good instruments that can yield orthogonal error decompositions. Econometric techniques guide us to select the most appropriate instruments and the most relevant estimation method.

Results

The results of the analysis indicate that the preferred estimates are obtained using the TSLS (Two Stage Least Squares) technique. The point estimate is negative **4.7**, with a 95% confidence interval around this estimate of negative **6.3 to negative 2.9**. Using the TSLS point estimate of negative **4.7**, we would infer that a 1% increase in the average monthly HOEP (with no change in the New York price) would lead to a roughly **5%** reduction in average monthly exports to New York.

Appendix

Elasticity Measure

The elasticity measure is simply a metric that allows us to calculate the percentage change in one variable (say, quantity) as a result of a percentage change in another variable(say price). In our analysis we specified a function in logarithmic form. One of the advantages of doing so is that the coefficient of the variable in the function then yields a direct measure of the elasticity.

Consider the export demand function below:

$$\log(\text{export}) = \lambda_0 + \lambda_1 \log(hoep) + \lambda_2 \log(nyprice) + \varepsilon \quad \textbf{[1]}$$

The elasticity measure indicates the percentage change in export volume that results from a percentage in the *hoep*. To show that the elasticity of export with respect to the *hoep* is actually equal to λ_1 (that is the coefficient on hoep in the model), take the first derivative of the function with respect to *hoep*. This yield

$$\frac{1}{\text{export}} * \frac{d(\text{export})}{d(\text{hoep})} = \lambda_1 * \frac{1}{\text{hoep}}$$

Rearranging terms we have,

$$\lambda_1 = \frac{d(\text{export})}{\text{export}} \bigg/ \frac{d(\text{hoep})}{\text{hoep}}.$$

Therefore λ_1 yields the percent change in export relative a per cent change in *hoep*. This is exactly the definition of the price elasticity of export with respect to the *hoep*.

Choice of Functional Form

The choice of functional form for the export model depends on the feasibility of the specified model as well as the economic theory behind its specification. To formally test whether the data were consistent with a log-log specification we first estimated equation [2].

$$\text{export} = \lambda_0 + \lambda_1 \log(hoep) + \lambda_2 \log(nyprice) + \lambda_3 hoep + \lambda_4 nyprice + \varepsilon \quad \textbf{[2]}$$

Next we conducted the following tests:

[A] $H_0 : \lambda_1 = \lambda_2 = 0$
[B] $H_0 : \lambda_3 = \lambda_4 = 0$

The result of this analysis showed that the data were indifferent between the two functional forms (i.e. log-log or linear form). Economic theory however led us to select the log-log specification. To see this we have to express the equation in a different way. Some algebraic manipulation results in the following expression:

$$\text{export} = \frac{e^{\lambda_0} e^{\varepsilon}}{hoep^{-\lambda_1}}$$

In this expression as hoep increases to a large number, quantity decreases to zero. Similarly as hoep decreases to a very small number, quantity of export increases to a large number. The properties of this functional form captures the essential properties of a demand curve as discussed in the main text.

In addition we also performed the Ramsey Regression specification test and this indicated that the functional form of the model was stable. Based on all the above evidence we chose the log-log model specification for the analysis.

Estimation Technique

Ordinary Least Squares (OLS) is a technique that is commonly used to estimate the parameters of the specified model. OLS works well when the explanatory variables are uncorrelated with the error term in the equation and when the error term, on average, equals zero. In our analysis, the former requirement is not satisfied because the HOEP variable is correlated with the error term in equation [1]. In practice this means a shock to HOEP simultaneously changes Export volume. To address this issue we use the technique of Two-Stage Least Squares (TSLS). With this technique we use variables (called instruments) that are correlated with HOEP but uncorrelated with the error term in [1] to derive a consistent estimate of λ_1, the elasticity of export. We use the F-test to select the instruments and we use the Sargan test to check for the orthogonality condition.