rEDM: An R package for calculating price changes due to an exogenous shock.

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Summary

Fairly central to economic theory is the fact that if the quantity in the market is either higher or lower than expected, there will be a corresponding price response. If the supply and demand functions are known, finding the change in price is a trivial exercise. If the exact functions are unknown or if there are multiple commodities, the task of finding the price changes is more involved.

A partial equilibrium approach (as opposed to a general equilibrium approach) uses only the immediately relevant supply and demand function information to find the price change. If the supply and demand functions are unknown, but elasticities are known or can be estimated, an Equilibrium Displacement Model (EDM) can be used to calculate the price changes. Researchers using the EDM are generally expected to have derived their model and often use Microsoft Excel to calculate the price change. At best, a model is derived and specific equations are written in a program such as MATLAB. Both approaches are fraught with opportunties for careless errors.

rEDM skips the deriving part of the exercise (though the analyst would need to understand this portion of the analysis to ensure that the model built by rEDM is the correct model to use) and builds a particular type of EDM. rEDM can build a linear market with a single vertical level.

For example, if one were analyzing impacts in corn, soybeans, wheat, rice, and peanuts markets from a type of wildlife damage, the analyst may choose to consider many locations for production (horizontal) and many markets (horizontal), but cannot use this model for multiple links in the value chain (vertical). If most of the damage happens on the farm, it would be appropriate for the analyst to consider farms as producers and all market players who purchase the product from the farmers as consumers (even if they do not directly consume the product).

Mathematics and Example

This section presents a mathematical representation of an EDM with an example and demonstrates rEDM along the way.

For illustration purposes, we will assume the market discussed herein is for commodity k at the farm gate. The commodities denoted by k are corn, soybeans, wheat, rice, and peanuts. At the core of this relationship is the idea that there is a market where conditions of perfect competition for both buyers and sellers holds. A single national market demands each crop k. Derived demand for commodity k is defined as:

$$Q_k^D = D_k(P_k^D, C_k)$$

where Q_k^d is the quantity demanded of product k and is a function of its own price (P_k^d) and an exogenous demand shock (C_k). Supply is defined for product k in two regions (ω): states where no treatment occurs (NT) and a region with treatment (WT).

Equation 2 describes the structural relationship for quantity supplied for the various crops:

$$Q^f_{k,\omega} = f_{k,\omega}(P^f_{corn}, P^f_{soy}, P^f_{wheat}, P^f_{rice}, P^f_{peanuts}, B_{k,\omega}).$$

$Q^f_{k,\omega}$ is the quantity supplied of product k in region ω. $B_{k,\omega}$ is the exogenous shock to supply.

Export and import functions are similar to the implementation of those categories by [**?**]. Exports (X) and imports (I) are modeled as functions of the world price P^W_k for the respective commodities:

$$Q^I_k = I_k(P^W_k)$$

$$Q^X_k = X_k(P^W_k)$$

A single price for all regions of the United States and the world was assumed.

$$P^W_k = P_k.$$

Market clearing conditions are found with the following equations:

$$Q^D_k + Q^X_k - Q^I_k = Q^f_{k,WPR} + Q^f_{k,AOS}$$

and

$$P^f_{k,\omega} = P^D_k = P_k \;\forall\; k \; and \; \omega.$$

The EDM is operationalized by the following steps.

The price elasticity of demand (ε_k)of product k is defined as the percent change in quantity demanded divided by the percent change in price.

$$\varepsilon_k = \frac{\%\Delta Q^D_k}{\%\Delta P_k} = \frac{\partial D}{\partial P^d_k} \times \frac{P^d_k}{D}$$

The equations are logged.

$$\ln Q^d_k = \ln D_k(P_k, C_k)$$

$$\ln Q^s_{k,FRS} = \ln S_{k,FRS}(P_{corn}, P_{soy}, P_{wheat}, P_{rice}, P_{peanuts}, B_{k,FRS})$$

$$\ln Q^s_{k,AOS} = \ln S_{k,AOS}(P_{corn}, P_{soy}, P_{wheat}, P_{rice}, P_{peanuts}, B_{k,AOS})$$

They are then totally differentiated.

$$d\ln Q^d_k = \frac{\partial Q^d_k}{\partial P_{corn}} d\ln P_k + \frac{\partial Q^s_k}{\partial C_k} d\ln C_k$$

$$d\ln Q^s_{k,FRS} = \frac{\partial Q^s_{k,FRS}}{\partial P_{corn}} d\ln P_{corn} + \cdots + \frac{\partial Q^s_{k,FRS}}{\partial P_{Peanuts}} d\ln P_{Peanuts} + \frac{\partial Q^s_{k,FRS}}{\partial B_k} d\ln B_k$$

$$d\ln Q^s_{k,AOS} = \frac{\partial Q^s_{k,AOS}}{\partial P_{corn}} d\ln P_{corn} + \cdots + \frac{\partial Q^s_{k,AOS}}{\partial P_{Peanuts}} d\ln P_{Peanuts} + \frac{\partial Q^s_{k,AOS}}{\partial B_k} d\ln B_k$$

The relative change operator, E, elasticities of demand ($\eta_{Y,X}$), and supply ($\epsilon_{Y,X}$) are substituted. The result is the following EDM. First in a condensed form,

$$EQ^d_k \;= \eta_{k,k} * EP^d_k + EC_k$$

$$EQ^s_{k,\omega} = \varepsilon_{k,k,\omega} EP^s_{k,\omega} + \sum_k \varepsilon_{k,j,\omega} EP^s_{k,\omega} + EB_{k,\omega}.$$

The supply equations written individually with abbreviated crop names on the price changes:

$EQ^s_{corn,AOS} = EP_c * \epsilon_{AOS,cc} + EP_p * \epsilon_{AOS,cp} + EP_r * \epsilon_{AOS,cr} + EP_s * \epsilon_{AOS,cs} + EP_w * \epsilon_{AOS,cw} + B_{AOS,c}$
$EQ^s_{corn,FRS} = EP_c * \epsilon_{FRS,cc} + EP_p * \epsilon_{FRS,cp} + EP_r * \epsilon_{FRS,cr} + EP_s * \epsilon_{FRS,cs} + EP_w * \epsilon_{FRS,cw} + B_{FRS,c}$
$EQ^s_{soy,AOS} = EP_c * \epsilon_{AOS,sc} + EP_p * \epsilon_{AOS,sp} + EP_r * \epsilon_{AOS,sr} + EP_s * \epsilon_{AOS,ss} + EP_w * \epsilon_{AOS,sw} + B_{AOS,s}$
$EQ^s_{soy,FRS} = EP_c * \epsilon_{FRS,sc} + EP_p * \epsilon_{FRS,sp} + EP_r * \epsilon_{FRS,sr} + EP_s * \epsilon_{FRS,ss}, EP_w * \epsilon_{FRS,sw} + B_{FRS,s}$
$EQ^s_{wheat,AOS} = EP_c * \epsilon_{AOS,wc} + EP_p * \epsilon_{AOS_wp} + EP_r * \epsilon_{AOS_wr} + EP_s * \epsilon_{AOS_ws} + EP_w * \epsilon_{AOS_ww} + B_{AOS_w}$
$EQ^s_{wheat,FRS} = EP_c * \epsilon_{FRS,wc} + EP_p * \epsilon_{FRS,wp} + EP_r * \epsilon_{FRS,wr} + EP_s * \epsilon_{FRS,ws} + EP_w * \epsilon_{FRS,ww} + B_{FRS,w}$
$EQ^s_{rice,AOS} = EP_c * \epsilon_{AOS,rc} + EP_p * \epsilon_{AOS,rp} + EP_r * \epsilon_{AOS,rr} + EP_s * \epsilon_{AOS,rs} + EP_w * \epsilon_{AOS,rw} + B_{AOS,r}$
$EQ^s_{rice,FRS} = EP_c * \epsilon_{FRS,rc} + EP_p * \epsilon_{FRS,rp} + EP_r * \epsilon_{FRS,rr} + EP_s * \epsilon_{FRS,rs} + EP_w * \epsilon_{FRS,rw} + B_{FRS,r}$
$EQ^s_{peanut,AOS} = EP_c * \epsilon_{AOS,pc} + EP_p * \epsilon_{AOS,pp} + EP_r * \epsilon_{AOS,pr} + EP_s * \epsilon_{AOS,ps} + EP_w * \epsilon_{AOS,pw} + B_{AOS,p}$
$EQ^s_{peanut,FRS} = EP_c * \epsilon_{FRS,pc} + EP_p * \epsilon_{FRS,pp} + EP_r * \epsilon_{FRS,pr} + EP_s * \epsilon_{FRS,ps} + EP_w * \epsilon_{FRS,pw} + B_{FRS,p}$
Market clearing conditions are not quite as straight forward to derive.
Again, market clearing conditions are:

$$Q^d_k + Q_{k,export} - Q_{k,import} = Q^s_{k,FRS} + Q^s_{k,AOS}.$$

Due to the addition involved, the desired effect of logging the equation will not work. So we begin by moving exports and imports to the right and totally differentiating:

$$dQ^d_k = -\frac{\partial Q^d_k}{\partial Q_{k,export}} dQ_{k,export} + \frac{\partial Q^d_k}{\partial Q_{k,import}} dQ_{k,import} + \frac{\partial Q^d_k}{\partial Q^s_{k,FRS}} dQ^s_{k,FRS} + \frac{\partial Q^d_k}{\partial Q^s_{k,AOS}} dQ^s_{k,AOS}.$$

Instead of logging to get the effect of a relative change operator we multiply each term by one where, $1 = x/x$.

$$\frac{dQ^d_k}{dQ^d_k} * dQ^d_k = -\frac{Q_{k,export}}{Q_{k,export}} * \frac{\partial Q^d_k}{\partial Q_{k,export}} dQ_{k,export} + \frac{Q_{k,import}}{Q_{k,import}} * \frac{\partial Q^d_k}{\partial Q_{k,import}} dQ_{k,import} + \frac{Q^s_{k,FRS}}{Q^s_{k,FRS}} * \frac{\partial Q^d_k}{\partial Q^s_{k,FRS}} dQ^s_{k,FRS} + \frac{Q^s_{k,AOS}}{Q^s_{k,AOS}} * \frac{\partial}{\partial Q^s_{k}}$$

By substitution,

$$\frac{\partial Q^d_k}{\partial Q_{k,export}} = \frac{\partial Q^d_k}{\partial Q_{k,import}} = \frac{\partial Q^d_k}{\partial Q^s_{k,FRS}} = \frac{\partial Q^d_k}{\partial Q^s_{k,AOS}} = 1.$$

We also substitute E for $\frac{dQ^d_k}{Q^d_k}$ as the relative change operator for each term. These substitutions leave:

$$dQ^d_k * EQ^d_k = -Q_{k,export} * EQ_{k,export} + Q_{k,import} * EQ_{k,import} + Q^s_{k,FRS} * EQ^s_{k,FRS} + Q^s_{k,AOS} * EQ^s_{k,AOS}.$$

We can then divide each side by Q^d_k leaving:

$$EQ^d_k = \frac{-Q_{k,export}}{dQ^d_k} * EQ_{k,export} + \frac{Q_{k,import}}{dQ^d_k} * EQ_{k,import} + \frac{Q^s_{k,FRS}}{dQ^d_k} * EQ^s_{k,FRS} + \frac{Q^s_{k,AOS}}{dQ^d_k} * EQ^s_{k,AOS}.$$

Further simplifying, replace $\frac{Q_{k,import}}{Q^d_k}$ with $s_{import,k}$, $\frac{Q_{k,export}}{Q^d_k}$ with $s_{export,k}$, $\frac{Q^s_{k,FRS}}{Q^d_k}$ with $s_{FRS,k}$ and $\frac{Q^s_{k,AOS}}{Q^d_k}$ with $s_{AOS,k}$:

$$EQ_k^d = -s_{export,k} * EQ_{k,export} + s_{import,k} * EQ_{k,import} + s_{FRS,k} * EQ_{k,FRS}^s + s_{AOS,k} * EQ_{k,AOS}^s.$$

The single price assumption stated earlier is maintained.

$$EP_{k,\omega}^s = EP_k^d = EP_k \ \forall \ \ k.$$

The individual supply and demand equations can then be substituted into the equilibrium condition equation. This results in a system of five equations.

Citations

References

R Markdown

This is an R Markdown document. Markdown is a simple formatting syntax for authoring HTML, PDF, and MS Word documents. For more details on using R Markdown see http://rmarkdown.rstudio.com.

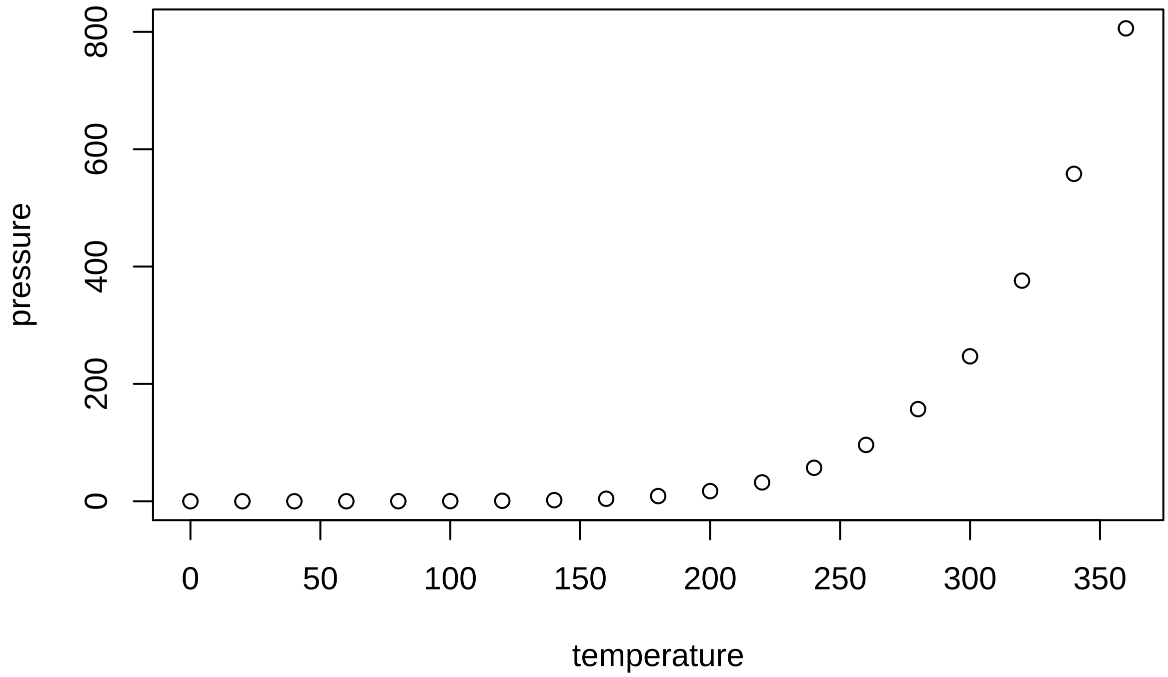
When you click the **Knit** button a document will be generated that includes both content as well as the output of any embedded R code chunks within the document. You can embed an R code chunk like this:

```
summary(cars)
```

```
##      speed           dist       
##  Min.   : 4.0   Min.   :  2.00  
##  1st Qu.:12.0   1st Qu.: 26.00  
##  Median :15.0   Median : 36.00  
##  Mean   :15.4   Mean   : 42.98  
##  3rd Qu.:19.0   3rd Qu.: 56.00  
##  Max.   :25.0   Max.   :120.00
```

Including Plots

You can also embed plots, for example:



Note that the `echo = FALSE` parameter was added to the code chunk to prevent printing of the R code that generated the plot.