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Marketing investments are designed to change consumer behavior in ways that help goods compete in the marketplace. Previous research has focused on using elasticity decompositions to measure how these investments affect either consumer decision making or competing goods. On the one hand, decision-based decompositions attribute the growth in own-good demand to changes in the consumers' decision-making processes. On the other hand, unit-based and share-based decompositions attribute the same growth to either rivalrous or nonrivalrous sources. The objective of this article is to provide a clear and accurate method that simultaneously attributes the growth in own-good demand to changes in (1) consumers' decisions, (2) competitive demand, and (3) competitive market share. The author accomplishes this by settling some confusion about what the decision- and share-based decompositions mean, by discussing how each of the decompositions are related to the others, and by discussing the research questions that each of the decompositions can answer. From a managerial perspective, the author discusses how this method can be used to simplify and clarify the data needed for decision making.

Measuring Consumer and Competitive Impact with Elasticity Decompositions

Three methods of decomposing the elasticity of demand have been used to study whether marketing actions expand the market or steal business from rival firms. When these decompositions are applied to the same problem, they produce seemingly contradictory results. For example, one method may suggest that all the demand created by an incremental marketing investment is generated by market expansion, whereas another may suggest that the same increase is stolen from rival firms. I explain why these apparently contradictory results actually are complementary and provide a more comprehensive understanding of the investment's impact.

Consider the following example: There are two firms that compete with each other in a market. Firm A is considering whether to increase its advertising investments by a small amount. Table 1 summarizes the unit sales and market shares the firms would earn at two investment levels. Firm A wants to know whether the growth in its demand comes at the expense of Firm B.

Several methods have been developed to address this issue. The crucial difference among them lies in how stolen business is measured. Some authors measure stolen business by the decrease in demand for competing goods (Van Heerde, Gupta, and Wittink 2003; Van Heerde, Leeflang, and Wittink 2004). I refer to these methods as "unit-based decompositions." In the foregoing example, the unit-based decomposition would claim that none of the growth in Firm A's demand comes at the expense of Firm B, because Firm B's demand would not be affected by the advertising investment. This is a reasonable point of view.

Other authors measure stolen business by the decrease in market share of competing goods (Berndt et al. 1995, 1997; Rosenthal et al. 2003).[1] I refer to these methods as "share-based decompositions." In the example, the share-based decomposition would claim that some of the growth in Firm A's demand comes at the expense of Firm B because Firm B's market share would drop by 1.3% as a result of the advertising investment. This is also a reasonable point of view.

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[1]Although the focus of his article is different, Clarke (1973) studies the impact of advertising investments on market expansion and market shares. I thank Al Silk for bringing this work to my attention.

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Table 1
UNITS DEMANDED AND MARKET SHARES

	Without Incremental Advertising	*With Incremental Advertising*	*Difference*
Firm A	500 units	530 units	+30 units
	33.3% share	34.6% share	+1.3 share points
Firm B	1000 units	1000 units	No change
	66.7% share	65.4% share	–1.3 share points
Market totals	1500 units	1530 units	+30 units

Although these two decompositions appear to offer similar measures of stolen business, they can produce strikingly different results. In our example, the unit-based method suggests that none of the growth in Firm A's demand comes at the expense of Firm B, but the share-based method suggests that two-thirds of it comes at its expense. Although Firm B's demand would be unaffected by the advertising investment, it would need to earn 1020 units in the expanded market to maintain its original market share. Because it would earn only 1000 units, the share-based method classifies 20 units of the 30-unit increase as being stolen from it.

Furthermore, the share-based method has not been precisely interpreted. For example, Berndt and colleagues (1997, p. 278) write,

> We distinguish between two types of marketing: (1) that which concentrates on bringing new customers into the market ("[market]-expanding" advertising), and (2) that which concentrates on competing for market shares from these consumers ("rivalrous" advertising).

This statement may be confusing because the share-based decomposition classifies only a portion of the market expansion as primary (or nonrivalrous) demand. In this example, the share-based method classifies only 10 units of the 30-unit increase in market demand as primary. In contrast, the unit-based method defines primary demand to be equivalent to the entire market expansion.

The unit- and share-based decompositions are not the only methods that have been used to study a marketing action's impact. A third set of authors has studied the problem from an entirely different perspective by measuring the influence of changes in the consumers' decisions on the growth in own-good demand (Bell, Chiang, and Padmanabhan 1999; Bucklin, Gupta, and Siddarth 1998; Chiang 1991; Chintagunta 1993; Gupta 1988). I refer to these as "decision-based decompositions."[2] Contrary to some suggestions otherwise, these decompositions are insufficient to determine a marketing investment's competitive impact because they measure changes only in own-good demand, not in competitive demand. Nevertheless, I show how to extend a decision-based analysis to competing goods by decomposing the elasticity of cross-good demand.

The objective of this article is to provide a clear and accurate method that attributes the growth in own-good demand to changes in (1) consumers' decisions, (2) competitive demand, and (3) competitive market share. I accomplish this by settling some confusion about what the decision- and share-based decompositions mean, by discussing how each of the decompositions is related to the others, and by discussing the research questions that each of the decompositions can answer. From the unit-based decomposition, a brand manager can learn whether the growth in own-good demand is due to stolen units. From the share-based decomposition, a manager can learn whether it is due to stolen market share. From the decision-based decomposition, a manager can learn which changes in consumer behavior lead to the growth in demand. Together, these methods provide a comprehensive understanding of a marketing investment's impact.

I organize the remainder of the article as follows: First, I derive the relationship between the unit- and the share-based decompositions. Contrasting the two decompositions clarifies the perspective that each method offers and coerces a more precise interpretation of the share-based method. I illustrate the difference between the methods using an example based on Berndt and colleagues' (1997) empirical results. Second, I decompose the elasticity of cross-good demand to isolate the impact of each consumer decision on competitive demand. This analysis clarifies the meaning of decision-based decompositions. Third, I derive the relationships between the decision-based and the unit- and share-based decompositions using the previous cross-good analysis.[3] This makes it possible to construct matrices that fully account for how a marketing action affects both consumers' decisions and the demand for and market share of competing goods. I illustrate the unified decompositions by returning to the coffee example and discuss a paradox that can arise when the own-good market share is low. Finally, I conclude and discuss directions for further research.

DECOMPOSITIONS THAT MEASURE COMPETITIVE IMPACT

I begin by comparing the unit- and share-based approaches to studying a marketing action's competitive impact. Both methods attribute the growth in own-good demand to rivalrous and nonrivalrous sources. The unit-based method measures stolen business by the decrease in demand for competing goods, whereas the share-based method measures stolen business by the decrease in the market share of competing goods. Neither method requires a model of the consumer decision-making process to make this judgment. I show that both decompositions accurately depict how a marketing action affects competing goods, and I explain how to interpret differences in their results.

It is necessary to begin with some notation. Let q_j represent the demand for good j, $Q_{-j} = \Sigma^J_{k=1, k \neq j} q_k$ represent the demand for competing goods (competitive demand), and $Q_{all} = \Sigma^J_{k=1} q_k$ represent the demand for all goods in the market (market demand). Similarly, let s_j represent the market share of good j and $S_{-j} = \Sigma^J_{k=1, k \neq j} s_k$ represent the share of competing goods. Let m_j be a marketing instrument for good j. The elasticities of demand are $\eta_{q_j,m_j} = (\partial q_j/\partial m_j)(m_j/q_j)$, $\eta_{Q_{-j},m_j} = (\partial Q_{-j}/\partial m_j)(m_j/Q_{-j})$, and $\eta_{Q_{all},m_j} = (\partial Q_{all}/$

[2]I show that any of the decompositions, even the unit-based one, can be derived from the elasticity of demand. Therefore, I eschew using the term "elasticity decomposition" to distinguish the decision-based decomposition from the others.

[3]All the decompositions discussed in this article measure contemporaneous effects.

$\partial m_j)(m_j/Q_{all})$. The elasticities of share are $\eta_{sj,mj} = (\partial s_j/\partial m_j)(m_j/s_j)$ and $\eta_{S_{-j},m_j} = (\partial S_{-j}/\partial m_j)(m_j/S_{-j})$.

Unit-Based Decompositions

Unit-based decompositions measure stolen business by the decrease in demand for competing goods. These decompositions are derived from the identity

$$q_j = Q_{all} - Q_{-j}. \quad (1)$$

Demand for the target good is expressed as the difference between demand for all goods in the market and demand for competing goods.

The impact of an incremental marketing investment is quantified by taking derivatives, such that

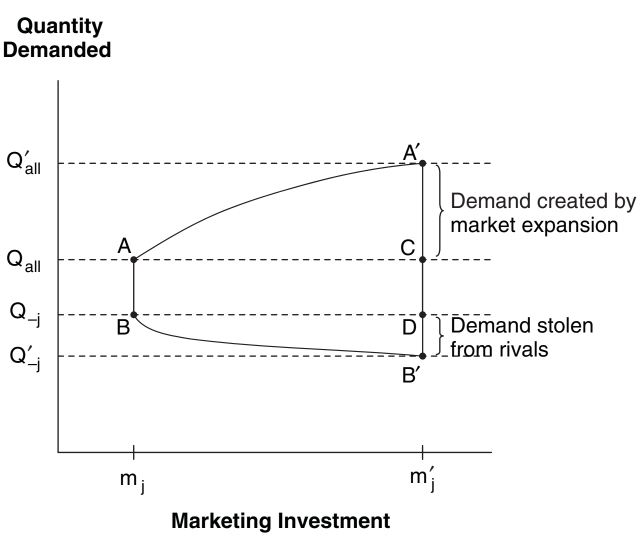
$$\frac{\partial q_j}{\partial m_j} = \frac{\partial Q_{all}}{\partial m_j} - \frac{\partial Q_{-j}}{\partial m_j}. \quad (2)$$

Equation 2 attributes the growth in own-good demand to two sources. The nonrivalrous source is measured by the increase in market demand, $\partial Q_{all}/\partial m_j$, and the rivalrous source is measured by the decrease in demand for competing goods, $\partial Q_{-j}/\partial m_j$.

Figure 1 provides a geometric depiction of the unit-based decomposition. As a result of an incremental marketing investment, the market expands from A to A′, and the demand for competing goods contracts expands from B to B′. Line segment $\overline{AB}$ represents the demand for good j before the incremental marketing investment, and line segment $\overline{A'B'}$ represents demand afterward. Demand for good j grows by $\overline{A'C} + \overline{DB'}$ units. Of the growth, $\overline{A'C}$ units are generated by market expansion, and $\overline{DB'}$ units are stolen from competing goods. Demand for competing goods decreases by $\overline{DB'}$ units. For small $\delta = m'_j - m_j$, the quantities represented by the line segments are $\overline{A'C} = (\partial Q_{all}/\partial m_j)\delta$ and $\overline{DB'} = -(\partial Q_{-j}/\partial m_j)\delta$.

Figure 1

HOW UNIT-BASED DECOMPOSITIONS CLASSIFY CHANGES IN DEMAND



Notes: Because of the marketing investment, the market expands from A to A′ and competitive demand decreases from B to B′. The unit-based decomposition classifies the entire increase in market demand, $\overline{A'C}$, as primary demand. Furthermore, it classifies the demand lost by rival firms, $\overline{DB'}$, as secondary demand.

Unit-based decompositions can be transformed from derivatives into elasticities by multiplying all terms by m_j/q_j. This transformation results in

$$\eta_{q_j,m_j} = \left(Q_{all}/q_j\right) \times \eta_{Q_{all},m_j} - \left(Q_{-j}/q_j\right) \times \eta_{Q_{-j},m_j}. \quad (3)$$

The leading term Q_{all}/q_j simply scales the change in market demand from being measured relative to the level of market demand to being measured relative to the level of demand for good j. Similarly, the leading term Q_{-j}/q_j scales the change in demand for competing goods from being measured relative to the level of demand for competing goods to being measured relative to the level of demand for good j.

The proportions

$$\Psi_{\substack{\text{market}\\\text{expansion},j}} = \frac{\eta_{Q_{all},m_j} \times Q_{all}}{\eta_{q_j,m_j} \times q_j}, \text{ and} \quad (4)$$

$$\Psi_{\substack{\text{stolen}\\\text{units},j}} = \frac{\eta_{Q_{-j},m_j} \times Q_{-j}}{\eta_{q_j,m_j} \times q_j} \quad (5)$$

provide unit-based measures of primary and secondary demand. The following interpretation applies: If own-good demand were to grow by 100 units following a marketing investment, $\Psi_{\text{market expansion},j} \times 100$ of the units would be created by market expansion, and $\Psi_{\text{stolen units},j} \times 100$ of the units would be stolen from competing goods. Demand for competing goods would decrease by $\Psi_{\text{stolen units},j} \times 100$ units.

The proportion of growth in own-good demand created by market expansion is not restricted to be less than one. However, a value greater than one does not imply that more than 100% of the growth comes from market expansion. Rather, it implies that the marketing investment creates $(\Psi_{\text{market expansion},j} - 1)$ units of demand for competing goods for every unit that it creates for the target good. For example, a value of $\Psi_{\text{market expansion},j} = 1.5$ implies that an advertising investment that creates 100 units of demand for the target good also creates 50 units of demand for competing goods.

Share-Based Decompositions

Share-based decompositions measure stolen business by the decrease in market share of competing goods. These decompositions are derived from the identity

$$q_j = Q_{all} \times s_j. \quad (6)$$

Demand for the target good is expressed as the product of market demand and the target good's market share.

The impact of an incremental marketing investment is quantified by applying the chain rule, such that $\partial q_j/\partial m_j = s_j(\partial Q_{all}/\partial m_j) + Q_{all}(\partial s_j/\partial m_j)$. This equation is better expressed as

$$\frac{\partial q_j}{\partial m_j} = s_j \times \frac{\partial Q_{all}}{\partial m_j} - \left(\frac{\partial Q_{-j}}{\partial m_j} - S_{-j} \times \frac{\partial Q_{all}}{\partial m_j}\right). \quad (7)$$

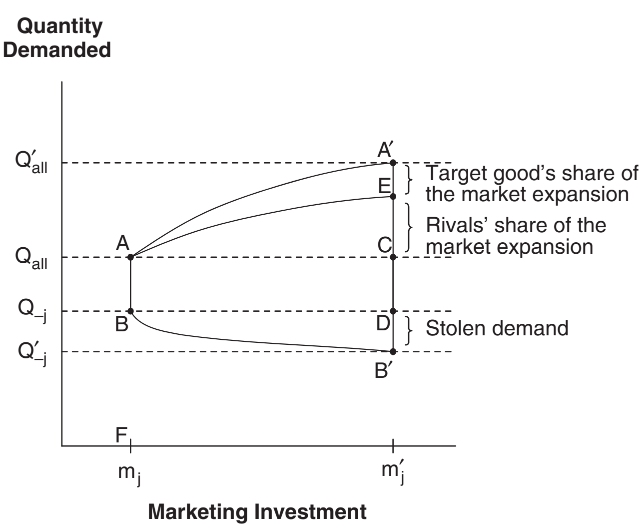
Equation 7 attributes the growth in own-good demand to two sources. The nonrivalrous source is $s_j(\partial Q_{all}/\partial m_j)$, a portion of the market expansion. The rivalrous source is defined as the demand that competing goods would need to regain to maintain their market share in the expanded market. Competing goods lose market share in the expanded market for two reasons: (1) They lose units to the target good, $\partial Q_{-j}/\partial m_j$, and (2) they fail to capture part of the expanded market, $-S_{-j}(\partial Q_{all}/\partial m_j)$.

The conceptual hurdle to understanding share-based decompositions is recognizing that their measure of primary demand is not equivalent to the demand generated by market expansion. Under share-based decompositions, marketing investments must create demand for competing goods in proportion to their market share to be considered nonrivalrous. This implies that it is possible for marketing investments to create some demand for competing goods (investment spillover occurs), but some of the growth in own-good demand is still classified as being stolen from them. Although the concept of stolen market share is immediately understood, its implication on primary demand is more subtle.

Figure 2 provides a geometric depiction of the share-based decomposition. As a result of an incremental marketing investment, the market expands from A to A′, and the demand for competing goods contracts from B to B′. Line segment $\overline{AB}$ represents demand for good j before the incremental investment, and line segment $\overline{A'B'}$ represents it afterward. Demand for good j grows by $\overline{A'EC}$ + $\overline{DB'}$ units.

Figure 2

HOW SHARE-BASED DECOMPOSITIONS CLASSIFY CHANGES IN DEMAND



Notes: Because of the marketing investment, the market expands from A to A′ and competitive demand decreases from B to B′. Unlike the unit-based decomposition, the share-based decomposition classifies only a share of the market expansion, $\overline{A'E}$, as primary demand. It classifies the remainder of the market expansion, $\overline{EC}$, as secondary demand because this portion of the expansion would reduce the rival firms' market share. As does the unit-based decomposition, the share-based decomposition classifies the demand lost by the rival firms, $\overline{DB'}$, as secondary demand.

For market shares to be preserved, the ratio of $\overline{A'E}$ to $\overline{A'C}$ is equivalent to the ratio of $\overline{AB}$ to $\overline{AF}$. Of the growth in demand for good j, $\overline{A'E}$ units are defined as nonrivalrous, and $\overline{EC}$ + $\overline{DB'}$ units are generated by stealing share from competing goods. Demand for competing goods decreases by $\overline{DB'}$ units. For small $\delta = m'_j - m_j$, the quantities represented by the line segments are $\overline{A'E} = s_j(\partial Q_{all}/\partial m_j)\delta$, $\overline{EC} = S_{-j}(\partial Q_{all}/\partial m_j)\delta$, and $\overline{DB'} = -(\partial Q_{-j}/\partial m_j)\delta$.

Expressed in terms of elasticities, the share-based decomposition is

$$(8)\quad \eta_{q_j,m_j} = s_j \times \eta_{Q_{all},m_j} - \Big[\big(Q_{-j}/q_j\big) \times \eta_{Q_{-j},m_j} - S_{-j} \times \big(Q_{all}/q_j\big) \times \eta_{Q_{all},m_j}\Big].$$

The proportions

$$(9)\quad \Theta_{\substack{\text{share-preserving}\\ \text{market expansion},j}} = \frac{s_j \times \left(\eta_{Q_{all},m_j} \times Q_{all}\right)}{\eta_{q_j,m_j} \times q_j}, \text{ and}$$

$$(10)\quad \Theta_{\substack{\text{stolen}\\ \text{share},j}} = \frac{-\left(\eta_{Q_{-j},m_j} \times Q_{-j}\right) + S_{-j} \times \left(\eta_{Q_{all},m_j} \times Q_{all}\right)}{\eta_{q_j,m_j} \times q_j}$$

provide share-based measures of primary and secondary demand. These measures are related to those of the unit-based decomposition through the expressions

$$(11)\quad \Theta_{\substack{\text{share-preserving}\\ \text{market expansion},j}} = s_j \times \Psi_{\substack{\text{market}\\ \text{expansion},j}}, \text{ and}$$

$$(12)\quad \Theta_{\substack{\text{stolen}\\ \text{share},j}} = \Psi_{\substack{\text{stolen}\\ \text{units},j}} + S_{-j} \times \Psi_{\substack{\text{market}\\ \text{expansion},j}}.$$

This relationship should be expected. Both decompositions attribute the growth in own-good demand to changes in demand for competing goods. However, the share-based decomposition attributes the demand that competing goods would earn in an expanded market if they kept their market share, $S_{-j} \times \Psi_{\text{market expansion},\, j}$, to the rivalrous source. The unit- and share-based decompositions are simply different measures of competitive impact, and one can be recovered from the other without consideration of consumers' decision-making processes. All the information needed to determine these decompositions is contained in the elasticities of own- and cross-good demand.

The following interpretation applies to share-based measures of primary and secondary demand: If own-good demand were to grow by 100 units after a marketing investment, $\Theta_{\text{share-preserving market expansion},j} \times 100$ of these units would be created by share-preserving market expansion, and $\Theta_{\text{stolen share},j} \times 100$ of these units would reduce the market share of competing goods. Competing goods would need to take back $\Theta_{\text{stolen share},j} \times 100$ units in the expanded market to maintain their market share and would need to take back $\Psi_{\text{stolen units},j} \times 100$ units to maintain their demand.

Empirical Example

Berndt and colleagues (1995, 1997) study the growth and changing composition of the U.S. antiulcer drug market. Peptic ulcer disease occurs in 10%–15% of the U.S. population and involves the inflammation of tissue in the digestive tract that is exacerbated by the presence of the body's naturally occurring gastric acid. SmithKline introduced Tagamet, a revolutionary treatment known as H_2-receptor antagonists, in August of 1977. Glaxo followed suit with Zantac in June of 1983, Merck with Pepcid in October of 1986, and Lilly with Axid in April of 1988.

Berndt and colleagues (1995, 1997) estimate a system of two equations to describe consumer demand for these drugs. They specify a log-linear demand equation to describe the relationship between the market (industry) demand and the firms' marketing investments. They also specify a relative demand equation to describe the relationship between the firms' relative market shares and the relative investments made in support of their drugs. I use Berndt and colleagues' (1997) estimates from the two-product market that contains Tagamet and Zantac. (Parameter estimates for the market-level equation appear in Column 2 of Table 7.1 on p. 301, and estimates for the market-share equation appear in Column 4 of Table 7.2 on p. 307.) The elasticity of market demand is –.268 for a change in the price of Tagamet and –.804 for a change in the price of Zantac. The own-good elasticity of demand is –1.154 for Tagamet and –1.690 for Zantac.

The share- and unit-based measures of primary and secondary demand appear in Table 2. The results of these methods provide different impressions of whether price cuts steal business. Regardless of whether Tagamet or Zantac cuts its price, the unit-based measure suggests that most of the growth in own-good demand comes from primary demand (92.9% for Tagamet and 63.4% for Zantac), whereas the share-based measure suggests that most of the growth comes from secondary demand (76.8% for Tagamet and 52.4% for Zantac).

The decompositions describe the competitive impact of the same price cut and should be interpreted as follows: A 1% decrease in Tagamet's price would yield a 1.154% increase in its demand. According to the unit-based decomposition, 92.9% of the growth in Tagamet's demand would come from market expansion, and 7.1% would be stolen from Zantac. This implies that Zantac would need to take back $.071 \times .01154 \times q_{Tagamet}$ units from Tagamet to maintain its demand. According to share-based decomposition, Zantac would need to take back 76.8% of the growth in demand for Tagamet, which amounts to $.768 \times .01154 \times q_{Tagamet}$ units, to maintain its market share in the expanded market. A similar analysis would apply to the growth in demand for Zantac if it were to cut its price.

The unit- and share-based methods provide complementary measures of the marketing action's competitive impact. The unit-based measure implies that only a small portion of the growth in Tagamet's demand would erode Zantac's demand, but the share-based measure implies that most of the same growth would erode Zantac's market share. One measure may be favored over the other depending on the brand manager's beliefs about what would trigger a competitive response from Zantac, lost demand or lost market share. Used in tandem, however, the measures provide the manager with a more complete understanding of whether the growth in Tagamet's demand has been stolen from Zantac.

Table 2
COMPARISON OF UNIT- AND SHARE-BASED DECOMPOSITIONS

		Unit-Based Measures		*Share-Based Measures*	
Drug	*Market Share*	*Primary Demand*	*Secondary Demand*	*Primary Demand*	*Secondary Demand*
Tagamet	25%	.929	.071	.232	.768
Zantac	75%	.634	.366	.476	.524

DECOMPOSITIONS THAT MEASURE CONSUMER IMPACT

Decision-based decompositions measure the relative influence of changes in consumers' decisions on the change in demand for goods. Gupta (1988) shows how to measure the influence of these decisions on own-good demand. I extend his analysis to measure their influence on competitive and market demand.

Decision-Based Decompositions

Decision-based decompositions require a model of the consumers' decision-making processes, so I begin by specifying a traditional model. I assume that own-good demand is the product of three decisions: whether to purchase (incidence), which good to purchase if a purchase is made (conditional choice), and how much to purchase if a particular good is chosen (conditional quantity). The expected demand for good j is

$$q_j = N \times u \times v_j \times w_j \quad \forall j, \tag{13}$$

where N is the number of shopping occasions, u is the probability of buying in the category, v_j is the probability of choosing good j conditional on buying in the category, and w_j is the expected units purchased conditional on good j being chosen.

As Gupta (1988) shows, the elasticity of own-good demand is decomposed using the chain rule as

$$\eta_{q_j,m_j} = \eta_{u,m_j} + \eta_{v_j,m_j} + \eta_{w_j,m_j} \quad \forall j, \tag{14}$$

where η_{u,m_j}, η_{v_j,m_j}, and η_{w_j,m_j} are the decision elasticities. Here, η_{v_j,m_j} and η_{w_j,m_j} are own-good decision elasticities because they quantify the impact of a marketing investment in support of good j on the conditional choice and conditional quantity decisions about good j. I refer to η_{q_j,m_j} as the comprehensive own-good elasticity.

Gupta's (1988) decision-based decomposition measures the relative influence of changes in consumers' decisions on the increase in own-good demand. The proportions

$$\Lambda_{incidence,m_j} = \eta_{u,m_j} / \eta_{q_j,m_j}, \tag{15}$$

$$\Lambda_{\substack{own\text{-}good\\ choice,m_j}} = \eta_{v_j,m_j} / \eta_{q_j,m_j}, \text{ and} \tag{16}$$

$$\Lambda_{\substack{own\text{-}good\\ quantity,m_j}} = \eta_{w_j,m_j} / \eta_{q_j,m_j} \tag{17}$$

summarize the relationship and can be interpreted as follows: Of the growth in own-good demand, $\Lambda_{incidence,m_j}$% is generated by consumers buying more frequently in the category, $\Lambda_{\text{own-good choice},m_j}\%$ is generated by consumers choosing the target good more frequently when they buy in the category, and $\Lambda_{\text{own-good quantity},m_j}\%$ is generated by consumers buying in greater amounts when they choose the target good.

The influence of changes in consumers' decisions on the demand for competing goods can be similarly quantified. The elasticity of demand for a single competing good is decomposed as

$$\eta_{q_k,m_j} = \eta_{u,m_j} + \eta_{v_k,m_j} + \eta_{w_k,m_j} \quad \forall k \neq j, \tag{18}$$

where η_{u,m_j} represents the purchase incidence elasticity (for a proof, see the Appendix). The same term appears in the own-good decomposition, as given in Equation 14, because competing goods benefit as the target good does if consumers buy more frequently in the category and their other decisions are held constant. The term η_{v_k,m_j} is the elasticity of conditional cross-good choice, and η_{w_k,m_j} is the elasticity of conditional cross-good quantity. Traditionally, it has been assumed that the marketing actions of good j do not affect the conditional cross-good quantity decisions, which implies that $\eta_{w_k,m_j} = 0 \quad \forall k \neq j$.[4] In keeping with this assumption, the elasticity of cross-good demand reduces to

$$\eta_{q_k,m_j} = \eta_{u,m_j} + \eta_{v_k,m_j} \quad \forall k \neq j. \tag{19}$$

The elasticities of market and competitive demand can be determined from the elasticities of cross-good demand. Under the assumptions of the demand model,

$$\eta_{Q_{all},m_j} \times Q_{all} = \eta_{u,m_j} \times Q_{all} + \eta_{w_j,m_j} \times q_j + \delta, \text{ and} \tag{20}$$

$$\eta_{Q_{-j},m_j} \times Q_{-j} = \eta_{u,m_j} \times Q_{-j} - \left(\eta_{v_j,m_j} \times q_j - \delta\right), \tag{21}$$

where

$$\delta = \eta_{v_j,m_j} \times q_j + \sum_{\substack{k=1 \\ k \neq j}}^{J} \eta_{v_k,m_j} \times q_k.$$

(For a proof, see the Appendix.) The influence of each decision on competitive and market demand can be summarized as follows:

- *Incidence*: If consumers make purchases more frequently, market and competitive demand increase.
- *Conditional quantity*: If consumers buy in greater amounts when they choose the target good, competitive demand remains the same, but market demand increases.
- *Conditional choice*: If consumers choose the target good more frequently when they buy in the category, both competitive and market demand can change. As expected, competitive demand decreases. However, market demand remains the same ($\delta = 0$) only in the special case in which consumers conditionally purchase all goods in the same amounts ($w_j = w \ \forall j$). If competing goods are purchased in lesser (greater) amounts than the target good, competitive demand does not decline as much as (declines more than) own-good demand increases. The switching offset δ quantifies these changes. There might be concern about δ in studies that define alternative goods by brand sizes rather than by brands.

Empirical Example

Some confusion still remains about what Gupta's (1988) decision-based decomposition means. To clarify its meaning and to ensure full understanding of its use, I reconsider his decomposition in the context of Van Heerde, Gupta, and Wittink's (2003, p. 484) coffee example. Suppose that there are 1000 shopping occasions in a given week for coffee. The probability of purchasing coffee on any of these occasions is .20, and the conditional probability of choosing Folgers given that coffee is purchased is .18. The conditional quantity purchased is 1.0 unit, no matter which brand is chosen. The elasticity of purchase incidence is $\eta_{u,m_j} = .034$, the elasticity of conditional choice is $\eta_{v_j,m_j} = .210$, and the elasticity of conditional quantity is $\eta_{w_j,m_j} = .004$ in response to feature-and-display promotion. The comprehensive elasticity of own-good demand is $\eta_{q_j,m_j} = .248$.

I begin by evaluating how the changes in the consumers' decisions would affect the demand for coffee. Gupta's (1988) analysis, expressed in Equation 14, evaluates the growth in demand for Folgers. The competitive demand analysis, which I develop here and express in Equation 21, evaluates the change in demand for other coffees. These calculations are Taylor approximations of the changes in demand that would occur as a result of a finite increase in Folger's promotional activity. They assume a 100% increase in Folgers's feature-and-display promotions from an average level of .086 to an average level of .172 promotions per week.

As a result of consumers buying coffee more frequently, the demand for Folgers would grow by 36 × .034 = 1.2 units, and the demand for other coffees would grow by .034 × 164 = 5.6 units. As a result of consumers choosing Folgers more frequently when deciding to buy coffee, the demand for Folgers would grow by .210 × 36 = 7.6 units, and the demand for other coffees would decline by –.210 × 36 + 0 = –7.6 units. (The switching offset would be zero in this case because the conditional purchase quantities are assumed to be the same for all goods, $w_k = 1.0 \ \forall k$.) As a result of consumers buying in greater quantities when choosing to buy Folgers, the demand for Folgers would grow by 36 × .004 = .1 units, and the demand for other coffees would be unaffected. In total, the demand for Folgers would grow by 1.2 + 7.6 + .1 = 8.9 units, and the demand for other coffees would decline by 5.6 – 7.6 = –2.0 units.

Why has interpreting Gupta's (1988) findings been difficult? Gupta's analysis evaluates the changes only in own-good demand. It does not evaluate the changes in competitive demand. As the previous analysis reveals, although Folgers would modestly benefit from a greater frequency of coffee purchases, the market would expand considerably because other coffees would greatly benefit from this change. (As a result of greater purchase frequency, the

[4]In making this assumption, Van Heerde, Gupta, and Wittink (2003, p. 489) note that it is "used in all five major decomposition articles (Bell, Chiang, and Padmanabhan 1999; Bucklin, Gupta, and Siddarth 1998; Chiang 1991; Chintagunta 1993; Gupta 1988)."

demand for Folgers would grow by 1.2 units, but the demand for other coffees would grow by 5.6 units.) This occurs because, holding their brand-choice decisions constant, consumers are more likely to choose coffees other than Folgers. Thus, it is not possible to claim that the market expansion is small on the basis of Gupta's findings alone.[5]

Van Heerde, Gupta, and Wittink (2003) correctly point out that Gupta's (1988) results do not necessarily imply that most of the growth in own-good demand has been stolen from competing goods, a claim that had been previously made in the literature. For example, they quote (p. 483, Table 2) Sethuraman and Srinivasan (2002, p. 380), who write, "Gupta (1988) and Bell, Chiang, and Padmanabhan (1999) show that promotions have a relatively small effect on category expansion compared with brand switching. Therefore, we isolate and study the profitability due to brand switching only." This claim cannot be made on the basis of Gupta's findings, and it turns out to be false.

However, only some of the articles listed by Van Heerde, Gupta, and Wittink (2003) misinterpret Gupta's (1988) findings. For example, Chiang (1991, p. 309) writes, "These results are similar to the ones obtained by Gupta (1998, p. 352), where 84% of the increase is due to brand switching, 14% by purchase time acceleration, and 2% by increases in quantity." This interpretation is correct. It simply attributes the growth in own-good demand to changes in the consumers' decisions-making processes. Of the 8.9 unit growth in demand for Folgers, 84% would be due to consumers choosing Folgers more frequently when buying coffee (84% of 8.9 is 7.6 units), 14% would be due to consumers buying coffee more frequently (14% of 8.9 is 1.2 units), and 2% would be due to consumers buying in greater quantities when choosing to buy Folgers (2% of 8.9 is .1 units). Combining the decompositions, as I discuss in greater detail subsequently, makes the difference between these two interpretations even more distinct.

DECOMPOSITIONS THAT MEASURE BOTH CONSUMER AND COMPETITIVE IMPACT

It is possible to measure the consumer and competitive impact of a promotion at the same time. Unified decompositions quantify how a marketing action changes consumers' decisions of whether, which, and how much to buy and how the change in each decision affects the own-good, competitive, and market demand. I show how the decision-based decomposition and unit- and share-based decompositions are related to one another and return to the coffee example to discuss what can be learned from combining them.

Unifying Relationships

The relationship between the unit- and decision-based decompositions is found by substituting Equation 20 into Equation 4 and by substituting Equation 21 into Equation 5:

$$(22)\quad \Psi_{\substack{\text{market}\\ \text{expansion},m_j}} = \frac{1}{s_j} \times \Lambda_{\text{incidence},m_j} + \Lambda_{\substack{\text{own-good}\\ \text{quantity},m_j}} + \Delta_{\substack{\text{switching}\\ \text{offset},m_j}}, \text{ and}$$

$$(23)\quad \Psi_{\substack{\text{stolen}\\ \text{units},m_j}} = -\left(\frac{1}{s_j} - 1\right) \times \Lambda_{\text{incidence},m_j} + \Lambda_{\substack{\text{own-good}\\ \text{choice},m_j}} - \Delta_{\substack{\text{switching}\\ \text{offset},m_j}},$$

where $\Delta_{\text{switching offset},m_j} = \delta/(\eta_{q_j,m_j} \times q_j)$. The unit-based measures are functions of the decision-based measures and an additional term, namely, the switching offset. The switching offset accounts for the change in demand due to consumers switching among goods that are conditionally purchased in different amounts.

The relationship between the share- and the decision-based decompositions is found by substituting Equation 20 into Equation 9 and by substituting Equation 21 into Equation 10:

$$(24)\quad \Theta_{\substack{\text{share-preserving}\\ \text{market expansion},m_j}} = \Lambda_{\text{incidence},m_j} + s_j \times \Lambda_{\substack{\text{own-good}\\ \text{quantity},m_j}} + s_j \times \Delta_{\substack{\text{switching}\\ \text{offset},m_j}}, \text{ and}$$

$$(25)\quad \Theta_{\substack{\text{stolen}\\ \text{share},m_j}} = S_{-j} \times \Lambda_{\substack{\text{own-good}\\ \text{quantity},m_j}} + \Lambda_{\substack{\text{own-good}\\ \text{choice},m_j}} - s_j \times \Delta_{\substack{\text{switching}\\ \text{offset},m_j}}.$$

The matrices in Table 3 express the relationship between the consumer impact and competitive impact decompositions. Panel A depicts the relationship between the decision- and unit-based decompositions, and Panel B depicts the relationship between the decision- and share-based decompositions. The cross-good elasticity decomposition is critical to this analysis because it quantifies how changes in each of the consumers' decisions influence competitive and market demand.

The matrices clarify how each decomposition accounts for changes in demand. First, note that the information contained in Gupta's (1988) decision-based decomposition is not sufficient to determine exactly the impact of a marketing action on the demand for competing goods. The switching offset needs to be determined in addition to the proportions given in Equations 15–17 to calculate the competitive impact. However, this is not troubling because the intent of this decomposition is to measure the relative influence of

[5]The following example should clarify this point further: Instead of the previous assumptions, suppose that u = .20, v_j = .82, w_k = 1.0 ∀k, η_{u,m_j} = .0073, η_{v_j,m_j} = .0463, and η_{w_j,m_j} = .0006. Under these assumptions, the demand for Folgers would still grow by the same amounts: 1.2 units due to greater purchase frequency, 7.6 units due to greater brand choice, and .1 units due to greater purchase quantities. However, consumers are more likely to buy Folgers than other coffees, so increasing the frequency of coffee purchase would mostly benefit Folgers. The demand for other coffees would grow by only .3 units as a result of greater purchase frequency. Because the demand for other coffees would still be reduced by 7.6 units as a result of consumers choosing Folgers instead of other coffees, the total change in competitive demand would be .3 – 7.6 = –7.3 units, a much greater reduction in competitive demand.

Table 3

RELATIONSHIPS BETWEEN THE CONSUMER AND COMPETITIVE IMPACT DECOMPOSITIONS

A: Relationship Between Unit- and Decision-Based Measures

		Decision-Based Measures			
		Incidence	*Conditional Quantity*	*Conditional Choice*	*Total*
Unit-Based Measures	Market expansion	$\frac{1}{s_j} \times \Lambda_{\text{incidence},m_j}$	$\Lambda_{\text{own-good quantity},m_j}$	$\Delta_{\text{switching offset},m_j}$	$\frac{1}{s_j} \times \Lambda_{\text{incidence},m_j} + \Lambda_{\text{own-good quantity},m_j} + \Delta_{\text{switching offset},m_j}$
	Stolen units	$-\left(\frac{1}{s_j} - 1\right) \times \Lambda_{\text{incidence},m_j}$	0	$\Lambda_{\text{own-good choice},m_j} - \Delta_{\text{switching offset},m_j}$	$-\left(\frac{1}{s_j} - 1\right) \times \Lambda_{\text{incidence},m_j} + \Lambda_{\text{own-good choice},m_j} - \Delta_{\text{switching offset},m_j}$
	Total	$\Lambda_{\text{incidence},m_j}$	$\Lambda_{\text{own-good quantity},m_j}$	$\Lambda_{\text{own-good choice},m_j}$	

B: Relationship Between Share- and Decision-Based Measures

		Decision-Based Measures			
		Incidence	*Conditional Quantity*	*Conditional Choice*	*Total*
Share-Based Measures	Share-preserving market expansion	$\Lambda_{\text{incidence},m_j}$	$s_j \times \Lambda_{\text{own-good quantity},m_j}$	$s_j \times \Delta_{\text{switching offset},m_j}$	$\Lambda_{\text{incidence},m_j} + s_j \times \Lambda_{\text{own-good quantity},m_j} + s_j \times \Delta_{\text{switching offset},m_j}$
	Stolen share	0	$S_{-j} \times \Lambda_{\text{own-good quantity},m_j}$	$\Lambda_{\text{own-good choice},m_j} - s_j \times \Delta_{\text{switching offset},m_j}$	$S_{-j} \times \Lambda_{\text{own-good quantity},m_j} + \Lambda_{\text{own-good choice},m_j} - s_j \times \Delta_{\text{switching offset},m_j}$
	Total	$\Lambda_{\text{incidence},m_j}$	$\Lambda_{\text{own-good quantity},m_j}$	$\Lambda_{\text{own-good choice},m_j}$	

changes in each consumer's decision on the growth in own-good demand. An analysis of the impact on cross-good demand, which is required by the competitive impact decompositions, is not necessary.

Second, strictly speaking, the measure of primary and secondary demand that Bell, Chiang, and Padmanabhan (1999) propose can be given neither a unit- nor a share-based interpretation. They define primary demand as the sum of the incidence and conditional own-good quantity proportions, $\Lambda_{\text{incidence},m_j}$ and $\Lambda_{\text{own-good quantity},m_j}$, and secondary demand as the conditional own-good choice proportion, $\Lambda_{\text{own-good choice},m_j}$. Although their measure of primary and secondary demand is equivalent to neither of the competitive impact measures, it closely approximates share-based measure when two conditions are met: (1) when the proportion of own-good demand generated by the conditional own-good quantity decision is small, $\Lambda_{\text{own-good quantity},m_j} \approx 0$, and (2) when the switching offset is small, $\delta \approx 0$. This approximation may be useful in interpreting previously published results.

Third, it is easy to determine why the general relationship between the decision- and unit-based decompositions is simpler in the special case in which the conditional own-good purchase quantity is the same for all goods. Van Heerde, Gupta, and Wittink (2003) show that if $w_j = w \ \forall j$, then

$$(26) \qquad \Psi_{\text{market expansion},m_j} = 1 - \Psi_{\text{stolen units},m_j}, \text{ and}$$

$$(27) \qquad \Psi_{\text{stolen units},m_j} = -\left(\frac{1 - v_j}{v_j}\right) \times \Lambda_{\text{incidence},m_j} + \Lambda_{\text{choice on own-good},m_j}.$$

These relationships hold because the market share of each good is equivalent to its conditional choice probability and the switching offset is zero in this special case.

Coffee Example Revisited

I revisit the coffee example to illustrate further the relationships between the decompositions. The changes in own-good and competitive demand due to each consumer's decision were determined previously. The change in market demand, which is also needed, can be constructively determined from Equation 20. The demand for coffee would increase by .034 × 200 = 6.8 units as a result of consumers buying coffee more frequently and .004 × 36 = .1 units as a result of greater amounts of coffee being purchased when Folgers is chosen. The demand for coffee is unaffected by consumers' conditional choice decisions because the assumptions of the example set the conditional purchase quantities to be equal for all goods. Thus, demand for coffee increases by 6.8 + .1 = 6.9 units in total. Table 4 accounts for all the effects due to the promotion. Panel A provides the changes in demand by each consumer's decision, and Panel B depicts the total changes in demand and market shares.

I can now address the questions that the Folger's brand manager would like to answer: How will consumers respond and how will competing goods be affected if he or she invests in feature-and-display advertising?

The unit- and share-based decompositions measure different aspects of how the promotion affects competing goods. These decompositions depend solely on the total changes in demand for coffee, not on each consumer's decision that gives rise to these changes. From the unit-based decomposition, the brand manager learns that of the 8.9 unit growth in demand for Folgers, 77.5% (6.9 units) would be due to an expanded market for coffee, and 22.5% (2.0 units) would be due to units being stolen from other coffees. This implies that other coffees would lose 2.0 units as a result of the promotion. From the share-based decomposition, the brand manager learns that of the 8.9 unit growth in demand for Folgers, 86.5% (7.7 units) would diminish the market share of other coffees.

The decision-based decomposition measures the influence of changes in consumers' decisions on the growth in demand for Folgers. From this decomposition, the brand manager learns that of the 8.9 unit growth in demand for Folgers, 13.5% (1.2 units) would be due to consumers buying coffee more frequently, 85.4% (7.6 units) would be due to consumers choosing Folgers more frequently when they choose to buy coffee, and 1.1% (.1 units) would be due to consumers purchasing coffee in greater amounts when they choose to buy Folgers. This analysis focuses solely on the growth in demand for Folgers, not on the changes in demand for other coffees.

The unified decompositions (see Table 5) provide a more complete understanding of how the promotion works. They explain why both of the following statements are true: (1) Most of the growth in demand for Folgers (84.5%) is due to consumers switching away from other coffees when they choose to buy coffee, but also (2) most of the growth in demand for Folgers (77.5%) is due to market expansion. This paradox exists because, when consumers' other decisions are held constant, a greater frequency of coffee purchases would benefit each brand in proportion to its market share. Folgers, which has a market share of 18%, would earn 1.2 units of the 6.8-unit increase in demand for coffee that is due to greater purchase frequency, but the other coffees would gain 5.6 units, or approximately 4.5 times more. This paradox would not arise if Folgers dominated the market, because it would benefit most from a greater frequency of coffee purchases.

Brand managers can use the unified decompositions to help them choose among marketing investments. For example, suppose that the Folgers brand manager is particularly concerned about the competitive response to his or her marketing action. Knowing that a small increase in consumers' desire for coffee can mitigate much of the losses in

Table 4

HOW DEMAND AND MARKET SHARES CHANGE IN THE COFFEE EXAMPLE

A: Changes in Demand by Decision				
	Purchase Incidence	*Conditional Quantity*	*Conditional Brand Choice*	*Total*
Folgers	+1.2 units	+.1 units	+7.6 units	+8.9 units
Other coffees	+5.6 units	.0 units	–7.6 units	–2.0 units
All coffees	+6.8 units	+.1 units	.0 units	+6.9 units

B: Units Demanded and Market Shares			
	Without Promotion	*With Promotion*	*Change*
Folgers	36.0 units	44.9 units	+8.9 units
	18.0% share	21.7% share	+3.7 share points
Other coffees	164.0 units	162.0 units	–2.0 units
	82.0% share	78.3% share	–3.7 share points
All coffees	200 units	206.9 units	+6.9 units

Table 5

COMBINING THE CONSUMER IMPACT AND COMPETITIVE IMPACT DECOMPOSITIONS IN THE COFFEE EXAMPLE

A: Unit- and Decision-Based Decompositions					
Source of Change in Demand for Folgers	*Incidence (Units)*	*Conditional Quantity (Units)*	*Conditional Choice (Units)*	*Total (Units)*	*Proportional Measures*
Market expansion	+6.8	+.1	.0	+6.9	77.5%
Stolen units	–5.6	.0	+7.6	+2.0	22.5%
Total (units)	+1.2	+.1	+7.6	+8.9	
Proportional measures	13.5%	1.1%	85.4%		

B: Share- and Decision-Based Decompositions					
Source of Change in Demand for Folgers	*Incidence (Units)*	*Conditional Quantity (Units)*	*Conditional Choice (Units)*	*Total (Units)*	*Proportional Measures*
Share-preserving market expansion	+1.2	.0	.0	+1.2	13.5%
Stolen share	.0	+.1	+7.6	+7.7	86.5%
Total (units)	+1.2	+.1	+7.6	+8.9	
Proportional measures	13.5%	1.1%	85.4%		

competitive demand might persuade the manager to use an advertising slogan that reads, "Folgers—the best way to brighten your morning!" rather than one that reads, "Folgers—the brightest tasting coffee!" It is an empirical question as to whether the former slogan entices more consumers to drink coffee in the morning. However, the unified decompositions provide a means for testing how each of these marketing actions would change consumers' decisions and, in turn, how the changes in each of these decisions influence own-good and competitive demand.

CONCLUSION

Marketing investments are designed to change consumer behavior in ways that help goods compete in the marketplace. Previous work has focused on either how marketing investments affect consumer decision making or how they affect competing goods. Decision-based decompositions attribute the growth in own-good demand to changes in the consumers' decision-making processes. Conversely, unit- and share-based decompositions attribute the same growth to either rivalrous or nonrivalrous sources. Combining the consumer and competitive points of view in a single decomposition provides a more complete understanding of the marketing investment's impact.

From a managerial perspective, the methods discussed herein can be used to simplify and clarify the data needed for decision making. In a single table, a manager learns how changes to a marketing action would affect both consumer behavior and competing goods in the market. If the manager wants to alter the firm's portfolio of investments, "what-if" scenarios can be constructed for each of the potential actions at multiple levels of investment. The scenarios can then be combined to find a portfolio that meets the consumers' needs and the firm's strategic objectives. Similarly, if the manager is looking for new ways to communicate with consumers, he or she can review the firm's history of investments to determine what has enticed them in the past, a first step toward finding creative ways of reaching them in the future.

All the methods discussed in this article study a marketing investment's contemporaneous effects. Future work might focus on how the effects of an investment persist over time.

TECHNICAL APPENDIX

P_1: The change in own-good demand can be decomposed as follows:

$$\frac{\partial q_j}{\partial m_j} = s_j \times \frac{\partial Q_{all}}{\partial m_j} - \left(\frac{\partial Q_{-j}}{\partial m_j} + S_{-j} \times \frac{\partial Q_{all}}{\partial m_j}\right).$$

Proof

$$Q_{all} \times \frac{\partial s_j}{\partial m_j} = Q_{all} \times \left[\frac{\partial\left(1 - S_{-j}\right)}{\partial m_j}\right]$$

$$= Q_{all} \times \left[\frac{\partial\left(-Q_{-j}/Q_{all}\right)}{\partial m_j}\right]$$

$$= -Q_{all} \times \left(\frac{\partial Q_{-j}}{\partial m_j} \times \frac{1}{Q_{all}} - \frac{\partial Q_{all}}{\partial m_j} \times \frac{Q_{-j}}{Q_{all}^2}\right)$$

$$= -\left(\frac{\partial Q_{-j}}{\partial m_j} - S_{-j} \times \frac{\partial Q_{all}}{\partial m_j}\right).$$

Thus,

$$\frac{\partial q_j}{\partial m_j} = s_j \times \frac{\partial Q_{all}}{\partial m_j} + Q_{all} \times \frac{\partial s_j}{\partial m_j}$$

$$= s_j \times \frac{\partial Q_{all}}{\partial m_j} - \left(\frac{\partial Q_{-j}}{\partial m_j} + S_{-j} \times \frac{\partial Q_{all}}{\partial m_j}\right).$$

Q.E.D.

P_2: If the demand model of Equation 13 is assumed, the cross-good elasticity of demand is $\eta_{q_k,m_j} = \eta_{u,m_j} + \eta_{v_k,m_j} + \eta_{w_k,m_j}$.

Proof

The demand for good k is $q_k = N \times u \times v_k \times w_k$, for $k \neq j$. Applying the chain rule yields the following:

$$\frac{\partial q_k}{\partial m_j} = N \times v_k \times w_k \times \frac{\partial u}{\partial m_j}$$

$$+ N \times u \times w_k \times \frac{\partial v_k}{\partial m_j} + N \times u \times v_k \times \frac{\partial w_k}{\partial m_j}.$$

Thus, the cross-good elasticity is as follows:

$$\eta_{q_k,m_j} = \frac{\partial q_k}{\partial m_j} \times \frac{m_j}{q_k}$$

$$= \left(N \times v_k \times w_k \times \frac{\partial u}{\partial m_j} + N \times u \times w_k \times \frac{\partial v_k}{\partial m_j}\right.$$

$$\left. + N \times u \times v_k \times \frac{\partial w_k}{\partial m_j}\right) \times \frac{m_j}{q_k}$$

$$= \frac{\partial u}{\partial m_j} \times \frac{m_j}{u} + \frac{\partial v_k}{\partial m_j} \times \frac{m_j}{v_k} + \frac{\partial w_k}{\partial m_j} \times \frac{m_j}{w_k}$$

$$= \eta_{u,m_j} + \eta_{v_k,m_j} + \eta_{w_k,m_j}.$$

Q.E.D.

P_3: If the demand model of Equation 13 is assumed and if $\eta_{w_k,m_j} = 0 \ \forall k \neq j$, then $\eta_{Q_{all},m_j} \times Q_{all} = \eta_{u,m_j} \times Q_{all} + \eta_{w_j,m_j} \times q_j + \delta$.

Proof

$$\eta_{Q_{all},m_j} \times Q_{all} = \sum_{k=1}^{J} \eta_{q_k,m_j} \times q_k$$

$$= \sum_{k=1}^{J} \left(\eta_{u,m_j} + \eta_{v_k,m_j} + \eta_{w_k,m_j}\right) \times q_k$$

$$= \eta_{u,m_j} \times Q_{all} + \eta_{w_k,m_j} \times q_j + \sum_{k=1}^{J} \eta_{v_k,m_j} \times q_k$$

$$= \eta_{u,m_j} \times Q_{all} + \eta_{w_k,m_j} \times q_j + \delta,$$

where

$$\delta = \eta_{v_j,m_j} \times q_j + \sum_{\substack{k=1 \\ k \neq j}}^{J} \eta_{v_k,m_j} \times q_k.$$

Q.E.D.

P_4: If the demand model of Equation 13 is assumed and if $\eta_{w_k,m_j} = 0\ \forall k \neq j$, then $\eta_{Q_{-j},m_j} \times Q_{-j} = \eta_{u,m_j} \times Q_{-j} - (\eta_{v_j,m_j} \times q_j - \delta)$.

Proof

$$\eta_{Q_{-j},m_j} \times Q_{-j} = \sum_{\substack{k=1 \\ k \neq j}}^{J} \eta_{q_k,m_j} \times q_k$$

$$= \sum_{\substack{k=1 \\ k \neq j}}^{J} \left(\eta_{u,m_j} + \eta_{v_k,m_j} + \eta_{w_k,m_j}\right) \times q_k.$$

If it is assumed that $\eta_{w_k,m_j} = 0\ \forall k \neq j$, then

$$\eta_{Q_{-j},m_j} \times Q_{-j} = \eta_{u,m_j} \times Q_{-j} + \sum_{\substack{k=1 \\ k \neq j}}^{J} \eta_{v_k,m_j} \times q_k$$

$$= \eta_{u,m_j} \times Q_{-j} - \eta_{v_j,m_j} \times q_j + \delta,$$

where

$$\delta = \eta_{v_j,m_j} \times q_j + \sum_{\substack{k=1 \\ k \neq j}}^{J} \eta_{v_k,m_j} \times q_k.$$

Q.E.D.

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