# Causality Analysis for Price on Sales Quantity for Elasticity Pricing

**To motivate a pricing decision the potential revenue needs to be evaluated. By analyzing the causal effects that a price change has on sales quantity one can estimate the price elasticity of sales quantity, to use as a guideline for pricing. In this Master Thesis price causality effects on sales quantity is analyzed, on product data provided by a food packaging company.**

PRICE ELASTICITY OF DEMAND is a measure of the sensitivity of sales volume caused by a change in price. More exactly the percentage change in sales given a 1% change in price. For consumer goods this elasticity is often negative. The price elasticity of demand can be used to maximize profit, which in simple terms is the product of price and quantity and assuming the demand curve is somewhat linear the revenue is a concave function with a maximum as seen in the figure below.
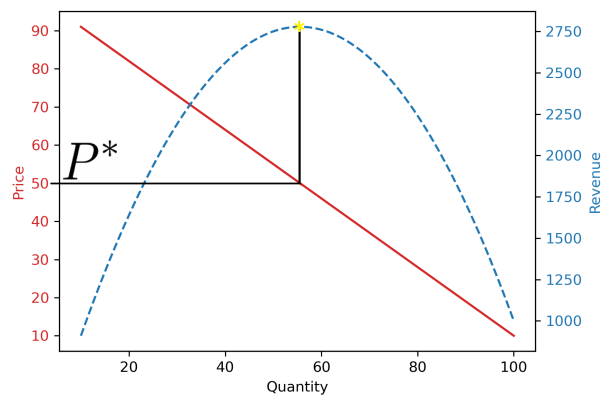


With the goal of maximizing the profits an estimation of the elasticity can be done to find the maximizing price. One way of finding the elasticity is to use historical price and sales data to make an estimation, for instance through a linear regression. However this model finds a correlation and not a causal relationship, this means that under the presence of bias such as from confounding variables, the estimation is not a good estimation of what will happen if an intervention is made on the price, since both the price and quantity can be influenced by a third variable that in fact creates the correlation. To analyze the causal effects *Causal Inference* needs to be conducted.

GRANGER CAUSALITY was proposed in 1969 by Granger Clive as a hypothesis test if one time series is useful for forecasting another. Granger argued that predictive performance could be used in economics to measure causality, but it is not necessarily true causality due to the *post hoc ergo propter hoc* fallacy. However White and Lu (2010) argued that if all confounding effects are controlled for, Granger Causality equals true causality. In this the-

sis, Granger Causality is used to determine what came first, the chicken or the egg, price change or change in quantity. Also to investigate if there are any significant time delayed effects.

STRUCTURAL EQUATION MODELS (SEM) uses theory of Bayesian models and directed acyclic graphs to model a proposed causality structure. It is used to model causal structures and if confounding effects are included the estimation can be seen as a true causal estimation. SEM also allows for latent variables, which means that variables that can not or were not measured can be included and estimated, using indicator variables. In this thesis the latent variable Demand is estimated which is essentially the end retail demand with indicator variables from macro data, consumer price index and retail sales index for food and beverages. The proposed causal structure can be seen in the figure below.
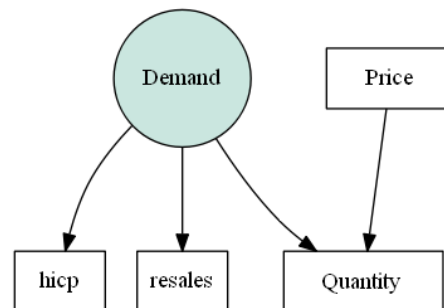


RESULTS FROM THE ANALYSIS suggest that some confounding effects exist between the price and quantity because for most of the products that were analyzed the new elasticity estimates using SEM models were pushed closer to zero. The price data was however not of sufficient range and it therefore was difficult to prove a significant causal effect when parameter estimates were close to zero. It was however discovered that the elasticities are in fact much lower than previously thought, and it was successfully illustrated how one can model confounding effects, even from variables that were not directly measured, by including suitable indicator variables to improve the estimation of the causal effects of price on quantity.

————Johan Ljung, 06-06-2022————