Unravelling Quantity Discounts

or: How to Gain more Insight into Supplier Cost Mechanisms and Make a Better Job of Negotiating

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Summary

Selling organizations often offer Quantity Discounts Schedules (QDS), but do not provide the underlying Quantity Discount Price Functions (QDPF). In literature an analysis on how QDPF could be derived from QDS is lacking. This is remarkable as QDPF contain a wealth of information for buying organizations. QDPF give more insight into the fixed and variable costs of selling organizations and can be a useful tool in the negotiation process for buying organizations. Furthermore, QDPF can be used for calculating and allocating price savings in group purchasing. In this paper we introduce one general QDPF defined by three parameters. These parameters can be easily derived from all different types of QDS. We prove that our QDPF is highly reliable by empirically testing it on 66 QDS. Finally, we compare the QDPF parameters of the 66 QDS and discuss their basic properties and the range and density of demand elasticity.

Keywords

Quantity Discounts; Price Function; Demand Elasticity of Price

Introduction of the topic

Quantity discounts have been used and discussed for centuries (Elmaghraby, 2002). Buying organizations often expect a price break for purchasing large amounts (Nason, 1983). Selling organizations often offer Quantity Discounts Schedules (QDS). Charging a higher price per unit for the first units sold allows covering fixed costs, while discounts increase efficiency as large customers are priced closer to marginal costs (Miravete, 1999). In contrast to Munson (1998) we also claim that a lower price due to quantity discounts could increase demand given a high price elasticity of demand. Marketing channel literature also suggests that the optimal reaction of sellers facing a decrease in costs is to pass some of the savings to their customers what could increase demand (Chan, 2003). More specific motivations for QDS are (Buchanen, 1953):

(1) Achieving perfect price discrimination against a set of homogenous customers;
(2) Achieving partial price discrimination against a set of heterogeneous customers;
(3) Influencing the buyer’s ordering pattern to increase the logistics system efficiency or to coordinate between levels in a channel of distribution and lower costs.

Practitioners encounter different types of QDS which can be determined by:

(1) The form may be either all-units or incremental (Munson, 1998);
(2) The item aggregation describes whether the discount applies to one or multiple items (Munson, 1998);
(3) The time aggregation describes whether the discounts apply to individual purchases or multiple purchases over a given time frame (Munson, 1998);
(4) Finally, the number of price break points may be one, multiple, or infinite (as represented by a continuous price schedule) (Dolan, 1987; Munson, 1998).

Research relevance

The literature on quantity discounts is extensive, and focuses for instance on QDS characteristics (e.g. Dolan, 1987). The application of quantity discounts in e.g. EOQ-models or inventory ownership has also been discussed (e.g. Viswanthan, 2003). What we still do not know is how
buying organizations can derive Quantity Discount Price Functions (QDPF) from QDS. As mentioned earlier selling organizations often offer QDS. However, mostly they do not provide the underlying QDPF. In literature a thorough analysis on how buying organizations could derive QDPF from QDS is lacking. This is remarkable as QDPF contain a wealth of information for buying organizations. QDPF give more insight into the supplier cost mechanism, i.e. its fixed and variable costs. Therefore, it can be a useful tool in the negotiation process for buying organizations. Furthermore, QDPF can be used to improve calculating and allocating price savings in group purchasing. QDPF can also be used by practitioners while negotiating quantity discounts: with a general QDPF for calculating QDS one can easily calculate the price for deviant quantities. More general, research results to QDPF will be applicable to studies and models incorporating quantity discounts.

**Research objectives**

Our first objective is to describe one general QDPF defined by a limited number of parameters. It should be easy for buying organizations to derive these parameters from all different types of QDS. Our second objective is to empirically test the validity of this general QDPF. A general QDPF makes it possible to compare the QDS of different selling organizations. Our third objective is therefore to compare the basic properties, range and density of demand elasticity of price of several QDS. We are especially interested in the demand elasticity of price as this topic is receiving little research attention (Ramsay, 1981; Schotanus, 2005). This is remarkable, especially given that the price elasticity of demand has been studied into great detail. Our research results to demand elasticity of price could be very useful for group purchasing studies, as demand elasticity (range and density) plays an important role in the fairness of allocating cooperative gains in e.g. purchasing consortia (Schotanus, 2005).

**Preliminary analytical results**

We propose a continuous QDPF to approximate QDS. Using a continuous QDPF will enhance analytical results. The disadvantage of such a function lies in practical issues. Despite these issues some other researchers also used continuous QDPF (e.g. Dolan, 1987; Jeuland, 1983). All QDS types can be approximated by a continuous QDPF. Note that using graduated QDPF could lead to an anomaly (e.g. Russell, 1991). This anomaly concerns the possibility that it can save money by purchasing more units than needed at a discount and throwing the surplus away.

Our QDPF is defined as \( p(q) = p_m + \frac{S}{q^{\eta}} \). Here \( p_m \) represents the minimum \((S \geq 0)\) or maximum \((S < 0)\) price, \( S \) represents the spread of the function, and \( \eta \) represents the elasticity. With these variables QDPF can be shaped into two main categories (positive versus negative elasticity) which are discussed into further detail in the final paper.

**Methodology of the empirical part of the study**

We tested if our QDPF was able to give a reliable approximation of 66 existing QDS. When we approximate QDS with a continuous QDPF we assume that the price given by the supplier for a certain range applies on average to the lowest quantity in this range. E.g., when a price of 400
applies to 50-99 items, and a price of 300 applies to 100-199 items, we assume that a price of 400 applies to 50 items and a price of 300 applies to 100 items. The supplier does not give the exact prices for 51-99 items, but we assume that while negotiating in most cases a lower price than 400 can be obtained due to economies of scale (Melymuka, 2001). Graduated price functions do not incorporate this flexibility. That most prices are negotiated is shown by Munson (1999).

Our continuous QDPF has 3 unknown parameters. We approximate the parameters with several nonlinear least squares algorithms and robust fittings methods which we discuss in the final paper into further detail. We use the Levenberg-Marquardt algorithm in combination with the least absolute residuals method as we claim that this combination usually gives the most reliable results within an acceptable calculation time for QDPF.

Preliminary empirical results

We analysed the 66 QDS using our general QDPF. Both the average $R^2$ (0.995) and the adjusted $R^2$ (0.988) are very high. The average adjusted $R^2$ is not significantly lower than the $R^2$. This normally means that no explanatory variable(s) are missing. In the final paper we analyse into more the detail several aspects concerning QDS:

- The range, mean, and density of demand elasticity of price, and the relationship between the difference between minimum and maximum prices and elasticity;
- The demand elasticity of price for several commodities;
- The range and mean difference between minimum and maximum prices in a QDS;
- The range and mean of price breaks;
- The relationship between the number of price breaks and elasticity;
- The relationship between aspects of QDS and the head office in different countries;
- The complete results, assumptions, limitations, conclusions, recommendations, and indications for further research are discussed in the final paper as well.

References

• Ramsay, J., 1981. Demand competition, Purchasing and supply management.