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## TEACHING ACROSS COURSES: USING THE CONCEPT OF RELATED MARKETS FROM ECONOMICS TO EXPLAIN STATISTICS' CAUSATION AND CORRELATION

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## ABSTRACT

While it is essential for students to be able to use and understand social science models, the time restrictions in the introductory microeconomics and statistics courses may not always allow for complete discussion of the details of these important tools. However, as some of the core concepts appear in both of these courses, explaining them from more than one perspective may help improve the students' understanding and retention. This paper discusses the importance of assumptions in social science models and provides an example where a change in assumptions explains the difference between causation and correlation. By using the economic concepts of complementary, sympathetic, and substitute goods, the examples presented support key topics in the introductory statistics course.

### *Introduction*

For many students, introductory courses are characterized by a crush of new terms, concepts, graphs, and equations, and it may also be the first time students are exposed to social science models. However, if important concepts are repeated across courses, these new ideas can be viewed from varying perspectives and learning becomes both easier and more comprehensive. This paper provides a series of examples that show the relationship between the economic concepts of related markets (complements, substitutes, and sympathetic goods) and the statistical concepts of causation and correlation.

In economics, the textbooks state and the students are taught that the definition of complementary goods is "two goods for which an increase in the price of one leads to a decrease in the demand for the other".<sup>1</sup> However, most students tend to remember this relationship as "two goods that are typically purchased and consumed together," but there is a significant difference between these two statements. As will be detailed below, these statements can be used to show the distinction between complementary and sympathetic goods and how these two economic concepts are closely related to the statistical concepts of causation and correlation.

In statistics, correlation is the broader relationship where a change in one variable will have some association with the change in another variable. For causation to be present, the reason for the correlation has to be a force from one variable acting on the other. Bringing the economic and statistical concepts together in a simple example can reinforce the differences between each of these four concepts (complementary goods, sympathetic goods, causation, and correlation) and make both the theory and real-world applications of these concepts easier for the student in these often challenging courses.<sup>2</sup>

This paper proceeds as follows. After introducing the markets for related goods, two different news events will be applied to the same pair of goods (hot dogs and hot

dog buns). In the first situation, there is consistency between intuition, the economic definition of complementary goods, and causation. In the second situation, intuition and observation appears to contradict the definition of complements, and this provides an example of sympathetic goods and correlation. Following these examples, a discussion of the Uber taxi system provides a contemporary application of these concepts. The paper concludes by discussing the importance of detailing a model's assumptions in order to clarify concepts for students in the introductory courses.

### ***The Economic Model for the Markets of Related Goods***

Textbooks for the principles of microeconomics courses tend to define the interaction between the markets for related goods in terms of the reaction of the demand for one good in response to a price change of another good. To summarize these definitions, if goods A and B are complements, a price change for A will lead to a shift in the demand of B in opposite direction as the price change in A. So, if the price of A increases, the demand for B will decrease, and because these goods are complements, consumers will purchase less of both of these goods (as they are *typically* consumed together).

Another situation that describes a set of goods in related markets is when the goods are substitutes. If goods C and D are substitutes, the price change for one will lead to a shift in demand for the other in the same direction. So, if the price of good C rises, the demand for good D increases as customers switch to the relatively lower priced good D. By definition, both complements and substitutes provide an observable example of causation, as the price in one market causes a change in consumer behavior in the related market.

However, these expected responses to changes in prices are based on a key assumption holding, that a consumer's preferences are constant.<sup>3</sup> If the assumption of fixed, well-ordered preferences is relaxed and preferences are allowed to change, then the observed reaction in the related market between these two goods may appear to contradict the textbook definitions. For example, when a good becomes more popular (which is a signal that consumers' preferences are changing) the demand for that good increases. This increase in demand results in both an increase in price for the popular good and an increase in demand for goods that are consumed with the newly-popular good. Relaxing the preference assumption allows for a discussion of sympathetic goods, a topic that was discussed while microeconomics was being formalized (Lange, 1940).

While this topic is not common in the introductory economics courses, sympathetic goods can explain why when the demand for ice tea rises, the demand for lemon and sugar also rises (to use the example from the Lange paper). It is not clear why a discussion of sympathetic goods has been dropped from the microeconomics principles textbooks and courses, other than to note that the relaxation of the fixed preference assumption would involve multiple markets, and it might be considered

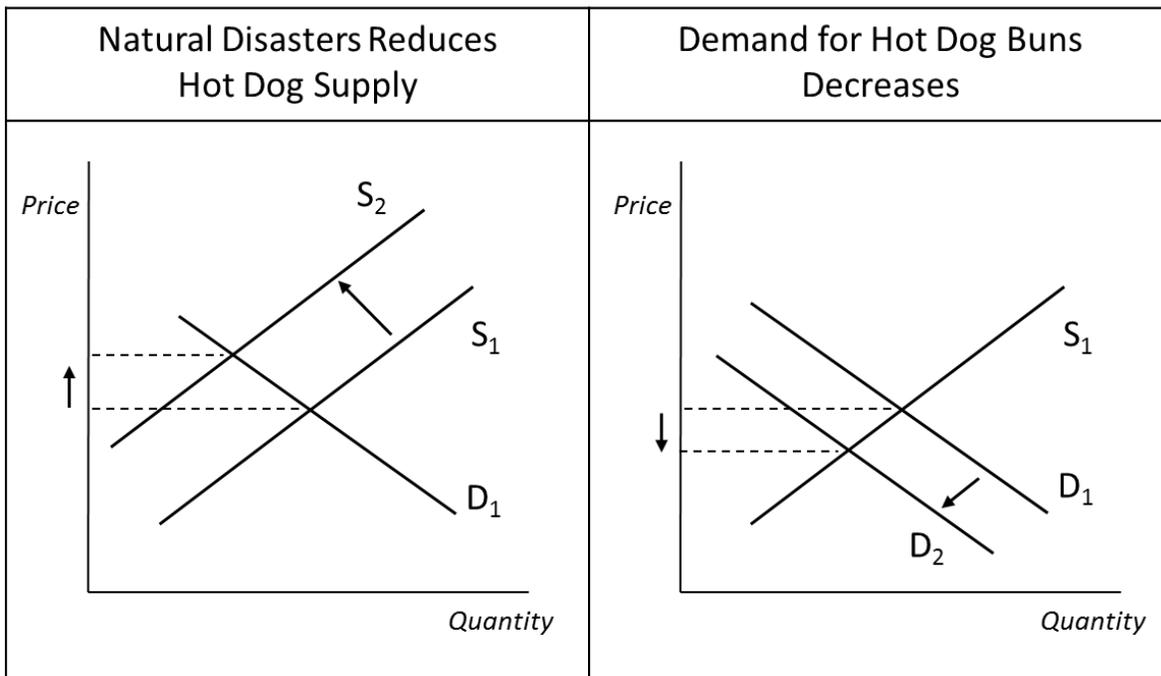
overly complicated for an introductory course. However, the interaction between the two goods in the sympathetic markets is something that students do observe, and this situation provided an example of correlation, where something else is driving the change in both markets.

These situations provide support for why it is so important for the students to understand a model's underlying assumptions. To transfer these concepts into a real world application, the examples provided below use fictitious news stories and the markets for hot dogs and hot dog buns. In the first situation, the classic relationship between these complements holds, and this situation provides support for direct causation. In the second situation, an increase in the price of hot dogs will occur concurrently with an increase in demand for hot dog buns. This result occurs when the demand change in both the hot dog and hot dog bun markets is the result of changing preferences, and this situation provides an example of correlation. Following these examples, the business practices of the new taxi service Uber will be discussed. Since Uber has flexible pricing practices, this company provides an interesting application of these concepts.

### ***Breaking News from the Hot Dog Market***

#### **News Item 1: A natural disaster causes hot dog supply to contract**

***Figure 1: Textbook Example of Complementary Goods (e.g., Causation)***



Two related markets are illustrated above in Figure 1, with the hot dog market on the left and market for hot dog buns on the right. Assume that due to a series of natural disasters, agricultural production is reduced and the supply of hot dogs decreases. This contraction of the supply of hot dogs causes the market price to rise, the quantity demanded to decrease, and the quantity sold in the market to decrease. Since the price of the hot dogs has increased while the preferences have remained the same and the budget constrains consumption, the price increase for hot dogs causes the consumption of buns to decrease. As predicted by the definition of a complementary good, the demand for hot dog buns contracts.

In this situation, the intuition is that an increase in the price of hot dogs would lead to a decrease in the purchase of hot dogs and hot dog buns. As preferences have remained constant, the rising price of hot dogs encourages consumers to switch to other and now relatively cheaper food items. An analysis of the correlation coefficient between the price of hot dogs and the quantity of hot dog buns would be negative. This would imply that as the price of hot dogs increases, the quantity of hot dogs buns sold decreases, and in both the economic and statistical courses, this problem provides consistency between intuition, textbook definitions, and empirical analysis. However, when the driver of the price change in the hot dog market is something other than a shift in supply, students need to understand a very different situation.

**News Item 2: New research shows hot dog consumption increases life expectancy**

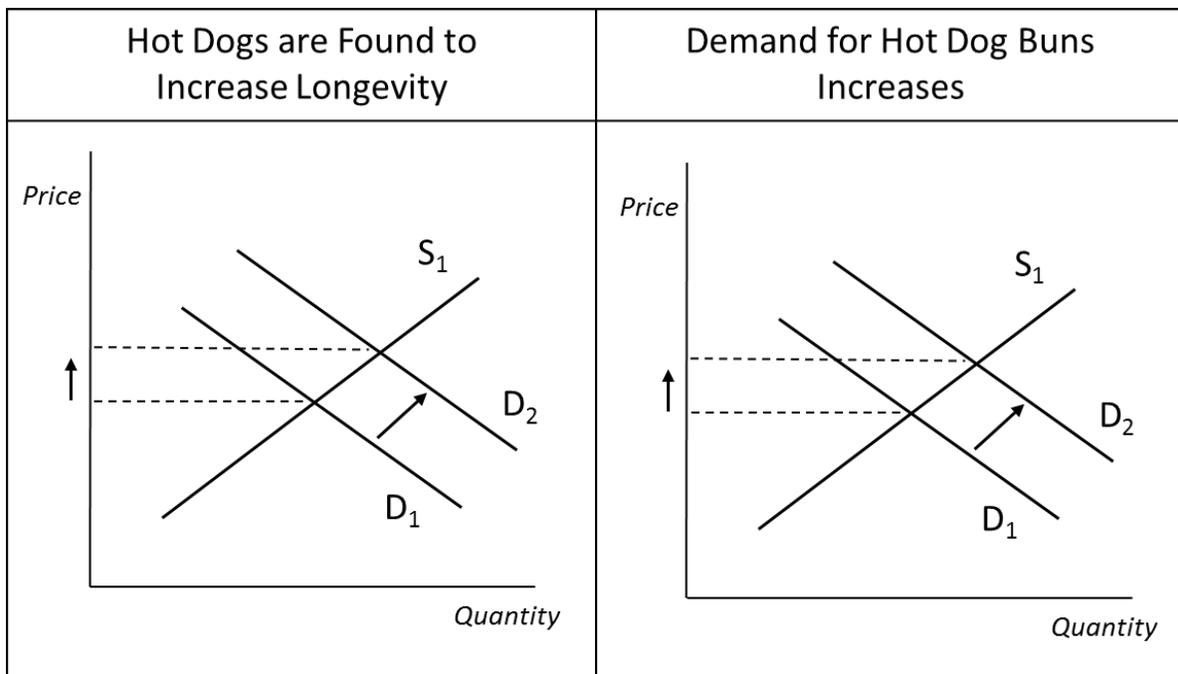


Figure 2 above diagrams the same markets as Figure 1, but in this example, the news is reporting on new research that shows hot dog consumption increases life

expectancy. This news drives an increase in the demand for hot dogs.<sup>4</sup> This increase in demand for hot dogs increases the market quantity, market price, and the quantity supplied of hot dogs, and it also increases the demand, market quantity, market price, and quantity supplied of hot dog buns in the related market. This situation is just as easy to understand as the first, and it seems intuitive that greater demand for hot dogs would also increase the demand for buns (even if the price of hot dogs has increased). After all, if individuals are consuming more hot dogs, they are likely to want at least some of those additional hot dogs on buns, so the demand for hot dog buns also increases.<sup>5</sup>

However, these actions do not match the definition of complements. In this case, the price of one good rises is concurrent with an increase in demand for the related good, so based on the textbook definition, they must be substitutes. But that conclusion does not make much sense, even for the novice economist. After all, the two foods are very different, and no new research has been released about hot dog buns increasing life expectancy, so how can they be substitutes? This situation shows what happens when there has been a change in preferences, and the activity in these related markets is one of correlation. The increase in hot dog prices does not cause the increase in demand and prices for hot dog buns, but something else is driving the actions in both markets. The news on hot dogs increasing life expectancy has changed preferences and increased demand in both markets for this pair of sympathetic goods. This result appears to contradict the textbook definition, but what it is really showing is that observing a price change in isolation is not enough to explain or predict the activity in the related market.<sup>6</sup>

Using a model that allows for changes in preferences, the intuition in this case would be that the correlation coefficient between the price of hot dogs and the hot dog buns would be positive. While this may appear to be the "wrong sign", understanding the conditions surrounding the data would clarify the situation (Kennedy, 2005). The relaxation of the preference assumption drives this result and highlights the importance of understanding a model's underlying assumptions in order for observations to be consistent with economic and statistical concepts.

### ***Uber: A Business Plan that Uses Correlated Demand***

Uber is a relatively new company that provides taxi and limousine services through a smart phone application in many cities around the globe. While the exact characteristics of Uber's operations may vary from city to city (based on local regulations and customs), it directly competes with taxis that are either hailed on the street or dispatched through a central call center. Unlike the traditional taxi companies, Uber does not own vehicles but uses independent contractors that supply their own vehicles. Uber's primary company resources are the technology that connects people wanting rides to these drivers and the payment system that eliminates cash transactions (Pullen, 2014).

While Uber has been able to gain market share by generally offering lower prices than its competitors for a ride, it differs from traditional taxis in that the price of a ride can change depending on the demand for services at any point in time. Uber uses "surge pricing" during periods of high demand. The increase in price during a surge may be relatively small when riders have alternatives (as during rush hour when riders have many substitutes including mass transit), but the price for rides can increase significantly during more isolated surges. For Uber, the greatest increases in prices tend to occur when transportation demand is correlated with special events and people are combining the consumption of both the transportation and the special event. Some examples of this correlated demand include concerts, sporting events, and New Year's Eve.

Using New Year's Eve to further describe this correlation, high demand drives up both the price of a restaurant meal and the cost of an Uber ride. If these two goods were complements, the increasing price of the restaurant meal would reduce the demand for the Uber services. However, these two goods are sympathetic goods and a change in preference (the desire to go out on New Year's Eve instead of the day before or the day after) increases the demand and the price for both of these goods.

While this surge pricing makes sense for Uber's business, riders are often unhappy about the additional costs. As Uber has developed, it has done more to make the client aware of the price, and consumers continue to use the service at these times. The continued demand for Uber services during these peak periods is likely the result of limited alternative (Campbell, 2015).

### ***Conclusion: Explaining the Details of Social Science Models***

The possibility of conflict between real world observations and the economic definitions of complements and substitutes shown in these examples can be resolved by explaining the difference in the assumptions. While both of the examples in the theoretical market for hot dogs assume a price increase, understanding how people will react to a news item is important when explaining the events in the hot dog bun market. In addition to clarifying the economic terms, these two situations also provide a contrast that details the difference between causation and correlation. While the importance of understanding the specific assumptions and the underlying claim of *ceteris paribus* is often stressed in both economics and statistics courses, these skills are vital when hypothesizing about a model's predictions. In the first hot-dog-and-buns situation, all of the classic economic definitions and the role of causation hold; in the second situation, the same two markets have a different relationship once the constant preference assumption is relaxed and correlation is explained.

The Uber business model provides a real world illustration that some students may already be aware of, and it also provides an example on how businesses use economics and statistics to develop a company.

By using both consistent and contrasting examples, students may be in a better position to understand the supporting details and underlying assumptions in social science models, and this application of complementary and sympathetic goods helps to explain difference between causation and correlation. In addition to clarifying these definitions, these examples show why understanding models is an important skill that helps prepare the student for the more complex models in the intermediate and advanced courses and for solving problems outside the classroom.

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## END NOTES

<sup>1</sup> Mankiw (South-Western), Hubbard and O'Brien (Person), Cowen and Tabarrok (Worth), and other introductory economics texts were reviewed, and all of them provided near identical definitions of complements.

<sup>2</sup> Research supports that many students find the introductory courses challenging. Shiller (2010) comments that this might be due to the difference between social science and natural science coursework's and the application of these concepts to real world situations. For the microeconomics principles course, Emerson and Taylor (2004) report average course grade of low to middle C's for sections taught in either the standard and experimental format. Ballard and Johnson (2004) report similar grades for a larger sample of students. From the statistics literature, Perney and Ravid (1990) start an article with "Statistics courses are often viewed by many college students as impediments to the attainment of a desired degree," and Johnson and Kuennen (2006) reported average grades in introductory statistical classes to be a high C.

<sup>3</sup> In addition to constant preference, other assumptions for the standard economic model of substitutes and complements include constant income (or wealth), the law of demand, and normal goods. All of these other assumptions will remain in place throughout this discussion.

<sup>4</sup> In my microeconomics principles courses, any new research that shows a good increases life expectancy or improves one's love life is assumed to cause an increase in demand for that good.

<sup>5</sup> This result can even occur if income or wealth is fixed, for expenditures on other goods can be reduced as the marginal utility to price ratio is re-evaluated based on the newly discovered health benefits of hot dogs

<sup>6</sup> In the introduction to microeconomics, this is a good time to remind the students that a price increase is caused by one of three situations: supply decreasing, demand increasing, or both of these actions occurring at the same time.

