Guidelines on Quantitative Techniques
for Competition Analysis

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Abstract
With newly developed empirical methods and increased data availability, quantitative analyses can play an important role in antitrust and competition investigations undertaken by competition agencies. Quantitative analyses can complement the conclusions from qualitative or theory-based analyses, and provide an empirical basis to choose between competing conceptual or theoretical conclusions. The range of techniques used in competition analysis has expanded rapidly in the past two decades, and there is now an accumulated body of knowledge that is routinely brought to bear in competition matters in the United States and Europe. These guidelines are intended to provide a selective overview of current best-practice empirical methods, focusing on those that are most widely used and readily applicable at each stage of an empirical analysis involving competitive issues. The guidelines begin with an introduction to general best practices at each step of a typical empirical analysis and on the development of an economic model that will guide the analysis. We then describe a set of methods used to address some of the most common questions that arise in competition cases, including market definition; market concentration, upward pricing pressure, and other questions relevant to merger enforcement; empirically identifying the potential outcomes of alleged horizontal conspiracies; and market power and monopolization.

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I. Introduction

As new empirical methods have been developed and technological progress has led to increased data availability, quantitative analyses are playing a more important role in antitrust and competition policy matters. Quantitative analyses can complement the conclusions from qualitative or theoretically based analyses, and provide an empirical basis to choose between competing qualitative approaches. Building on advances in the academic and policy literature, the range of techniques used in competition analysis has expanded rapidly in the past two decades, and there is now an accumulated body of knowledge in the field that is routinely brought to bear in competition and antitrust matters in the U.S. and Europe.

This document provides a selective overview of these emerging *best practice* methods, focusing on the most widely-used and readily applicable methods. The goal is to provide practitioners and other interested parties with an accessible but relatively complete introduction to the methods commonly used at each stage of an empirical analysis. The guide proceeds as follows. Section II presents a brief overview of general best practices in empirical work, starting with methods for collection and initial processing of data, and continuing with general approaches to the design and implementation of an empirical analysis. The following sections then elaborate on particular methods used in different contexts in antitrust analysis. Section III presents quantitative methods for determining market definition, which is frequently a critical first step in antitrust analysis. Section IV then moves on to a review of methods that can inform merger review. Section V turns to quantitative methods that help evaluate the existence of horizontal conspiracies. Finally, Section IV discusses methods for market power investigations.

II. General quantitative methods best practices

Quantitatively-based analyses usually involve many steps, including the collection of data, initial data checking, and the development of an identification strategy that will guide the analysis. Since an entire analysis can be undermined by errors or omissions at any stage, it is critical that the procedures at each step meet best-practice standards. The reliability of an analysis (including whether the results are considered statistically meaningful and whether they have unambiguous interpretation in regard to the question at issue) is critical for it to be credible, useful and to carry weight with the fact finder.

There are a number of general considerations that underlie best practice standards that, if carefully addressed, will help to ensure the reliability, accuracy, and relevance of the resulting analysis. Is the analysis based on relevant and high quality data? Are the conclusions of the analysis robust to minor changes in underlying assumptions or benchmarks? Are the steps involved in deriving the conclusions based on widely accepted economic arguments and standard scientific practices? Finally, are the conclusions consistent with other analyses, both qualitative and quantitative? In this section we outline the various stages of a typical empirical analysis that might emerge in an antitrust or competition analysis, and highlight the procedures and best practices at each step that are necessary to insure the accuracy, reliability, and ultimate quality of the analysis.

A. Data Collection

The data for an empirical analysis in an antitrust or competition matter can come from many sources. The parties involved in litigation may provide data voluntarily, or through the discovery process. Governmental oversight agencies may have access to relevant data, may have the power to obtain data from relevant parties, or may commission private agencies to collect or generate the data (e.g., through surveys). Interested third parties, such as competitors in a merger review, may also be willing to provide information and data. Trade publications gather and often distribute or sell industry-wide and firm-level data for particular industries.[1] Certain firms may sell outputs or buy inputs that are traded on public exchanges, providing "spot" prices for these products. Finally, in many countries a wide variety of data are available from government statistical agencies, including information on demographic trends, incomes, and consumer prices.

Even though many types of data are potentially available, it is often very challenging to collect useful and reliable data for analysis of a competition or antitrust matter. Firm-specific sales, prices, and cost data are rarely publicly available. Even firms themselves do not necessarily maintain detailed data on sales and costs.[2]

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[1] For example, the Oil and Gas Journal publishes a list of all refineries in the world, with estimates of capacity and production.

[2] This may happen for various reasons. Consider a few examples. A firm may not sell directly to the end consumer, but rather to intermediate retailers. This can be problematic if the transactions of interest are the sales to the final consumer. Keeping detailed sales information can be time-consuming and expensive, and such data might be difficult to analyze, which may make some firms less likely to gather such data and instead focus on more aggregate data or third party analysts. Finally, sometimes data is available, but the firm has changed the way they gather and maintain that data over time, making it difficult to measure variables of interest consistently or easily over time. This may be a particular issue in, say, a merger review context, where time is of the essence.

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Firms frequently do have accounting data available, but such data can present a number of challenges for economic analysis. One issue is the level of aggregation: accounting reports are usually created to represent aggregative measures of firm performance. The available data may not distinguish between revenues from different products or services offered by the firm. Likewise, it may be impossible to obtain separate cost information for different products or services. A second issue is that accounting principles do not necessarily correspond to economic principles in distinguishing between fixed and variable costs, for example, or in defining the cost of capital. Firms may also use different accounting standards for measuring the depreciation of different capital investments, depending on tax laws, special investment incentives, and other factors. The aggregated nature of most accounting data and the nature of accounting standards often make it difficult to accurately measure the main variables of interest in an antitrust or competition analysis, most prominently detailed measures of price, volume, and marginal economic cost.[3]

Regardless of where the data are obtained, it is very important to develop a clear understanding of the available data, including its limitations and weaknesses. Normally it is useful to ask clarifying questions and (if possible) to speak directly to the individuals supplying data, since accountants and business managers may not use the same terms as professional economists, which can lead to confusion and misunderstanding.[4] Clearly communicating about the nature of the available data and its limitations can expedite the data collection process – a concern that is often paramount in time-sensitive investigations like merger review.

Since the available data rarely correspond exactly to the constructs envisioned in the model underlying the empirical analysis, it is important to characterize the nature of the discrepancies between the theoretically appropriate concept and the construct represented in the data. For example, consider the theoretical concept of economic marginal cost. This is an economic cost, so it includes opportunity cost. If, for example, an increase in the production of one product reduces the available production capacity or engineering resources that can be used to produce another, this tradeoff should be reflected in the marginal cost. On the other hand, if production utilizes a sunk resource, such as a factory that the firm has committed to renting for a fixed amount of time, its costs should not be included in marginal cost.

In spite of these and other nuances about the appropriate calculation of marginal economic cost, average accounting costs are often used to proxy for marginal costs. Average accounting costs will not include opportunity costs, and may well include a component reflecting fixed or sunk costs. In some cases it can be difficult to control for such discrepancies. Opportunity costs, for example, may be hard to identify or quantify. But sometimes the likely magnitude of the worst-case discrepancies can be bounded (e.g., it

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[3]   For example, see Russell Pittman, "Who Are You Calling Irrational? Marginal Costs, Variable Costs, and the Pricing Practices of Firms," *U.S. Department of Justice Economic Analysis Group Discussion Papers*, EAG 09-3, 2009, at http://www.justice.gov/atr/public/eag/248394.pdf; and Peter Davis and Eliana Garces, *Quantitative Techniques for Competition and Antitrust Analysis*, Princeton University Press, 2010 at pp. 125–130.

[4]   Certain words may be terms of art within a firm, especially within large organizations, but may have different meaning to outsiders. Individuals responding to data requests from outside the organization may not realize that the person making the request is unfamiliar with their organization's terminology.

may be determined that the errors are unlikely to be larger than +/– 10 percent).[5] In other cases it may be possible to characterize the statistical properties of the measurement error gap. For example, in many cases the discrepancies in consecutive months or years are relatively similar, implying that the measurement error is positively correlated over time. As explained in more detail below, if the nature of the measurement errors can be characterized it may be possible to use sensitivity analysis to determine the likely impact of these errors on the main conclusions of the analysis.[6] If modest changes to the data do not change the main conclusion of the analysis, the presence of measurement error may be relatively unimportant.

B.   Data preparation

1.   Understanding the data

Once data have been collected the analysis proceeds to the task of understanding the data and preparing it for further analysis.[7] The first step is to investigate the variable definitions and to try to verify that the variables actually correspond to their stated definitions. This step can lead to surprises. For example, variables may be mislabeled, or inadvertently mixed up.[8] It is often instructive to perform simple validation checks to ensure that the initial understanding of the variables is correct.[9] For example, information on the typical magnitude of prices for a given market may be readily available, and can be compared to the range of a variable thought to represent prices in the available data set.[10]

A second step is the calculation of formal summary statistics for each variable.[11] The maximum and minimum of each variable should make economic sense. For example, a

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[5] An unknown parameter is said to be bounded if it is known to be within a certain range, even if a precise estimate of its true value within that range is not available. For example, the marginal cost of a product may not be known with precision, but there might be evidence on the record that it is definitely below a certain value. Then the marginal cost can be bounded between zero and that value. If additional information becomes available, it might be possible to tighten the bound further.

[6] A variable may be measured with error for a number of reasons. For example, if data on a company's sales is obtained not through accounting documents but rather by interviewing a sales person, it is possible that the data is going to be "measured" with error. Similarly, if a company discloses its sales in a region but rounds to the closest million, sales may again be "measured" with error; e.g., instead sales of $32,412,000 may be reported as $32,000,000. In the latter case, the error would be at most half a million dollars, while in the former case the magnitude of the potential error may be less clear.

[7] This is not, strictly speaking, a "second step" that happens after all data collection has finished. Rather, while preparing the intial data for further use the economist may determine limitations in the data and decide to go back and attempt to gather more or alternative data. As such, it can be good practice to start attempting to analyze the data as it comes in, in order to better inform any further requests that can be made in the time available.

[8] In some cases it may be possible to infer certain variable definitions from the relationships among the variables. For example, if revenue and per unit price are clearly labeled but a third column is not clearly labeled, it might be possible to check that the third column is always equal to the ratio of revenue divided by per unit price, and thus measures volume.

[9] A validation check refers to different checks that can be implemented at different stages of data analysis. In the data preparation step presently discussed they refer to checks that validate our understanding of the data. For example, one may want to verify that if price, volume, and revenue are all present, the data always corresponds to the expected formula of revenue being equal to price times volume. In other contexts, validation checks may refer to other types of checks. For example, when evaluating a regression model, plotting the model's residuals against the explanatory variables included in the model may serve as a validation check for functional form.

[10] This can be useful to check the units of measurement. For example, reported prices for agricultural products may be reported in kilograms or tonnes. Or a multinational company may report revenues in either euros or dollars.

[11] A summary statistic refers to any number of simple statistics that can be used to characterize the values taken by a variable, e.g., the maximum, minimum, average, median, standard deviation, inter-quartile range, and so on.

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zero or a negative value for a price variable may indicate a missing value, but it may also indicate an accounting practice or other feature that needs to be understood before using the data.[12] Likewise, a very large price value may represent a data entry error, or it may indicate a lump sum payment from the client, or some other issue.[13] Values that are outside of some plausible range should be identified and resolved as soon as possible. These steps are critical because if data is faulty, analysis based on that data may point to false and/or unreliable conclusions. Similarly, the mean and median values of each variable should be compared to each other and to the plausible range of values for the variable. Finally, the fraction of missing values for key variables should be carefully assessed. A high rate of missing values may indicate a problem with the data source, and could also lead to challenges to the representativeness of the final analysis.[14]

When dealing with data from multiple sources – such as data from different firms, or data from different regional subsidiaries or the same firm, or data from older and newer data bases of the same firm – it is important to attempt to verify the consistency of the definitions and units of measurement. Problems can often be identified by calculating separate summary statistics for the variables from each data source. If, for example, different firms treat credits and/or rebates differently in their data, the minimum and maximum values of a price variable will differ across firms.

A third highly recommended step is to a construct a series of plots and charts, starting with a histogram for each variable and time series plot of any time-related variables. These simple plots quickly and efficiently summarize major features of the data, and will often lead to the identification of "outliers" that may be caused by data entry errors or errors in the assembly process.[15] Time series plots can also be useful in identifying "regime changes" or other institutional changes that affect a market.[16] For example, a plot of the average prices received by farmers in different regions of a country should reveal any major changes in the regulatory system affecting trans-shipments of products between regions. More generally, time series plots can identify time periods where any underlying relevant

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[12] For example, firms sometimes offer a customer a volume discount once they reach a threshold volume in a given time period, say a month. These volume discounts may not be applied retroactively to all transactions over that month, but rather they may only be applied to the last transaction that pushed the customer over the threshold, which may make the revenue for that particular transaction, and hence the implied price, negative.

[13] For example, a variable may be "missing" for a particular entry even though there may be information available for the other variables for that entry. In some statistical packages, missing values are treated as really high values; this may in some circumstances lead to large positive outliers, depending on how summary statistics are calculated.

[14] Statistical analysis is frequently done on a sample of data as opposed to all the relevant data. Determining whether the sampled data and the analysis based on the sampled data is sufficiently representative of all relevant data will depend on a number of factors and must be evaluated on a case-by-case basis, for instance by examining the criteria with which the data was gathered, industry knowledge, and other evidence produced in the case. For example, in competition analysis, detailed transaction data may be available for a company's top fifty clients but not for smaller clients. In this case, whether that data is representative for the task at hand may depend on the question investigated (is it about these large clients, all clients, or smaller clients), on the makeup of sales (do these large clients make up the vast majority or small part of sales), and other factors.

[15] An outlier is a value that is very different from the vast majority of values in the data. For example, an outlier may be a data entry error; for example, an extra zero may have been added to a number by accident.

[16] A regime change or structural break refers to a change in the underlying model generating the data. In other words, it refers to a change in the relationship between the various variables. For example, consider a situation where the objective is to model the costs associated with the production of a given product, but that halfway through the available data, new technology was introduced that halved the amount of energy required in production. The relationship between the energy and output variables is different before and after the introduction of the technology.

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economic changes took place, such as large demand or supply shocks. Even if the plot itself cannot explain what these changes where, by identifying when they happened it can focus where further investigation of the data is necessary.

Bivariate scatter plots of all variables that are likely to be related to each other can also be extremely useful. For example, simple scatter plots of volume and price can help identify whether pricing seems to be uniform or disperse, and whether substantial volume discounts are in effect. Likewise, if the data set includes prices for different firms, it is often extremely useful to plot one firm's price against each of the others' (or the ratio of the two prices). Such plots can provide numerous insights, ranging from the detection of errors and outliers to the identification of major features of the data that will be critical in the more formal quantitative analysis. For example, examining changes in patterns in bivariate plots after particular events of interest may help uncover relationships between the variables that may be relevant.

2. Data Cleaning

Most data sets contain errors, inconsistencies, and missing values. Procedures and assumptions must be developed to resolve or address these problems. For example, one approach is to drop all observations that have values for certain key variables that are missing or outside of a plausible range. An alternative approach is to use an imputation procedure to impute missing values and replace unusually high or low values with bounded values (e.g., replace all implausibly low values with the fifth percentiles of observed values). The specific procedures used in a given analysis depend on the context and the preferences of the research team. In any case, however, the assumptions and procedures should be clearly documented, and whenever possible re-evaluated later in a sensitivity analysis. For example, if the main analysis is conducted by dropping all unusually high or low values, then an alternative analysis can be done in which these values are replaced by bounded values, to determine whether the decision of how to treat these particular observations affects the bottom line conclusions of the analysis.

Special care must be taken when dealing with indexes or other aggregated variables. The choice of how to index or aggregate has the potential to impact the bottom line conclusions of an analysis. Consider, for example, an analysis of automobile pricing. When buying an automobile, a consumer needs to choose a particular make of automobile (e.g., Audi), a model (e.g., A5), a body type (e.g., hatchback or convertible), and a set of options. Even if such highly granular data are available, the analysis might be more effectively conducted at a more aggregative level – for example, at the model-month level. In such cases, a price index is normally constructed by averaging the prices paid for all body type and option package combinations of a particular model in a given month. How this price index is constructed will likely impact the end results. Standard procedure is to construct a price index using a fixed set of weights, based on the relative sales of different units over the entire period, or in a base year. If instead one were to simply use the average price of all units sold in a month, prices would appear to change because of changes in the choices made by consumers across body types and option packages. This leads to measurement error and can also affect the results of the analysis. In the case of monthly auto sales, for example, if prices for a certain model *fell* in a month, and consumers bought more cars with relatively expensive options, the use of the average price paid on all units

sold in the month – rather than a fixed weight index – could lead to the conclusion that higher prices caused an *increase* in the number of units sold.

Often, available price data are already aggregated across different product lines (for example, by dividing total sales revenues by the number of units sold). This measurement error is correlated with shifts in demand, which can in principle be handled by an instrumental variables technique, discussed below.

C.   Model development

Quantitative analyses for antitrust and competition matters are normally conducted using a theoretical framework that informs the empirical analysis and provides the basis for the legal or regulatory conclusions of the exercise. *Any quantitative analysis necessarily involves the development and refinement of a working model.* Typically, the precise details of the model specification will change over time as the research team gains a better understanding of the available data and the main institutional and economic forces in the market being analyzed. In some cases the model the team is ultimately working towards is a relatively straightforward adaptation of a standard model from economic theory, such as a model of consumer choice or bidding behavior in a private-values auction. In other cases a more specialized model may be required to reflect the relevant features of a particular marketplace for the antitrust question at hand. For example, if the question is whether a cartel was in place in which it was agreed that one firm led price announcements and the other firms followed, a test could be constructed to assess whether and to what extent that behavior appeared to be present in the observed pricing data.

A common and useful practice is to ultimately present a "baseline" model that captures the main features of the analysis as the basis for the main presentation and argumentation, and reserve more complicated or sophisticated versions of the model for robustness purposes. A simplified model can be more easily explained to non-technical audiences (such as judges, jurors, or regulatory agents), while robustness checks can help build additional confidence in the conclusions drawn by the model.

Regardless of the particular model one is working towards or ultimately chooses to present, there are a number of best practices that are helpful in the model development phase. First, start simple. Second, run checks of model validity early on so as to inform model development. Third, once the baseline model has been chosen, undertake further robustness checks to understand and build confidence in what drives the salient results. We briefly discuss each of these points:

1.   *Start simple and add complexity one step at a time*

It is important to start simple in model development. Instead of attempting to estimate what may be the final model from the beginning, it is usually preferable to begin by estimating a simplified version of the model that focuses on a few main variables and the main economic forces at issue in the matter. This is particularly true in situations where time is limited. Building the complexity of the model up one step at a time minimizes mistakes and false starts, and helps to focus on key questions and critical data needs. Adding complexity step-by-step can also help to more easily identify what the baseline model should be and which extensions of the model should be held as robustness checks.

It is important to note that adding complexity to make the model richer and more complex is different from exploring the data to find the combination of variables and modeling choices that lead to a particular result. As explained later in the discussion of robustness checks, economic theory and industry knowledge should be brought to bear on any modeling decisions that affect the bottom line outcome of an analysis.

2. *Check the validity of the model throughout model development*

A second and related best practice is to ensure that standard checks of model validity are performed early on and throughout the process as needed. These checks include residual diagnostic tests,[17] as well as checks of the identification assumptions underlying the estimation (see below). Undertaking these tests on an ongoing basis can inform next steps in model development, for example that a different functional form must be considered, that certain explanatory variables may be omitted, or that robust standard errors must be used. The tests will help ensure that the baseline model that is ultimately chosen is credible and defensible. They can also save time: if a lot of modeling work is done without conducting any validity tests, the model may need to be re-evaluated and thus a lot of analysis may be wasted.

3. *Robustness checks build confidence in the results*

Once a final working model is selected, it is important to carefully consider and understand the features of the data, the model, and the estimation procedure that drive the main conclusions of the analysis. In principle every aspect of data processing, model specification, and the estimation procedure can be examined to evaluate the robustness of the final conclusions. For example: if outliers are eliminated by dropping extreme values of certain key variables (e.g., the top and bottom 1% of observations) do the main results change substantively? If the final model is a regression model that predicts prices using a set of explanatory variables, how do the results change if any one of the explanatory variables is taken out of the model? How do the results change if a different functional form is assumed for the key variables in the model (e.g., if log prices are used instead of price levels)? Do findings of statistical significance or insignificance change if the standard errors are calculated using alternative procedures (e.g., robust or clustered standard errors)?

Ideally, minor changes in data processing, model specification, and estimation procedures will have no impact on the main conclusions of the analysis. It is critical that the final choice of model is driven by a defensible scientific or economic principle. Ignoring a change that does affect the main conclusion is not good practice, especially since it is a simple matter for someone to illustrate such sensitivities. For example, it may be important and appropriate as a matter of economic theory for an analysis of orange juice prices to take into account the cost of oranges. Not including the cost of oranges into such a model may be questionable, especially when the bottom line result of the analysis changes substantively when the cost is included. In contrast, adding a variable that is hard to justify as a matter of economics or industry knowledge may also be questionable. For

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[17] William E. Griffiths, "Heteroskedasticity," *A Companion to Theoretical Econometrics*, ed. Badi H. Baltagi, 2000 at pp. 82–100; and Jeffrey M. Wooldridge, "Diagnostic Testing," *A Companion to Theoretical Econometrics*, ed. Badi H. Baltagi, 2000 at pp. 188–192.

example, a model of national steel production whose bottom line result is robust to all reasonable variations may still be seen as robust even if its bottom line result changes substantively when a variable that is not seen as relevant is included, such as cumulative rainfall.

D.   Model identification and benchmarking

Economic models are simplified representations of reality that leave out or ignore many factors. The models that are used in antitrust and competition policy matters are often further simplified to reflect data and time limitations. It is therefore important that in the process of developing a model, one identifies the different sources of variation in the data. In fact, the interpretation of regression analyses in competition matters often critically rely on what *is not* explained. For example, suppose we are interested in understanding the market for tuna, and in particular why prices and quantities moved in a certain direction over a certain period of time. Was it because of the actions of a cartel? Was it because of an increase in industry-wide costs? Was it because unseasonably bad weather reduced productivity? Was it because of an increase in demand, perhaps during Lent? Prices and quantities vary for many reasons, and only some of this variation will ultimately be explainable by factors included in the model of interest. The remaining variation may be unrelated to the main question of interest (in this case, whether a cartel increased the price of tuna), but could nevertheless *confound* the estimation of the parameters of the model. In other words, the remaining variation may be *misattributed* to other factors. An example is the seasonal variation in prices and quantities sold in the fashion and accessories market. In this example, volume and unit prices may be higher in November and December. In that case, an analysis of monthly data may well be dominated by this variation, which may lead to an erroneous finding that increased prices are associated with increased volume, as opposed to a finding that seasonal variation causes increased volume despite the increase in prices. A standard approach in such a situation would be to include explanatory variables like seasonal variables that can capture the relevant variation in the data. Adding a seasonal variable to a model of price and quantity will help ensure that the estimated parameters of the model are unaffected by movement in prices and quantities that are explained by seasonal trend factors.

Rather than trying to control for all sources of variation that may confound the estimation, an approach which is not always feasible, an alternative approach is to specifically focus on variation attributable to a known source. For example, assume one wanted to estimate average demand sensitivity to cigarette prices in the United States. Since cigarette prices vary from state to state, one might be tempted to simply relate per capita sales in each state to the average price. Since consumer tastes and many other factors vary widely across states, however, the variation in cigarette sales across states will reflect differences in supply as well as differences in demand that cause producers to set higher or lower prices. A simple comparison of sales and prices would confound the effect of price with the effect of all these factors.

Instead of attempting to hold other factors that affect demand and supply constant, one can identify a source of price variation that is independent of these factors. In this particular case, a potential source of variation is state-level taxes that are imposed on cigarettes. One could argue that changes in tax rates are unrelated to demand and supply

factors in the cigarette market in a state. In this case, instrumental variables techniques (explained in more detail below) can be used to estimate the model parameters using *only* the variation in prices that arises from changes in taxes. A similar situation arises in the analysis of prices for an imported good. Changes in the exchange rate affect the cost of supplying the imported good, and may be useable as an exogenous source of variation in cost to evaluate a model of price setting.

A third situation arises in certain antitrust and competition matters where the focus is on possible collusion or anti-competitive behavior in a particular geographic market or time frame, and there are other markets or time periods in which such behavior is thought to be absent. In this case the behavior of prices, sales, and other variables in the suspect market or time period can be compared against the "benchmark" time period or geographic market which is meant to represent competitive behavior in the market. In a benchmarking analysis, the focus of attention is directed toward comparisons between the suspect market or time period and the benchmark, rather than explaining all of the observed variation in the benchmark itself, which may be more difficult. Thus, benchmarking is a particular way to attempt to simplify the modeling exercise and to narrow it to comparisons that are most informative about the question of interest.

The precise delineation of the sources of variation that will be used to estimate the key parameters of a model is known as the "identification" strategy in a quantitative analysis. Identification is a term of art in applied economics and statistics for the process of isolating certain changes in key variables that are independent of other factors.[18] Proper identification depends on many factors, including the context and what is being measured. A full discussion of identification strategies and techniques is beyond to scope of this guide. Instead, in the remainder of this section we discuss identification in the context of a couple of relevant contexts – linear demand estimation and cross-sectional price tests – that illustrate many of the main issues that arise in antitrust and competition matters. Readers most interested in particular applications and examples can skip to the following section.

1.   *Linear demand estimation and endogeneity*

In this section we illustrate some of the general principles of model specification and identification using the example of demand estimation. Demand estimation is frequently employed in competition analysis. For example, demand estimates can be used to calculate price elasticities, which can be used to determine whether two products are close substitutes or to determine the potential price effects of a merger.

In what follows, we assume that the objective of the empirical analysis is to obtain an estimate (or range of estimates) for the price elasticity of demand for a product in a certain market. The elasticity of demand corresponds roughly to the percentage change in the quantity *demanded* that would result from a given percentage change in price. Graphically, this is related to estimating the slope of the demand curve, or movements of price and quantity *along* the demand curve. We can therefore attempt to estimate the elasticity using a demand equation, which relates the quantity demanded to price and other factors affecting demand. We expect that higher prices will lead to, everything else being equal, a lower

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[18]   Such variation will lead to parameter estimates that are "unconfounded" with other unspecified or undesirable sources of variation.

quantity demanded. But the quantity demanded is unlikely to be directly observed. Instead, the observed price and quantity are set by the interaction of demand *and* supply, both of which may be changing at the same time. An increase in demand for reasons other than lower prices (in other words, graphically, a *shift of* the demand curve, rather than a move *along* the demand curve) will tend to be associated with higher quantity demanded at any price level and, because suppliers generally demand higher prices to increase the quantity they produce, also with higher prices. Thus naively estimating the relationship between price and quantity could be misleading; in particular, in certain situations one may observe quantity and price moving together and erroneously conclude that the elasticity of demand is positive instead of negative. This problem is known as *endogeneity*. There are different ways to address this problem. A frequently employed solution is the use of *instrumental variables*. In this case, this would refer to a variable that would affect supply but not demand. For example, a measure of marginal cost should not in and of itself affect demand directly, but likely will only do so through its effect on price. Using marginal cost as an instrumental variable can help isolate changes in price and quantity that occur only because of supply changes, in other words, changes in price and quantity occurring *along* the demand curve. In what follows we walk through the logic highlighted above in more detail.

Assume that the working model is a simple linear specification of the relation between the monthly quantity and price in the market:

$$q_t = a + b\,x_t + c\,p_t + u_t \; ,$$

where q_t represents the quantity of sales to consumers in month t, p_t represents the per-unit price in month t (which is assumed to be constant throughout the month), x_t represents a set of control variables that have a direct effect on quantity demanded, independent of prices (e.g., consumer income), u_t represents other unmeasured factors that contribute to changes in quantity demanded in each month, and a, b and c are constants. Notice that c represents the rate at which the quantity purchased by consumers responds to a change in prices: thus the "elasticity of demand" among consumers in the market is $e = (p_t/q_t)\,\partial q_t/\partial p_t = (p_t/q_t)\,c$, which we expect to be negative.

The key issues in model development and identification for the simple linear demand model revolve around two questions: (1) why are prices higher or lower in some months than others? (2) which of the various sources of movement in monthly prices do we want to use as the basis for estimating the price response c? In the most straightforward estimation approach – ordinary least squares ("OLS") – *all* of the correlation between quantity and prices that remains after removing the effect of x_t is used to estimate e.[19] Unfortunately, however, in most market situations some of the variation in price used by OLS arises because demand itself is unusually high or low, i.e., because of variation in the unmodeled factors u_t. Consider the case where there is a positive demand shock (i.e., $u_t > 0$). If there is a positively sloped *supply curve* in the market under analysis, this shock will lead to a higher quantity of sales and a higher price. Likewise, a negative demand shock (i.e., $u_t < 0$) will cause quantity and price to both fall. In fact, shifts in demand attributable to variation in u_t actually trace out the supply curve in the market, rather than the demand curve.

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[19] For this reason the OLS estimate of c is sometimes called a "partial correlation coefficient."

As discussed above, the fundamental problem is that quantity and price are jointly determined in the market: unobserved factors that shift the quantity demanded will also tend to shift price in the same direction. This induced correlation between u_t and p_t is often referred to as an endogeneity problem. The solution to the endogeneity problem is to focus on the reactions of consumer demand to price changes that arise because of shifts in supply.

To illustrate this idea as simply as possible, we will complete the model of the market by specifying a supply function:

$$q_t = \alpha + \beta z_t + \gamma p_t + v_t \ .$$

Here, the quantity supplied to the market depends on an observable supply-shift variable z_t (for example, the price of inputs used by supplying firms), on the price p_t , and on other unmodeled factors v_t. Together, the demand and supply equations constitute the "structural form" of the model, reflecting the precise way in which the market clearing price and quantity are determined. Solving for the market clearing price we obtain an equation for prices that depends on the observed shifters in demand and supply, x_t and z_t, and on a combination of the unmodeled factors, u_t and v_t:

$$p_t = \pi_0 + \pi_1 x_t + \pi_2 z_t + \varepsilon_t ,$$

where $\pi_0 = (a-\alpha) / (\gamma-c)$, $\pi_1 = b / (\gamma-c)$, $\pi_2 = - \beta / (\gamma-c)$, and $\varepsilon_t = (u_t-v_t) / (\gamma-c)$. This is the so-called "reduced form" model for prices, which focuses on the interaction of demand and supply rather than separating the two. While estimating supply and demand separately (the structural form of the model) can provide more insight into the working of the market, it is frequently more practical to simply estimate a reduced form price equation.

The reduced form price equation above allows us to decompose the equilibrium price in the market in period t into 3 parts: a component due to the observed demand-shifters x_t, a component due to the observed supply-shifters z_t, and a component due to the combined effect of the unmodeled determinants of demand and supply, u_t and v_t. The problem with an OLS approach to estimation of the demand function is that it treats all three components equally, creating an endogeneity problem.

The solution is to isolate the "exogenous" component of price variation attributable to observable shifts in supply, and use this in the demand estimation. Mechanically, this is accomplished by a two-stage least squares procedure. The first stage involves estimating by OLS the reduced form price equation and obtaining a predicted price in the market, given the observed demand and supply shifters:

$$\hat{p}_t = \hat{\pi}_0 + \hat{\pi}_1 x_t + \hat{\pi}_2 z_t \ .$$

In the second stage, the demand equation is estimated by OLS, using the predicted price in place of the actual market price. By using the predicted price in the second stage the two-stage approach removes the component of price variation attributable to the unmodeled demand shift component u_t, avoiding the endogeneity problem that arises in a one-stage approach. Note that it is important that z_t have no direct effect on demand, but only influence consumers indirectly through the effect of supply on prices. This condition is known as the exclusion condition for identification, and can be problematic. For example, consider the use of energy prices as a variable z_t that shifts the supply of a certain product.

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Since energy prices may also affect consumer demand, the exclusion restriction may be invalid. This issue is discussed further below.

An important feature of the two-stage least squares approach is that one need not fully specify how prices are determined to use the approach. For example, suppose that it is known that the supply of an agricultural crop depends on a wide range of factors, including weather conditions, prices of inputs like fertilizer, and prices of other crops that producers could potentially grow. Even if data on other inputs and outputs are unavailable, one could still implement a two stage least squares approach for estimating the response of consumer demand for prices, using the weather during the growing season as the exogenous component of price variation. Such an approach has the added benefit that weather shocks are unlikely to have any direct effect on consumer demand, so the exclusion condition is plausible.

To summarize, a fundamental problem in market demand studies is that prices respond to unobserved demand shocks (i.e., prices are endogenous). Unobserved demand shocks will cause prices and quantities to rise and fall together, confounding the estimation of the demand elasticity, which is supposed to measure consumer's responsiveness to prices, holding constant all other factors on the demand side. The solution to this problem is an identification strategy that isolates an exogenous source of price variation. In a traditional market analysis, variables that shift the supply function of producers but have no effect on consumer demand provide such exogenous price variation. In economic parlance these variables are called "instrumental variables", and the two-stage estimation approach is sometimes referred to as an instrumental variables approach.

In many market settings different choices for the instrumental variable lead to different estimates of the consumer demand elasticity. Since the precise magnitude of the elasticity is an important issue in antitrust and competition policy analyses, it is important to try to validate a particular identification strategy. Recall that an ideal instrumental variable for a demand analysis is one that affects supply but has no effect on demand. The latter exclusion requirement can be checked in a number of ways. One is to examine demand in periods of stable prices, and check that market quantities do not respond to changes in the instrumental variable (i.e., check that q_t does not depend on z_t in a set of time periods where p_t is constant). Most often, however, the decision about what instruments to use in a given study depend on a priori economic arguments.

2. Cross-sectional price tests

In trying to assess the impact of collusive price-setting behavior during a certain time period, or in a certain geographic market, economists frequently compare the level of prices in the allegedly collusive time period or geographic market to levels in other benchmark periods or markets. Since prices may vary across time periods or markets for many other reasons besides collusive behavior, a regression model may be used to specify the counterfactual or "but-for" level of prices, taking into account as many of these other factors as possible. A typical specification for an examination of an alleged conspiracy in a certain time period has the form:

$$p_t = a + b F_t + d D_t + e_t ,$$

where p_t is some measure of average prices in month t, F_t represents a set of variables that measure shift factors on the supply- and demand-sides of the market, D_t is an indicator variable taking a value of 1 during the period of the alleged conspiracy, and 0 in other periods, and e_t represents the effect of other unmeasured factors that potentially affect prices. Notice that this equation can be interpreted as a version of the "reduced form" price determination equation described above, with F_t including both x_t and z_t, and the addition of an extra explanatory variable indicating the period of alleged collusion. The coefficient d on the indicator D_t provides a summary measure of the difference between prices in the alleged conspiracy period and prices in other periods, taking account of differences in the measured factors F_t.

Of course a finding that the estimated coefficient d is positive and significant does not in and of itself typically provide conclusive evidence of the existence of a conspiracy. This is because the coefficient d is capturing nothing more than an otherwise unexplained difference between prices during the alleged conspiracy and prices in other periods. This unexplained difference may be caused by any number of valid economic features of the marketplace that are not represented by variables included in the model and thus are not controlled for in the model. For example, precise data on input prices or other elements of cost may be unavailable. If costs were unaccounted for in the model and had risen during the time in which the conspiracy is alleged to be in operation, the coefficient d would be reflecting the impact of those costs on prices. This impact could be confused with any potential impact of a conspiracy. It may be difficult to differentiate these two factors in the context of a regression model. For this reason, fact finders frequently also consider qualitative analyses on the likely causes of measured differences in price.[20]

A very similar setup can be used in situations where an alleged conspiracy concerns a subset of geographic markets. Here a typical specification would have the form:

$$p_i = a + b\,F_i + d\,D_i + e_i$$

where p_i is a measure of average prices geographic market i (e.g., a particular state), F_i represents a set of variables that measure shift factors on the supply- and demand-sides of the market that are relevant for that market, D_i is an indicator variable with value of 1 in the markets where the conspiracy is alleged, and 0 for other markets, and e_i represents other unmeasured factors in market i. As in the case of comparisons over time, comparisons of prices across different geographic markets can be confounded by unobserved market-specific factors. For example, differences in zoning and labor regulations in different states may lead to higher costs that might be inadvertently attributed to collusive pricing behavior by retailers in those states.

Sometimes information is available on multiple geographic markets over multiple time periods, and the allegation of price collusion concerns only a subset of markets in certain periods. In this situation, a more powerful "difference in differences" technique is available that combines information from both sets of markets (the benchmark markets and those where the conspiracy is alleged from the periods when there was no conspiracy and

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[20] For example, whether the industry's features and structure make it more or less likely that collusive behavior may arise or succeed, or whether observed price changes are more or less consistent with hard to quantitatively measure competitive market factors.

the periods when the conspiracy was supposed to be in effect). This allows one to establish that in normal competitive periods market A and B may not be exactly alike but are related, and then to test whether this relationship between how market A and B operate changed during the alleged cartel period. The idea of this method is to first calculate the average difference in prices between the markets where the conspiracy is alleged and the benchmark markets *in periods when the conspiracy is thought to be inoperative.* This difference provides an estimate of the price difference that would prevail between the collusive markets and the benchmark markets in the absence of collusion. Then a second difference is computed between average prices in the collusive markets and the benchmark markets *during the period of the alleged conspiracy.* The difference in differences provides an estimate of any additional price difference between the collusive market and the benchmark markets during the period of the conspiracy.[21]

Similar regression methods can be used to test for an alleged reduction of volume. In fact, an examination of both price and quantity can serve as an important check on the results. Recall that the observed price and quantity are in fact determined by the interaction of demand and supply. A conspiracy of sellers to raise their prices must presumably act through the supply curve. In other words, as explained above, it should lead to higher prices but lower quantities. A finding that both price and quantity appears to have increased may be more consistent with an increase in demand rather than supply. Such a finding would not *preclude* a conspiracy, which may have been in effect at the same time that an expansion in demand took place. Rather, it would necessitate further investigation to disentangle the two effects.

General quantitative methods best practices: key takeaways

- Quantitative evidence should be given more weight if it is consistent with qualitative evidence, conforms to economic theory, is robust to sensitivity analysis, and its results can be replicated using alternative methodologies.

- Take steps to understand the available data and prepare it for analysis by checking the variable definitions, calculating summary statistics, and creating plots and charts.

- During model development, start simple, adding complexity one step at a time,

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[21] A difference in differences model is implemented in a regression framework using a specification like:

$$p_{it} = a + b\,F_{it} + d_1\,D_i + d_2\,D_t + d_3\,D_i\,D_t + e_i$$

where p_{it} is the price in market i in period t, F_{it} is a set of controls for market i in period t, D_i is an indicator for the collusive markets, and D_t is an indicator for the period of the alleged conspiracy. The coefficient d_3 on the interaction of D_i and D_t is the estimate of the difference-in-differences.

and check the validity of the model throughout the model development process.

- Present a "baseline" model that captures the main features of the analysis and is easier to understand.

- To build further confidence in the results and to better understand their main drivers, undertake robustness checks of the model and its assumptions, perhaps including more sophisticated versions of the model. Modeling choices, especially those that are critical to the bottom line result of the analysis (e.g., the inclusion or exclusion of a particular variable) should be justified through economic theory, industry knowledge, other qualitative evidence, etc.

III. Market definition

A. Overview

In most antitrust investigations a necessary step of analysis is to assess whether a certain firm, or group of firms, has the potential to exert market power. To do so, courts and antitrust authorities are interested in the extent to which a firm or group of firms face competitive pressures that constrain their ability to exercise market power.[22] Defining the scope of the market, or *antitrust* market, in which the firm or firms operate and compete for sales is frequently a first step in answering this question. Market definition generally requires an identification of both the products and the geographic area in which competition exists. For example, two products are found to be in the same antitrust product market (or geographic market) if competition from one product (or from one geographic area) would limit the ability of the seller of the other product (or from the other geographic area) to exert market power by raising the selling price.

Any investigation into market definition begins with a qualitative evaluation: what products appear to be interchangeable in function and considered substitutes for each other by buyers? These types of evaluations can be based on course of business documents, testimony of market participants or industry experts, or customer surveys.[23] The qualitative evaluation can help define the potential scope of the empirical market definition investigation, although the word "market" has many meanings in the business world and its use in the business context may not have the same meaning as in an antitrust exercise.[24] That said, in some situations the institutional context has been found by authorities to

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[22] See, for example, the discussion in Carl Shapiro, "The 2010 Horizontal Merger Guidelines: From Hedgehog to Fox in Forty Years," *Antitrust Law Journal*, Vol. 77, 2010, pp. 701– 759, at p. 708 ("The revised Guidelines emphasize that merger analysis ultimately is about competitive effects. … In most cases, especially where market boundaries are unclear, DOJ staff will analyze evidence of possible harm before it has determined the scope of the relevant market. Indeed, the same piece of evidence may be relevant to competitive effects and to market definition….") citing the *U.S. Department of Justice and Federal Trade Commission 2010 Horizontal Merger Guidelines* ("U.S. Guidelines") at § 4 ("The Agencies' analysis need not start with market definition. … Evidence of competitive effects can inform market definition, just as market definition can be informative regarding competitive effects.").

[23] In certain circumstances, customer surveys can be helpful in obtaining information that may be relevant to an antitrust inquiry. The degree of helpfulness, however, is directly related to the reliability of the survey information itself. Survey results from poorly designed surveys are not reliable and can be biased and misleading. A full discussion of survey methods is beyond the scope of this document, although some key issues can include the survey sample (i.e., whether it was random, whether it is the relevant population), the order of survey questions (i.e., whether survey questions were leading) and the type of survey questions (i.e. open-ended vs. multiple choice or rating, whether the relevant questions were asked to draw the conclusions required by the antitrust inquiry). One example of a survey that was found to be flawed and unreliable can be found in the court's opinion on the proposed *H&R Block-TaxAct* merger; see *United States of America v. H&R Block, Inc.*, Civil Action No. 11-00948 (BAH), U.S. District Court for the District of Columbia, "Memorandum Opinion," November 10, 2011, at pp. 42–50. The U.K. Competition Commission is one antitrust agency that extensively uses surveys in the context of merger review, specifically to aid in market definition and also to help determine the likely effects of the merger. For examples and an extended discussion of common complications with such a survey approach, see Graeme Reynolds and Chris Walters, "The Use of Customer Surveys for Market Definition and the Competitive Assessment of Horizontal Mergers," *Journal of Competition Law and Economics*, Vol. 4, 2008. See also Peter Davis and Eliana Garces, *Quantitative Techniques for Competition and Antitrust Analysis*, Princeton University Press, 2010 at pp. 167–169 and 194–198.

[24] For example, a salesman may discuss his "market" when describing his geographic territory, or the version of the product for which he is responsible. This type of statement could be made even when the actual geographic or product antitrust market is larger than the given salesman's geography or territory or version of product.

suffice to provide a clear market definition, with little or no additional qualitative analysis.[25] More frequently, however, the qualitative evaluation may suggest that a number of differentiated products may potentially be in the same market, and thus determination of the antitrust market is an empirical question.[26]

Market definition can be a complex exercise, and a large number of quantitative market definition methods have been used over time and in different contexts. In this section we discuss three classes of methods that have seen practical use. The choice of method used in any one case will depend on the context (some methods may be more appropriate than others in certain markets), time constraints (some methods may be too complicated to implement with confidence in a short amount of time), and available data.[27]

The first set of methods involves price comparisons over time: either price correlations or tests of relative price stationarity. These methods are generally simple to apply, but may be of limited use as they rely on the assumption that if the prices of two products move together, then they are likely to be competing in the same market. We motivate and illustrate the advantages and disadvantages of this approach analysis through the review of the proposed *Nestlé-Perrier* merger.

The second set of methods requires more data, but can more conclusively document the degree of customer substitution across products. We specifically explore two types of econometric analyses. The first is direct estimation of own- and cross-price elasticities for potentially competing products. We motivate and illustrate this analysis through the review of the proposed *Pan Fish-Marine Harvest* merger. The second, which is applicable when there are differentiated products sold in localized markets, uses differences in the prices observed under different marketplace conditions to determine the competitive relationship between different products, and thus inform market definition. We discuss the application of such techniques in the proposed *Staples-Office Depot* and *Whole Foods-Wild Oats* mergers.

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[25] For example, see the U.S. Federal Trade Commission's challenge of the proposed *Thoratec-HeartWare* merger (http://www.ftc.gov/opa/2009/07/thoratec.shtm). The product in question was a highly specialized medical device. Because the marketing of such devices in the U.S. requires extensive clinical trials with the U.S. Federal Drug Administration agency, the FTC could determine, after reviewing documents submitted to the FDA, that no close substitutes currently existed to offer the functions provided by the devise. The FTC also found that entry by any company other than the proposed merging entities would be delayed or relatively unsuccessful. The two companies abandoned their plans to merge after the FTC's challenge.

[26] Consider the following three examples. Review of the proposed *Nestlé-Perrier* merger required an examination of whether soft drinks were in the same market as bottled water. See 92/553/EEC: Commission Decision of 22 July 1992 relating to a proceeding under Council Regulation (EEC) No 4064/89 (Case No IV/M.190 - Nestlé/Perrier). Similarly, review of the proposed *Staples-Office Depot* merger included the question of whether the antitrust market should include stores other than office-supply superstores that sold consumable office supplies. See Jonathan Baker and Robert Pitofsky, "A Turning Point in Merger Enforcement: Federal Trade Commission v. Staples," in *Antitrust Stories*, eds. Eleanor M. Fox and Daniel A. Crane, 2007. Finally, review of the proposed *Whole Foods-Wild Oats* merger involved an examination of whether the merging parties competed in a narrower premium natural and organic supermarkets market or more broadly with other supermarkets. See Cartlon Varner and Heather Cooper, "Product Markets in Merger Cases: The *Whole Foods* Decision," *Antitrust Source*, 2007. In each of these cases, quantitative analysis is important in determining the appropriate market definition, because one could make arguments based on qualitative evidence for either a narrower or a broader market.

[27] In particular, every method discussed below requires information on prices. Many of them also require information on quantity and marginal costs. Some methods can provide usable results using only average estimates for these figures, while others require more granular information, with time series over time or multiple cross-sectional observations.

The third set of methods are empirical implementations of the U.S. Guidelines' Hypothetical Monopolist Test.[28] These analyses test whether a proposed market is an antitrust market by examining whether a monopolist could in fact exert monopoly power, and earn monopoly profits, within the market as defined. Specifically, the U.S. Guidelines ask: If all the products in the proposed market were controlled by a single hypothetical monopolist, would that monopolist find it profitable to impose a small but significant and non-transitory increase in price ("SSNIP")? If the answer is no, then the hypothetical market is defined too narrowly. A broader market is necessary because consumers can turn to other products to defeat the price increase proposed by the hypothetical monopolist.[29] The advantage of the SSNIP test is that it provides a coherent framework within which to think about market definition.   However, while the theoretical framework is straightforward, calculating whether the SSNIP will be profitable or not can be relatively complex. This is discussed in detail below.

We discuss each of these three types of quantitative market definition methods in turn below.   Our discussion assumes that the antitrust market is not already monopolized. Should the market already be operating at the monopoly price, either due to a single dominant firm or through collusion, market definition analysis starting at that baseline price may erroneously suggest that the market should be broader. This is known in the antitrust literature as the *Cellophane fallacy*. The main point is that a product or set of products that are already priced monopolistically may appear to have more and closer substitutes than they would in the absence of monopolization. The higher monopoly price could push consumers towards products that they would not find attractive substitutes in other circumstances.[30]

B.   Price comparisons over time

The relationship between the prices of different products can potentially provide information as to whether the products compete in the same product or geographic market. For example, imagine two competing products in the same market. If the cost of an input used to produce one of the products were to fall, in a competitive market the sellers of this product would then reduce prices in an attempt to attract more customers. This competition would lead sellers of the competing product to reduce their prices as well in order to avoid losing large numbers of customers. This example is related to the simple intuition behind the law of one price,[31] and illustrates how the prices of products in the same market can move together over time. The law of one price provides the logic behind a number of relatively simple techniques that examine market definition through price comparisons. In particular, as discussed below (a) price correlations and (b) relative price stationarity tests.

Such price comparisons have two important advantages: ease of implementation and relatively simple data requirements. They only require prices over time for the relevant

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[28] See U.S. Guidelines at pp. 8–12.

[29] Sometimes applications of the hypothetical monopolist test are also referred to as a SSNIP test or a critical loss analysis.

[30] See Donald F. Turner, "Antitrust Policy and the Cellophane Case," *Harvard Law Review*, Vol. 70, 1956.

[31] The prices of two products competing in the same market will constrain each other and therefore be related over time. In particular, in a frictionless commodity market, the prices of all products will be equal at the equilibrium price. Jeffrey M. Perloff, *Microeconomics*, Third Edition, Pearson Addison Wesley, 2004 at p. 228.

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products,[32] although care must be taken to ensure that the price information obtained through different sources is relevant and comparable.[33] However, there are limitations to the information provided in these tests. One would expect competing products to have prices that respond to each other over time, and hence finding that two proposed products do *not* have this characteristic may be helpful in disproving that they are in the same product market. But a finding that two products have prices that *do* move similarly over time may not be sufficient to determine that they are in the same market − additional corroboration may be necessary, whether quantitative or qualitative.

1. *Price Correlation Tests*

The *Nestlé-Perrier* merger investigation provides a helpful example for the uses and limitations of price correlation tests. The antitrust authority had to determine the scope of the product market. Specifically, the question of interest was whether mineral water sold within France was a market in and of itself, or whether other "refreshing drinks" such as soft drinks should be included in the market definition.

Qualitative analysis had been informative but inconclusive. It indicated that still and sparkling bottled water were likely to experience considerable demand and supply side substitution, while it was less clear whether soft drinks should also be considered within the relevant product market.[34] Quantitative analyses, in particular price correlations, were then employed to further investigate the matter. After the agency prepared comparable average price series for each brand of beverage,[35] correlations were calculated between different pairs of beverage brands across the various categories of drinks that were potentially competing in the same market. The analysis found that the prices of bottled water brands were highly correlated with each other, but that they were negatively or very weakly correlated with the price of soft drinks, even for brands of bottled water and soft drinks sold by the same company.[36] These results, in conjunction with course-of-business documents

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[32] The parties that are merging or that are otherwise involved in litigation will presumably be able to provide information on the prices of their own products. Information on prices for other products may be compelled through discovery, volunteered by interested parties, or may be available through analyst reports or third party data services.

[33] For example, do the prices used measure wholesale or retail prices? Do they account for credits or rebates? Do they account for any differentially applied taxes or regulations? Are the prices of all products measured in the same units? Are the prices of any products that are averaged over multiple versions of the product (different sizes, different models, etc.) being averaged consistently, or should a single representative version be used for consistency? For a more extended discussion, see the data section of the first chapter.

[34] See 92/553/EEC: Commission Decision of 22 July 1992 relating to a proceeding under Council Regulation (EEC) No 4064/89 (Case No IV/M.190 - Nestlé/Perrier).

[35] In *Nestlé-Perrier,* the antitrust authority considered the prices of plastic 1.5 liter bottles to ensure that the prices it was comparing were indeed comparable. See 92/553/EEC: Commission Decision of 22 July 1992 relating to a proceeding under Council Regulation (EEC) No 4064/89 (Case No IV/M.190 - Nestlé/Perrier). Using prices for a particular size avoids potential problems with, say, using the average selling price of each product over all sizes, which could have introduced questions about whether the composition of these averages was the same across different products or whether the composition was the same even for a given product over time.

[36] "The coefficient of correlation of real prices among the different brands of waters ranges between a minimum of 0,85 (Badoit and Vittelloise) and 1 (Hépar and Vittel). Real price correlation among soft drinks marketed by different companies is often positive and relatively high (see for instance correlation coefficients between Coca-Cola, Indian Tonic (Schweppes) and Banga (Pernod Ricard)). However, correlation between each soft drink and bottled water is in most cases negative, or when positive, very low. … It is particularly illustrative in this respect that BSN's Orange Passion is not significantly correlated with BSN's water brands, although it is the same company deciding on the pricing of both products." See 92/553/EEC: Commission Decision of 22 July 1992 relating to a proceeding under Council Regulation (EEC) No 4064/89 (Case No IV/M.190 - Nestlé/Perrier).

produced during the merger review, strongly suggested that soft drinks should not be included in the relevant antitrust market. Thus, in this case, price correlation was used to disprove the hypothesis that soft drinks and bottled water competed in the same market.

It is important to note the limitations of correlation analysis. First, correlation analysis was helpful on making an inference on market definition in the *Nestlé-Perrier* merger because there were strong, clear correlation patterns in the data, with an unambiguous difference between the price correlations among bottled water brands (all very highly correlated) and those between bottled water and soft drink brands (negatively or very weakly correlated). Had the data patterns been less stark, it would have been more difficult to draw firm conclusions from the results.[37]

Second, correlations are only as reliable as the underlying data used. The researcher must take care to ensure that the price data are measuring the relevant prices. If there is doubt, sensitivity analysis could be applied. One may consider, for example, whether the results of the analysis change significantly when using one or more alternative price series. These alternative price series may be obtained by changing the assumptions that were used to prepare the original data,[38] or may be provided by alternative data sources.

Third, given the nature of the correlation calculation, the results can be sensitive to the frequency of the data. For example, the correlation results might differ depending on whether the calculation is applied to quarterly, monthly, weekly, or daily data. Again, qualitative evidence (for example, on the frequency of price negotiations and changes) and sensitivity analyses can be employed to build confidence in the results. For example, if industry knowledge strongly indicates that price negotiations between wholesalers and retailers only take place once a month, using monthly data would likely be appropriate, and less weight might be placed on the results based on weekly data, especially if those results differed from the results based on monthly data.

Fourth, the finding of positive correlation between two products does not necessarily imply that the products are close substitutes. In particular, there are various circumstances where two products' prices may be correlated, but where the correlation may be driven by factors other than a meaningful competitive relationship between the two products.[39] It is important, then, that any inference that two products are close substitutes from positive correlation patterns must be combined with and supported by the qualitative evidence.

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[37] Imagine a hypothetical situation where the correlations between bottled water and soft drink brands were positive, statistically significant, but still lower than those among bottled water brands. How much lower would these correlations have to be to be declared too low? There is no such threshold correlation value over which we can declare with confidence that soft drinks are within the same antitrust market. In such a case, the price correlation evidence might be inconclusive.

[38] Continuing the *Nestlé-Perrier* example above, the analysis using wholesale prices charged by wholesalers to retailers could be repeated using (a) prices for different bottle sizes, (b) average price per ounce across a variety of bottles, or (c) prices both before and after credits and rebates to retailers are applied.

[39] For example, if the time horizon over which prices are analyzed is very long, inflation may drive spurious correlation between two otherwise relatively stable prices. Clive W.J. Granger, "Spurious Regressions in Econometrics," *A Companion to Theoretical Econometrics*, ed. Badi H. Baltagi, 2000 at pp. 557–561. Common supply shocks can provide another example. For instance, wood is used to produce furniture but it is also used, in various parts of the world, to build houses. An increase in the price of wood would lead to an increase in the price of both furniture and new house construction. But it is unlikely that consumers faced with increased furniture prices will substitute into building new houses instead.

Moreover, it is also important for researchers to consider and test potentially relevant alternative explanations for any such patterns.

2. *Relative Price Stationarity Tests*

A methodology that is closely related to price correlation analysis is that of relative price stationarity tests. One of the challenges with price correlation analysis, discussed above, is that common shocks may induce a spurious, and even high, correlation between the prices of two products even though in reality the products do not meaningfully compete with each other.[40] For example, imagine two products which both share a common key ingredient, but are purchased by different consumers for different uses. Some of this spurious correlation can be eliminated by focusing not on the relationship of the levels of two price series over time, but rather on the *relative price* of the two products. The intuition is that the relative price (e.g., the price ratio) of two products that are substitutes should be relatively constant over time, as they will face a common set of supply and demand factors. Alternatively, the prices of two products that are generally unrelated, but share only one factor in common, may diverge substantially over time.

This method builds closely on the statistical concept of stationarity. In general, a time series variable (like real per capita income, for example) is said to be stationary if the variable eventually returns to a particular long term value, even if it deviated from that value for short periods of time. Intuitively, if the two products are in direct competition and are viewed as very close substitutes by most consumers their relative price should be stationary.

The data requirements for these tests are the same as those for price correlation tests. Moreover, the same care must be exercised to determine whether the data are truly relevant and consistent, both within a product over time and across the multiple products being considered. Once the data are available, testing for stationarity of a series is straightforward in most statistical packages, for example through application of the Dickey-Fuller test.[41]

Like correlation tests, relative price stationarity tests are limited in their use. While they reduce some of the risk of falsely attributing a competitive relationship between two products that are due to common shocks and spurious correlation, they still retain a substantial risk of false identification.[42]

For the reasons described above, correlation analysis and relative price stationarity tests are generally more useful as methods to cast doubt on two products being in the same

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[40] Spurious correlation refers to a finding of correlation between two variables even though no causal relationship links the two. For example, ice-cream sales and sunscreen sales likely both increase during the summer, but it would be wrong to assume that one *causes* the other.

[41] See David A. Dickey and Wayne A. Fuller, *Journal of the American Statistical Association*, Vol. 74, 1979 at pp. 427–431.

[42] The relative price of two products may always revert to a long term value even if the two products do not compete with each other. This might occur if the price of *each* of the products would revert to its own long term value, irrespective of the other product. For example, if oil and wine each have a certain long-term inflation-adjusted price, their *relative* price may appear to revert to the ratio of these two prices over time (i.e., their relative price may appear to be stationary). But this is meaningless, because the two products are not substitutes. Rather, the relative price is stationary because each of the two *individual* prices is stationary.

relevant antitrust market and less useful as methods that can prove that two products are in the same market. This was, for instance, the conclusion reached by the U.K. Competition Commission when reviewing a proposed merger between two large Atlantic salmon farming firms in Scotland and Norway. The parties had presented both correlation and stationarity analyses to suggest a broad product market. The Commission did not challenge these analyses, but nevertheless considered them inconclusive. Rather, the Commission considered a direct examination of demand substitution more convincing (and found it to confirm the findings of the price comparison analysis).[43] We now turn to discussion of such analyses.

C. Econometric evidence of demand substitution and price competition

The price comparison techniques discussed above examine the competitive relationship between two products indirectly, by determining whether their prices appear to be linked over time. Econometric methods can be used to more directly quantify the substitution that occurs between two products. Here we focus on a couple of types of econometric analysis that have proved useful in practice. First, the estimation of the own- and cross-price demand elasticities of products can provide direct evidence for whether two products are close substitutes or not. Second, the application of careful econometric analysis of prices in different localized marketplaces under different competitive conditions has been an approach used in at least a couple of high profile merger review cases with differentiated products and numerous local marketplaces.

1. Econometric estimation of demand elasticity

The own-price elasticity of demand measures the proportional change in demand for a product that occurs as the price of the product is changed. The cross-price demand elasticity between two products measures the change in demand for one product in response to change in the price of the other product. Reliable estimates of own- and cross-price elasticities between products can speak directly to questions of market definition.[44] However, as discussed earlier in this guide, the proper empirical estimation of demand elasticity can be challenging, and sometimes empirically impossible.[45]

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[43] "However, while informative, neither the correlation test, nor the extent of co-movement in prices (stationarity) test can be viewed as definitive evidence of the existence of a relevant market. The prices of two products can be correlated overtime and yet the products do not belong to the same relevant market. Prices of products may move together for a number of reasons even when the products are not in the same market, for example spurious correlations may result from seasonal influences, common costs driving prices, or similar trends in the data for other reasons. The extent of price correlation also does not show how closely substitutable the products are. … Therefore, whilst these types of analyses are helpful, in our view they are better at demonstrating that products are not in the same market, through an absence of price correlation, than that they are in the same market through the presence of such price correlation." See "Pan Fish ASA and Marine Harvest NV Merger Inquiry – Final Report," *Office of Fair Trading*, 18 December 2006 at 5.9–5.13, 5.36–5.37 at http://www.competition-commission.org.uk/our-work/directory-of-all-inquiries/pan-fish-asa-marine-harvest-nv/final-report-and-appendices-glossary.

[44] For example, a finding that two products have own-price elasticities of –5 and cross price elasticities of 4 implies that if the price of product A increases by 1%, it is going to lose 5% of its demand, while at the same time the demand for product B would increase by 4%. These products face elastic demand, in that price changes lead to larger proportional demand changes. Their demand is more elastic, for example, than two products facing an own-price elasticity of –1.5 and a cross-price elasticity of 0.1.

[45] Despite our focus on demand substitution here, note that supply substitution can also act to restrain the exercise of market power. Suppose that the price of product A increases. Product B is not a substitute as far as consumers are concerned, but producers of product B are able to easily switch their production to produce product A instead, and may be

A key challenge is that demand and supply conditions can both be changing at any point in time. The actual quantities and prices observed are determined not just by the demand curve, but rather by the interaction of both supply and demand. For this reason, it is frequently necessary to use econometric techniques to help disentangle the part of the relationship between quantity and prices that is due to underlying demand conditions from the part that is due to changes in supply conditions. Instrumental variable techniques achieve this goal. For example, reliable data on changes in marginal costs are useful information to help estimate the demand curve. Why? Because for any given demand curve, the changes in observed prices and quantities that happen when the supply curve moves up and down intersecting with the demand curve in different places allow one to assess the nature of the demand curve's shape. As such, marginal cost data can be used as an instrument for demand estimation. In the absence of such data, finding a proper instrument to actually implement these techniques can be difficult, as discussed in the best practices section above.

A comprehensive description of methodologies to properly estimate demand in any possible context is beyond the scope of this document.[46] In what follows we provide an overview of the techniques that are most likely to be applicable in a regulatory context, due to both the likely data availability and time constraints. We do so using the real-world example of *Pan Fish-Marine Harvest*, a proposed merger between two farmers of Atlantic salmon. The merging parties both had substantial salmon farming activities in Norway and Scotland. A central question in the merger review was whether Norwegian and Scottish salmon were part of the same antitrust market. To reach a conclusion on the subject, the antitrust authority chose not to rely on price correlations over time but rather estimated a regression model with the goal of evaluating the cross-price elasticity between the two products directly.[47]

The objective was to estimate the relationship between the *demand* for Scottish salmon (as opposed to the quantity transacted in the market, which is a combination of supply and demand) and the prices of both Scottish and Norwegian salmon. Because the available data referred to market sales (rather than the quantity demanded), an ordinary least squares regression framework potentially suffers from endogeneity, as explained in the best practices section above. One of the goals then, is to resolve the endogeneity problem

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incented to do so after the increase in product A's price. Whether these producers and product B should be included in the market definition is frequently debated and may depend on the particular context. For example, see Jonathan B. Baker, "Market Definition: An Analytical Overview," Antitrust Law Journal, 2007, pp. 129–173 at pp. 133–138. Here, we focus on the identification of substitutes in demand and demand elasticity. That said, evidence on supply substitution frequently informs other aspects of the analysis, such as the possibility of entry. Additionally, the techniques that are described to measure demand substitution can also readily be employed to examine supply substitution. For a discussion of circumstances under which supply substitution might be relevant to market definition, see U.K. Competition Commission and Office of Fair Trading, *Merger Assessment Guidelines*, 2010 at § 5.2.a.ii.

[46] For a number of different applications, see, e.g., Peter Reiss and Frank A. Wolak. "Structural Econometric Modeling: Rationales and Examples from Industrial Organization," *Handbook of Econometrics*, eds. Robert Engle and Dan McFadden, Vol. V, 2004 at pp. 1–42; Angus Deaton and John Muellbauer, "An Almost Ideal Demand System," *American Economic Review*, Vol. 70, 1980, pp. 312–326; Steven Berry, "Estimating Discrete Choice Models of Product Differentiation," *RAND Journal of Economics*, 1994 at pp. 242–262; Steven Berry, James Levinsohn, and Ariel Pakes, "Automobile Prices in Market Equilibrium," *Econometrica*, Vol. 63, 1995, pp. 841–890; or Aviv Nevo, "Measuring Market Power in the Ready-to-Eat Cereal Industry," *Econometrica*, Vol. 69, 2001, pp. 307–342.

[47] See "Pan Fish ASA and Marine Harvest NV Merger Inquiry – Final Report" *Office of Fair Trading*, 18 December 2006 at 5.9–5.13, 5.36–5.37, and Appendix C.

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through the use of instrumental variables. Moreover, the model should reflect other sources of variation in the quantity demanded, for example income effects. The actual equation that was estimated by the antitrust authority,[48] using instrumental variables, was:

$$LSQ = \alpha + \beta\,LSP + \gamma\,LNP + \delta\,LEX + \varepsilon,$$

where *LSQ* and *LSP* refer to the log of market quantity and price respectively of Scottish salmon, *LNP* refers to the log of Norwegian salmon price, *LEX* refers to the log of an index of household expenditures in food stores, and ε represents an error term that balances the equation, capturing everything not measured by the other included variables, and which the estimation will minimize. In this model the coefficient α is a constant term, the coefficient β is interpretable as an estimate of own-price elasticity of demand for Scottish salmon, the coefficient γ is similarly interpretable as an estimate of the cross-price elasticity between Scottish and Norwegian salmon, and the coefficient δ can be interpreted as the income elasticity of demand for Scottish salmon.[49]

Of course this interpretation of the coefficients β and γ is only valid if the regression model is truly estimating the demand relationship between price and quantity, and not some hybrid of the demand and supply sides of the market. In order to identify the demand side of the market, the antitrust authority used instrumental variables for the potentially endogenous prices on the right hand side of the equation. In particular, the exchange rate between Norwegian Krone and British Pounds was used as an instrument for *LSP*, while monthly feed costs and the exchange rate between the Euro and British Pounds were used as instruments for *LNP*.

An instrumental variable is valid if it is correlated with the variable which it is meant to predict, but uncorrelated with the error term in the equation. For example, the cost of feed can be assumed to affect the supply of salmon but not (beyond its effect on the price) the demand for salmon.[50] Intuitively, allowing into the model only those fluctuations in price that are caused by shifts in supply (rather than fluctuations resulting from either demand or supply shifts) allows us to trace out the demand curve and thus estimate the relationship between price and quantity demanded.[51]

In the particular example, the antitrust authority was able to determine that (a) the own-price elasticity of Scottish salmon was negative and statistically significant, roughly at –3.5, and that (b) the cross-price elasticity between Norwegian and Scottish salmon was positive and statistically significant at a lower value of roughly 3.[52] An own-price elasticity of –3.5

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[48]   See "Pan Fish ASA and Marine Harvest NV Merger Inquiry – Final Report" *Office of Fair Trading*, 18 December 2006 at Appendix C.

[49]   The own-price elasticity of Scottish salmon is defined as *(dSQ / dSP) x (SP / SQ)*, where SQ and SP are the quantity and price of Scottish salmon respectively. This expression is equal to *(dLSQ / dLSP)*, which is what the regression model estimates as β. Similarly, the cross price elasticity of Norwegian and Scottish salmon is given by *(dSQ / dNP) x (NP / SQ)*, which is equal to *(dLSQ / dLNP)*, which is what the model estimates as γ.

[50]   Likewise, the rationale underlying the use of exchange rates as instruments stems from the premise that changes in the exchange rate affect the opportunity cost of selling to different geographic areas. Thus they affect the supply of salmon in the U.K. and through it the equilibrium price and quantity, but they do not directly affect demand.

[51]   See the first chapter for more discussion of instrumental variables and the choice of instruments.

[52]   See "Pan Fish ASA and Marine Harvest NV Merger Inquiry – Final Report: Appendix C" *Office of Fair Trading*, 18 December 2006 at C2–C4.

implies that if the price of Scottish salmon increased by 2%, the quantity demanded would drop by approximately 7%. A cross-price elasticity of 3 implies that if the price of Norwegian salmon increased by 2%, the quantity of Scottish salmon demanded would increase by approximately 6%. While there is no particular threshold past which one can definitively declare whether or not two products are in the same relevant market, these particular estimates helped the antitrust authority to more confidently conclude that Norwegian and Scottish salmon were in the same antitrust market. A number of factors appear to have built confidence in the results of the model. First, the own- and cross-price elasticity estimates appear reasonable on face value and are presumably broadly consistent with the qualitative evidence in the case. Second, the antitrust authority undertook various sensitivity analyses of their regression model, and found it to be robust. For example, certain assumptions were made when preparing the quantity and price data; as a sensitivity analysis, the antitrust authority changed these assumptions and re-ran the analysis, finding that the salient bottom line results did not change. Rather than focusing too closely on the precise elasticity point estimates derived from their main model, they instead focused on the findings that appeared to be robust against the different assumptions they could make during the data preparation.[53]

The agency in this case concluded that the cross-price elasticity was sufficiently large as to support the view that Norwegian and Scottish salmon are in the same antitrust market.[54] A related calculation that could further quantify this relationship is the *diversion ratio*. The diversion ratio is based on the following conceptual question: if the price of product A increases, what proportion of its lost sales are diverted to product B? In some cases such a ratio could be calculated directly from the data or documents produced in litigation,[55] or in some cases may be estimated with a well-defined survey. Otherwise the statistic can be calculated through own- and cross-price elasticities similar to those calculated in the example above.[56] A finding of a high diversion ratio across two products within the proposed antitrust market (i.e., a large price increase in product A leads to a

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[53] See "Pan Fish ASA and Marine Harvest NV Merger Inquiry – Final Report: Appendix C" *Office of Fair Trading*, 18 December 2006 at C3. As another example, the agency reran the estimation using lagged rather than contemporaneous feed costs as an instrument and found that this did not substantially change the results.

[54] See "Pan Fish ASA and Marine Harvest NV Merger Inquiry – Final Report: Appendix C" *Office of Fair Trading*, 18 December 2006 at C4.

[55] For example, consider a situation where sales information that identifies particular customers is available for two firms who offer potentially competing subscription products. Furthermore assume that firm A discretely raised its prices. The data could be used to calculate (a) how many subscribers left firm A (say within a year of the price increase), and (b) how many of those same subscribers subscribed to firm B's product. An example where diversion ratios were directly measured was the successfully challenged proposed *H&R Block–TaxACT* merger. The companies provided tax preparation software and the U.S. Department of Justice was able to collect historical information on how taxpayers filed their taxes directly from the U.S. Internal Revenue Service. This methodology had limitations which were recognized by the court (notice that it did not identify *why* someone switched between different methods of preparing taxes, so it did not directly tie diversion to price changes). But the court found that the testimony tended to confirm its conclusion on the relevant market based on other evidence. See James A. Keyte, "*United States v. H&R Block*, The DOJ Invokes *Brown Shoe* to Shed the *Oracle* Albatross," *Antitrust,* Vol. 26, 2012, pp. 32–39, at p. 35.

[56] For a proposed market with only two products, A and B, the diversion ratio for product A would be calculated as the increase in quantity demanded for product B for any given increase in the price of product A, divided by the decrease in quantity demanded for product A given the same increase in the price of product A. In the particular example of Norwegian and Scottish salmon, this could be calculated as *(dNQ / dSP) / (-dSQ / dSP)*, which if the model is properly estimated and assuming symmetric cross-price elasticities, is equal to *(γ / -β) x (SP / NP)*. Further assuming the average prices of Scottish and Norwegian salmon were equal, the diversion ratio in this hypothetical would have been 85% (= 3 / 3.5). The symmetry assumption could be avoided by estimating a similar model for Norwegian salmon demand.

small amount of product diverted to product B) may be consistent with a more narrow market that does not include product B. The diversion ratio can also be used in the hypothetical monopolist test, as discussed below. Like elasticity, there is no single threshold for what constitutes a "high" diversion ratio. However, the concept of upward pricing pressure, described later in this document,[57] is an attempt to make such a binary determination regarding diversion ratios in a particular economic context.

Quantifying own- and cross-price elasticities and calculating diversion ratios can provide direct evidence of competition that in turn speaks directly to market definition questions. However, the data required to accurately estimate such models may not always be available. For example, in the salmon case, the agency noted that it would have preferred to use spot prices for both products, but could not because the relevant data were not available. Rather, the agency had to use price data provided by a particular significant customer of farmed salmon, which the merging parties noted were inconsistent with some of the prices that they reported.[58] The agency did not choose to challenge this merger, but if it had, the merging parties could have challenged the validity of the data more forcefully.

Another potentially significant point of contention is the validity of the instrumental variable(s) used to properly identify the demand curve. As discussed in the best practices section above, publicly available data that can be used as instruments can be difficult to come by. Marginal cost data will generally provide good instruments, but finding cost data that actually measures marginal costs can be difficult. Even if reliable marginal cost data are produced in the course of litigation, the available information may still be highly correlated across different products and thus may prove to be a weak instrument in practice.[59]

More generally, estimating demand econometrically involves a number of assumptions. It is important to undertake sensitivity analyses to understand when the results of the model may be driven by particular assumptions or whether they are robust to relaxing these assumptions. If some assumptions are critical, is there qualitative or other quantitative evidence in support of the assumptions made? For a discussion of a hypothetical model similar to the one actually used by the agency in *Pan Fish-Marine Harvest* and the potential questions one might ask about the accuracy of such a model, see Baker and Bresnahan (2008).[60]

Finally, the above example provides a good illustration of how such estimation can proceed in practice given the realistic time constraints involved in regulatory review. The academic literature examines demand estimation in different contexts and under different assumptions. For example, economists have proposed demand models that are more

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[57]   See the discussion starting on p. 43.

[58]   See "Pan Fish ASA and Marine Harvest NV Merger Inquiry – Final Report: Appendix C" *Office of Fair Trading*, 18 December 2006 at C1–C2.

[59]   For a discussion of demand estimation, including various challenges involved in choosing appropriate instruments, see Peter C. Reiss and Frank A. Wolak, "Structural Economic Modeling: Rationales and Examples from Industrial Organization," *Handbook of Econometrics*, Vol. 6, Part A, eds. James J. Heckman and Edward Leamer, 2007, pp. 4277–4415.

[60]   Jonathan B. Baker and Timothy F. Bresnahan, "Economic Evidence in Antitrust: Defining Markets and Measuring Market Power," *The Economics of Antitrust Law*, ed. Paolo Buccirossi, MIT Press: 2008.

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flexible than the simple linear models discussed above.[61] They have also proposed discrete choice multinomial models that can be used in situations where customers choose whether or not to buy a single unit of a product rather than a certain quantity of a product (e.g., choosing what automobile brand and model to buy, as opposed to deciding how much gas to buy for one's car).[62]

A detailed technical discussion of these alternative models is beyond the scope of this guide. That said, while some of these alternative techniques can appear substantially more complicated than linear models and may in some instances require more time for implementation, they may also provide a better model of demand in certain situations. In the automobile choice example above, a discrete choice logit model is arguably more appropriate for modeling the choices of any individual consumer. This is because a discrete choice model by definition assumes that a consumer makes a single choice out of range of possible options. Such models provide predicted probabilities that a certain individual will buy a certain model of car that are always between zero and one, and can also be used to analyze (and predict) market shares.[63] In contrast, simple linear models may be ill-suited to making individual-level predictions.

As explained above, demand estimation and the calculation of own- and cross-price elasticities is a complex empirical exercise for which necessary and relevant data may not always be available. However, other related analyses may be possible when conventional demand estimation is not possible. For example, when detailed pricing information is available, it may be possible to draw useful conclusions about market definition even without detailed quantity and marginal cost information. We illustrate the potential for such analyses by discussing the review process of two proposed mergers, both of which involved differentiated products and detailed information on multiple local marketplaces: the proposed *Staples-Office Depot* merger, and the proposed *Whole Foods-Wild Oats* merger.

In *Staples-Office Depot*,[64] given the fact that the relevant purchasers were retail customers that purchase at store locations, local rather than regional or national markets

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[61] For example, see Angus Deaton and John Muellbauer, "An Almost Ideal Demand System," *American Economic Review*, Vol. 70, 1980, pp. 312–326.

[62] Particularly relevant for demand estimation are those discrete choice multinomial models that also effectively allow for the use of instrumental variables. See, for example, Steven Berry, James Levinsohn, and Ariel Pakes, "Automobile Prices in Market Equilibrium," *Econometrica*, Vol. 63, 1995, pp. 841–890; Aviv Nevo, "Measuring Market Power in the Ready-to-Eat Cereal Industry," *Econometrica*, Vol. 69, 2001, pp. 307–342; and for a more step-by-step explanation of how to estimate such demand models, Aviv Nevo, "A Practitioner's Guide to Estimation of Random Coefficients Logit Models of Demand," *Journal of Economics & Management Strategy*, Vol. 9, 2000, pp. 513–548. However, these models are not generally available as part of standard statistical packages. Programming and debugging them can be very challenging. Estimating the models can be very computationally taxing, which can make running sensitivities and gaining confidence in the results under time constraints harder. Moreover, such complicated models can be sensitive to various assumptions, so sensitivities can be important. See, for example, Christopher R. Knittel and Konstantinos Metaxoglou, "Challenges in Merger Simulation Analysis," *American Economic Review Papers & Proceedings*, Vol. 101, 2011, pp. 56–59.

[63] See Steven Berry, "Estimating Discrete Choice Models of Product Differentiation," *RAND Journal of Economics*, 1994 at pp. 242–262. This technique can also be used to employ instrumental variables in simple logit models, which can be important in demand estimation settings, as discussed earlier.

[64] For a more detailed description of the merger review and ensuing litigation, focusing specifically on the econometric analysis undertaken by the merging parties and the antitrust agency, see Orley Ashenfelter, David Ashmore, Jonathan B. Baker, Suzanne Gleason, and Daniel S. Hosken, "Empirical Methods in Merger Analysis: Econometric Analysis of Pricing in *FTC v. Staples*," *International Journal of the Economics of Business*, Vol. 13, 2006, pp. 265–279. For more

were considered. Pricing evidence showed that the prices charged by Staples stores were lower in cities where one of the other two office-supply superstores (Office Depot and OfficeMax) were located than in cities with no other office-supply superstore competitors. It was also established that average prices charged by Staples in a city fell with the addition of more office-supply superstore competitors.[65] The price data set produced by Staples in the merger review was large and very detailed: revenue and quantity data were available at the stock keeping unit ("SKU") level for every time period and every Staples store. A typical Staples store carried over 7,000 different SKUs. In order to make the analysis of all these prices more manageable, the merging parties and the agency agreed in advance to a use a particular weighted average across all these individual SKUs as a price index for each store. Even after aggregating in this way, the data remained very rich, with observations for a large number of stores across the United States over a period of months.

These rich data allow the econometrician to ask the following question: controlling for other factors that might affect prices, how does the average price that Staples charges in a particular store depend on (a) the number of nearby competing office-supply superstores, and (b) the number of other nearby competitors who are not office-supply superstores?[66] A finding that an increase in the former decreases prices but an increase in the latter does *not* would suggest that office-supply superstores compete more closely with each other than they do with other stores and that therefore office-supply superstores and other stores could be considered a separate relevant market.

Both the merging parties and the antitrust agency estimated relatively simple regression models based on the above intuition.[67] Both ultimately focused on difference-in-difference style specifications which effectively measured the effect of local competition on prices by calculating the average *change* in Staples' price when a competitor superstore entered or exited the local marketplace.[68] Both parties estimated models that controlled for local

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context on the course of the litigation and the role different types of evidence played in trial, see also Jonathan Baker and Robert Pitofsky, "A Turning Point in Merger Enforcement: Federal Trade Commission v. Staples," in *Antitrust Stories*, eds. Eleanor M. Fox and Daniel A. Crane, 2007.

[65] "The district court enjoined the proposed Staples/Office Depot merger, primarily because it found, based on the pricing evidence, that the sale of office supplies through the office superstore retail channel constituted a relevant product market. … The evidence that Staples charged lower prices when it faced rivalry from other office superstore chains convinced the court that non-superstore vendors of office supplies did not provide sufficiently close substitutes for the superstores to constrain office superstore pricing." See Orley Ashenfelter, David Ashmore, Jonathan B. Baker, Suzanne Gleason, and Daniel S. Hosken, "Empirical Methods in Merger Analysis: Econometric Analysis of Pricing in *FTC v. Staples*," *International Journal of the Economics of Business*, Vol. 13, 2006, pp. 265–279, at p. 18.

[66] Note that there are a variety of stores that could compete with office-supply superstores. Gathering data on all such stores might be prohibitively time consuming (especially gathering data on very small competitors), however both the government and the merging parties attempted to control for the presence of "major types of non-[office-supply superstore] competitors, e.g., discounters, club stores, and computer superstores." See Orley Ashenfelter, David Ashmore, Jonathan B. Baker, Suzanne Gleason, and Daniel S. Hosken, "Empirical Methods in Merger Analysis: Econometric Analysis of Pricing in *FTC v. Staples*," *International Journal of the Economics of Business*, Vol. 13, 2006, pp. 265–279, at pp. 6–7.

[67] See Orley Ashenfelter, David Ashmore, Jonathan B. Baker, Suzanne Gleason, and Daniel S. Hosken, "Empirical Methods in Merger Analysis: Econometric Analysis of Pricing in *FTC v. Staples*," *International Journal of the Economics of Business*, Vol. 13, 2006, pp. 265–279 at pp. 6–9.

[68] Using a panel regression may be important. As explained in the best practices section above, trying to identify an effect through cross-sectional variation alone may end up confounding the measurement with a number of other factors that may vary from region-to-region. Depending on the context, controlling for every factor that differs may be difficult. Instead, it may be easier to introduce market-specific fixed effects, which control for any such factors within a region that do not change over time.

competition, allowed for different local marketplaces to have different price levels, and allowed for a nationwide trend in prices. Notably, the models did not control for other local factors that might affect prices, such as local unemployment or disposable income.[69] This was considered less of a potential concern because the time period used for analysis covered only twenty months, and the regression models included unrestricted fixed effects for each city that control for any systematic differences in average prices in a particular city. Despite using similar broad methodologies, the government and the merging parties made a number of different assumptions and came to different conclusions; the government argued that office-supply stores were their own antitrust market, while the parties argued that the market should be broader.[70]

How is the court to decide whether the statistical model presented by the government or that presented by the parties is more valid? A general observation is that *a statistical model is more persuasive when its conclusions are corroborated by the qualitative evidence*. Language from internal documents in this matter were used to argue that the parties recognized other office supply superstores as their core competition. Additionally, econometricians must always carefully consider the assumptions made in the model and, wherever possible, perform sensitivity analyses to check whether the results are sensitive to changing these assumptions. The agency performed several sensitivity analyses in this case that gave it confidence in its results.[71] For example, the agency found that its regression yielded similar results whether it used the panel structure of the model or not, suggesting that the model did not suffer from a significant omitted variables problem. Moreover, the agency identified each difference in the assumptions made by the merging parties' regression model and the agency's own model and then examined the contribution of each difference to the discrepancy in the final result. This allowed the court to evaluate the validity of each assumption and give different weight to the two competing models.[72]

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[69] Time allowing, the merging parties and the antitrust agency could potentially have tested whether any such factors affected the results. If these factors did not materially change the results, one could have decided to omit them in order to focus the analysis and the court's attention to the factors that appeared to be more central to the question at hand, namely local competition. Furthermore, while data on many such factors might eventually be publicly available, data that are sufficiently granular to match the level of detail of the price information produced in litigation may only be available with a certain delay. Depending on how outdated and long of a time series is produced on price information, it may not be possible to match a substantial amount of that data to publicly available data sources on demographics.

[70] The most important differences between the two models regarded the geographic model of price setting (the government assumed prices were set uniformly in one geographic area, while the parties assumed that prices responded to competition in a more local fashion), the geographic regions that were included in the analyses (the parties argued that Staples set prices differently in California than it did in the rest of the U.S. and estimated separate models for California and the rest of the country), and the calculation of consumer harm (the government calculated the increase in prices in the geographic markets where the merger would result in a change in market structure, while the parties calculated the *average* change in prices across the entire country). See Orley Ashenfelter, David Ashmore, Jonathan B. Baker, Suzanne Gleason, and Daniel S. Hosken, "Empirical Methods in Merger Analysis: Econometric Analysis of Pricing in *FTC v. Staples*," *International Journal of the Economics of Business*, Vol. 13, 2006, pp. 265–279.

[71] See Orley Ashenfelter, David Ashmore, Jonathan B. Baker, Suzanne Gleason, and Daniel S. Hosken, "Empirical Methods in Merger Analysis: Econometric Analysis of Pricing in *FTC v. Staples*," *International Journal of the Economics of Business*, Vol. 13, 2006, pp. 265–279 at pp. 6–9, 10–16.

[72] In the absence of such analysis, each regression model can appear to be a black box that produces different results, based on a bundle of assumptions that is difficult to evaluate jointly. Analyzing the effect of each assumption individually can help the agency focus its analysis on the most important assumptions. Furthermore, such individual analysis can help better align qualitative facts with the quantitative evidence. For example, in *Staples-Office Depot*, while both the agency and the merging parties focused their econometric models on identifying the effect of local competition from office-supply superstores and other competitors, the specific formulation of this local competition differed between the two models. While the agency assumed that all stores within a certain area would charge the same prices, the merging parties'

Ultimately, the district court primarily cited documentary evidence on pricing rather than econometric evidence to support its opinion to enjoin the merger. The documentary evidence on pricing was consistent with the results of the antitrust agency's econometric analysis. Moreover, the econometric analysis is understood to have played a role in making the agency more comfortable with the qualitative evidence and with its decision to challenge the case.[73]

It is instructive to contrast this to the review of the *Whole Foods-Wild Oats* proposed merger. In that case, the FTC made a similar market definition argument. However, both the qualitative and quantitative facts of the case did not appear to be as favorable to the agency's case as they were in the *Staples-Office Depot* merger. As a result, the court rejected the agency's proposed market definition and allowed the merger transaction to go forward.[74] In particular, the agency argued here that the merging parties were part of a narrower premium natural and organic supermarket ("PNOS") market, rather than part of the broader conventional supermarket market. In terms of quantitative pricing evidence, in the *Staples-Office Depot* case the agency showed that office-supply superstores lowered their prices after entry by other office-supply superstores, but did *not* lower their prices after entry by other competitors. In contrast, in the *Whole Foods-Wild Oats* case the court was not convinced that PNOS entry reduced the prices of incumbent PNOS stores. In terms of qualitative evidence, internal documents in the *Staples-Office Depot* case were consistent with office-supply superstores not competing with other stores. In the *Whole Foods-Wild Oats* case, the qualitative evidence was mixed. While the Whole Foods CEO had made several statements that could be interpreted to support a narrow market definition, internal documents also showed PNOS stores regularly reviewing prices at non-PNOS stores.[75] Meanwhile, the merging parties' expert successfully argued for a broader market mostly based on a review of actual (third party) market studies, which evaluated both qualitative and quantitative evidence.[76]

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analysis assumed that stores reacted more closely to competitors who were located closer to them, thus allowing for multiple Staples stores in the same geographic area to charge different prices. Empirically, these different assumptions drove substantial differences in the bottom line results. Further sensitivity analysis indicated that neither assumption was entirely right, though documentary evidence tended to be more consistent with the assumption made by the agency. See Orley Ashenfelter, David Ashmore, Jonathan B. Baker, Suzanne Gleason, and Daniel S. Hosken, "Empirical Methods in Merger Analysis: Econometric Analysis of Pricing in *FTC v. Staples*," *International Journal of the Economics of Business*, Vol. 13, 2006, pp. 265–279 at pp. 10–15.

[73] See Orley Ashenfelter, David Ashmore, Jonathan B. Baker, Suzanne Gleason, and Daniel S. Hosken, "Empirical Methods in Merger Analysis: Econometric Analysis of Pricing in FTC v. Staples," International Journal of the Economics of Business, Vol. 13, 2006, pp. 265–279, at p. 2.

[74] See Carlton Varner and Heather Cooper, "Product Markets in Merger Cases: The *Whole Foods* Decision," *Antitrust Source*, 2007; and Jon B. Dubrow and Carla A. R. Hine, "How did Whole Foods ever manage to pull it off?" *Antitrust Law Journal*, November 5, 2007.

[75] See Carlton Varner and Heather Cooper, "Product Markets in Merger Cases: The *Whole Foods* Decision," *Antitrust Source*, 2007 at pp. 5, 7–8.

[76] Neither the merging parties nor the agency offered evidence of cross-price elasticity between PNOS and non-PNOS stores. Rather, the merging parties' expert argued on market definition based on a review of various market studies showing that (a) customers were price sensitive, (b) regularly purchased different products at both PNOS and non-PNOS stores, and (c) could shift their purchases of specific products from one to the other; while (d) when Whole Foods entered a market, it impacted the share of both PNOS and non-PNOS stores; and (e) on evidence that when PNOS chains set their prices, they reviewed non-PNOS stores' prices and vice-versa. See Carlton Varner and Heather Cooper, "Product Markets in Merger Cases: The *Whole Foods* Decision," *Antitrust Source*, 2007 at p. 6.

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The court accepted the agency's market definition argument in *Staples-Office Depot* case, but rejected a similar market definition argument in *Whole Foods-Wild Oats*. This difference was likely driven by the fundamentally different facts in each case, and suggests the importance of quantitative evidence. Consistency across both qualitative and quantitative types of evidence is likely to enhance the credibility of both.

D.   Hypothetical monopolist test

We now turn to the U.S. Guidelines' Hypothetical Monopolist Test (also sometimes referred to as a SSNIP test or critical loss analysis).[77] Recall that an antitrust market should include the set of products (or geographies) that impose competitive restraints on each other's ability to exercise monopoly power. The hypothetical monopolist test is designed to determine such a set of products (or geographies). It aims to find the narrowest market definition in which it would be possible to exert monopoly power. Starting with a narrow market, it asks the following: if all the products (or geographies) in the proposed market were controlled by a single hypothetical monopolist, would that monopolist find it profitable to exert monopoly power by imposing a small but significant and non-transitory increase in price ("SSNIP") in the proposed market? If the SSNIP is found to be profitable, then the proposed market is found to be an antitrust market. The ability to profitably raise the price implies that there are not substitutes outside the market that are close enough to constrain an exercise of monopoly power within the proposed market. If the SSNIP is *not* found to be profitable, then it must be that the hypothetical monopolist's price increase caused substantial substitution to one or more products (or geographies) currently outside the proposed market. The test would then reject the narrow proposed market and proceeds to expand it to include one or more of these substitutes. The test is then repeated, until the market is broad enough that exerting monopoly power is found to be profitable, at which point it is found to be a relevant antitrust market for the analysis at hand.

Like other empirical analyses discussed in this guide, it is important to keep in mind that the hypothetical monopolist test is going to be more credible if its results are consistent with economic theory, industry knowledge, and qualitative evidence. For example, a SSNIP that finds that two products are not in the same market may not be credible if the products are known to be functional substitutes and between which substantial switching has been documented. As another example, a result that two geographic regions are not in the same market may not be credible if there is extensive evidence of flows between the two regions. More generally, empirical evidence of consumer switching combined with clear evidence that products are functional substitutes may be informative for questions of market definition and, in particular circumstances, may obviate the need for complicated statistical analysis.

In the rest of this section, we first discuss the conceptual implementation of the hypothetical monopolist test, followed by discussion of how one may go about to actually calculate whether the SSNIP is profitable or not. The latter exercise can be informed both by simpler calculations based on assumptions derived from economic theory, and by direct

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[77]   See U.S. Guidelines at pp. 8–12. The Hypothetical Monopolist Test is also used and endorsed by other competition authorities around the world. For example, see U.K. Competition Commission and Office of Fair Trading, *Merger Assessment Guidelines*, 2010.

empirical analysis, such as the estimation of own- and cross-price elasticities we reviewed above.

1.   Conceptual implementation of the test

The advantage of the SSNIP test is that it provides a coherent framework within which to assess market definition. The other methodologies discussed above provide direct or indirect evidence of substitution and price competition, but do not offer a definitive threshold that can be used to declare that a particular product is or is not a "close enough" substitute. The SSNIP test provides such a threshold: if a SSNIP is profitable, the products not included in the market definition are by definition not close enough substitutes.

On the other hand, there are a number of shortcomings associated with applying the SSNIP test. First, the test will not necessarily result in a definitive, unique market definition. Rather, the resulting market definition may depend on both the initial market chosen; the way in which that market is expanded; and the size of SSNIP used in the analysis.[78] The initial market chosen typically includes at least the products involved in the litigation or merger review. If a reasonable aggregate of that category naturally lends itself, it is more plausible to begin with that category instead.[79] Similarly, when the market is expanded, depending on the context it may be reasonable to evaluate the single closest substitute and to expand with only that product, or it may be more reasonable to expand with a particular aggregate.[80] The SSNIP may also lead to different results depending on the size of the price increase used in the analysis. The U.S. agencies that originated these tests typically use either a 5% or a 10% value. Yet, these values are in a sense arbitrary and other values could be used if appropriate for a particular market or as a sensitivity test.[81] Finally, how long should the price increase be sustained to be considered non-transitory?[82] The idea is to provide customers of the hypothetical monopolist with adequate time to substitute to alternative products,[83] yet not so much time to jeopardize the integrity of the assumptions and restrictions of the test. For example, when implementing the SSNIP the prices for products outside the candidate market are fixed. In addition, a typical SSNIP test will not allow for the entry or exit of firms. These restrictions become less reasonable over longer timeframes.

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[78]   See U.S. Guidelines at pp. 8–10.

[79]   See Jonathan B. Baker, "Market Definition: An Analytical Overview," Antitrust Law Journal, 2007, pp. 129–173 at pp. 144–151. For example, in the examples discussed in the previous section, the initial narrow markets were chosen to be (a) all office-supply superstores (Staples, Office Depot, and OfficeMax), not just the two merging parties; and similarly (b) all premium natural and organic supermarkets, not just the two merging parties.

[80]   For example, if the SSNIP test finds that German luxury cars are too narrow of a market and the closest group of substitutes appears to be Japanese luxury cars, it may be more reasonable to add Japanese luxury cars as a group rather than to incrementally add them by specific model.

[81]   See Jonathan B. Baker, "Market Definition: An Analytical Overview," Antitrust Law Journal, 2007, pp. 129–173 at pp. 146. As an example of alternative SSNIP values in use, consider the merging parties' expert in the proposed *Whole Foods-Wild Oats* merger, who used both a 1% and a 5% value for his SSNIP analysis in the supermarket industry. See Carlton Varner and Heather Cooper, "Product Markets in Merger Cases: The *Whole Foods* Decision," *Antitrust Source*, 2007 at p. 6.

[82]   Although the 1992 version (revised in 1997) of the U.S. Guidelines at §3.2 stated a two-year benchmark for timely entry, the 2010 U.S. Guidelines do not state a specific time frame over which timeliness should be evaluated.

[83]   For example, if the product requires one-year subscriptions, we may want to consider substitution an entire year after the price increase, in order to allow for all customers' contracts to expire.

Therefore, like other market definition methods described above, the SSNIP can be best thought of not as a methodology that can lead to the definitive market definition, but rather (a) a methodology that can be used to reject market definitions that are improperly narrow (and may lead to mistakenly finding anti-competitive effects), and (b) that can provide quantitative evidence when choosing between market definitions that are otherwise plausible given the qualitative evidence available in the case.

2. *Critical loss analysis*

The above discussion does not consider *how* to determine whether imposing a SSNIP is actually profitable for the hypothetical monopolist. This is frequently referred to as critical loss analysis. Critical loss analysis consists of two steps. The first step is calculating the value of the critical loss itself. The critical loss is simply identifying the lowest sales volume that the hypothetical monopolist must lose as a result of the SSNIP for the price increase to become unprofitable. Identifying the critical loss sales volume is an algebraic exercise given data on the hypothetical monopolist's prices and costs (and thus margins). In particular, the higher the margins, the lower the value of the critical loss, because lost sales are relatively more costly to the seller.[84] In the second step of the critical loss calculation one must estimate in the face of a hypothetical monopolist imposing a SSNIP whether it would lead to an *actual loss* that was above or below the critical loss. This second step of estimating of the actual loss is more challenging and complex.

Calculating the actual loss requires an estimate of the own-price elasticity of the products in the proposed market; when each product raises its price, what proportion of its sales is it expected to lose? It also requires an estimate of the cross-price elasticities between the products; when a product loses sales as a result of a price increase, how many of those sales are likely to be diverted to another product within the hypothetical monopolist's market, as opposed to diverted outside the hypothetical monopolist's market?[85] Putting these two types of information together, one can calculate the actual loss for any given proposed SSNIP.[86]

There are a number of considerations to keep in mind when calculating the actual loss. Assuming firms maximize profits – an assumption commonly made in economics and on

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[84] If the percentage price increase is given by *s,* price *p*, marginal cost *c*, and margin *m* (= *(p – c) / p*), then the critical loss is *s / (m + s)*. See Joseph Farrell and Carl Shapiro, "Improving Critical Loss Analysis," *Antitrust Source*, 2008, at pp. 3 and A1.

[85] This proportion can be calculated through the diversion ratio; see fn. 56 above.

[86] For example, consider two products, A and B, both of which have a margin of 10% and equal market shares. To evaluate whether a SSNIP on those two products would be profitable, first calculate the critical loss. Assuming constant marginal costs a SSNIP of 5% on product A would lead to a hypothetical monopolist's critical loss of roughly 33% (= 5% / (5% + 10%)). The pre-SSNIP margin is two-thirds of the post-SSNIP margin; the SSNIP increases the margin on each unit sold from 10% to 15%. For the hypothetical monopolist to be worse off under the SSNIP, the SSNIP must cause it to lose at least one-third of its sales. If one estimates that the own-price elasticity of product A is –7, a 5% SSNIP for product A would cause an approximately 35% fall in the demand for product A, higher than the critical loss. However, if the cross-price elasticity between products A and B is estimated to be 3, then the 5% SSNIP for product A would result in a 15% increase in the demand for product B. All in all, then, 15% of the 35% of demand lost by A are diverted to B, still within the hypothetical monopolist's umbrella. After taking the diversion to B into account, the SSNIP increases the hypothetical monopolist's margin on 65% of the units of A from 10% to 15%, while it loses the 10% margin on 20% of the units, and does not experience a difference in the other 15% (they are diverted to B and still enjoy a 10% margin). After taking substitution into account, then, the actual loss is smaller than the critical loss (the gain in revenue, 65% of its units receiving an additional 5% margin, is greater than the loss of the 10% margin on 20% of its units) and the SSNIP is therefore profitable.

which much of antitrust economics is based on – economic theory can be used to get some insights into the actual loss. In particular, it can suggest a test of internal consistency of the margins used to calculate the critical loss and the elasticities used to calculate the actual loss.

The *Lerner equation* is a result from economic theory that states that in order to maximize profits, the profit margin for a product will be set to the inverse of the own-price elasticity of that product; the less elastic the demand for the product, the higher the margin that maximizes profits.[87] This relationship has implications for the calculations of critical loss and actual loss. If margins are higher, then every unit of lost sales is more costly to the hypothetical monopolist, and hence the critical loss will be lower. However, the finding of higher margins implies that elasticity is lower; therefore the actual loss will be lower. The opposite is true for a finding of lower margins; each unit of lost existing sales will cost the hypothetical monopolist less, so the critical loss will be lower. But the finding of lower margins implies that elasticity is higher and therefore actual loss will be higher. The Lerner equation thus suggests that if one calculates margins and estimates elasticity separately, the two should be consistent. A finding of both high margins (implying a lower critical loss and lower elasticity) and high elasticity (implying higher actual loss and lower margins), may need to be scrutinized and explained, otherwise the validity of either the margins calculation or the elasticity estimate may be called into question.[88]

The weight that this theory-based test of internal consistency should be given may vary depending on the situation. On the one hand, one may argue that evidence about a firm's conduct (its price setting) when its own money is on the line should be given particular weight.[89] On the other hand, the Lerner equation calculation of elasticities critically depends on the accurate estimation of margins, which may not always be a possibility. Moreover, own- and cross-price elasticities best inform a counterfactual where a single product's price is increased; if the prices of *all* products in the hypothetical monopolist's market increase at once by the same amount (a common way to apply the SSNIP), in many cases it may be unclear why there should be any substitution *within* the market.[90]

Keeping in line with the best practices recommendations throughout this document, quantitative evidence should be given more weight if it (a) is consistent with qualitative evidence, (b) conforms with economic theory, (c) is robust to sensitivity analysis, and (d) its results can be replicated using alternative methodologies. Thus the theoretically predicted elasticities from the Lerner index may inform the reasonableness of empirical estimates of diversion and actual loss. But the opposite is also true. Careful empirical

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[87] The Lerner equation states that for margin *m* and own-price elasticity *ε*, a firm maximizes its profits at *m = – (1 / ε)*. See W. Kip Viscusi, John M. Vernon, and Joseph E. Harrington Jr., *Economics of Regulation and Antitrust*, Second Edition, pp. 266–267.

[88] See Daniel O'Brien and Abraham Wickelgren, "A Critical Analysis of Critical Loss Analysis," *Antitrust Law Journal*, Vol. 71, 2003 pp. 161– 184 at pp. 162, 164, 171; and Joseph Farrell and Carl Shapiro, "Improving Critical Loss Analysis," *Antitrust Source*, 2008, at p. 4.

[89] See, for example, Joseph Farrell and Carl Shapiro, "Improving Critical Loss Analysis," *Antitrust Source*, 2008, Daniel O'Brien and Abraham Wickelgren, "A Critical Analysis of Critical Loss Analysis," *Antitrust Law Journal*, Vol. 71, 2003 pp. 161–184, and Michael L. Katz and Carl Shapiro, "Critical Loss: Let's Tell the Whole Story," *Antitrust*, 2003, pp. 49– 56.

[90] For these and other critiques of the theory-based test described here, see Malcolm B. Coate and Joseph J. Simons, "Critical Loss vs. Diversion Analysis: Clearing up the Confusion," *Competition Policy International*, 2009.

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analysis can also call into question the validity of drawing conclusions based on simple theoretical assumptions that may or may not be true in any given context.

Market definition: key takeaways

- Market definition can be a complex exercise. A large number of quantitative market definition methods are available. The choice of method will depend on the context, time constraints, and available data.

- Price comparisons, price correlations, and relative price stationarity tests can be simple to apply and can be useful in certain situations. However, they do not on their own offer conclusive evidence of market definition.

- Estimating own- and cross-price elasticities provides more direct evidence of market definition, though one must be careful in interpreting the results of such analysis, particularly since no clear threshold is available to resolve questions of market definition.

- The U.S. Guidelines' Hypothetical Monopolist Test can provide, in theory, a specific answer to market definition. In practice, the test may be conducted in different ways and one should check the robustness of its outcome on the model's underlying assumptions or inputs.

IV.   Merger enforcement

The goal of merger analysis is to identify and challenge mergers that are likely to harm competition while avoiding interference with those that are competitively neutral or beneficial.[91] Merger analysis is concerned with two types of harmful effects. First, once two firms merge, they may, as a joint entity, unilaterally have an increased incentive to increase prices – or alternatively, to lower quality or impede innovation. In particular, consider the horizontal merger of two firms, each of which produces a single product (A and B) that compete in the marketplace. Whereas previously each firm would have evaluated implementing a possible price increase or decrease only based on the effect it would have on its own product, the merged firm recognizes that consumers substitute between both products produced by the merged entity. Thus, the merged entity recognizes that if it lowers the price of product A to increase its sales, some of these sales will come at the expense of the product B. If the entity were not merged the producer of product A would not care about the loss of sales of product B. Put differently, for the merged entity each additional sale of product A comes, to at least some extent, at the opportunity cost of an additional sale of product B. This cannibalization of the other product is generally modeled as a post-merger increase in each of the products' marginal costs.[92] Conceptually this is akin to saying that for the merged entity each additional sale of product A is associated with a higher cost than before – this increase in cost is obviously the added consideration of any potential associated loss of sales of product B. This difference in incentives between the merged entity and the prior independent entities can potentially leads to *unilateral effects* of the merged entity, or an everything-else-being-equal incentive to increase prices across product A and B that is independent of what other firms in the market do. Of course, depending on the industry and the substitutability of the merging parties' products, this incentive may be small or it may be offset by efficiencies that reduce the products' marginal costs.

Second, after the merger the market will include one fewer competitor. Depending on the industry, the market structure, and the identity of the merging parties, it is possible that the change in market structure caused by the merger may facilitate increased cooperation and reduced competition between the remaining firms in the market. This is said to lead to *coordinated effects*. Such effects are more likely in situations where products are more homogeneous but firms are asymmetric. In such contexts some firms, frequently referred to as mavericks, may be less likely than others to agree to a collusive strategy and thus may help the industry stay closer to a competitive outcome.

Antitrust agencies can employ a variety of empirical methods to evaluate unilateral or coordinated effects. These range from a simple examination of industry concentration to complex and detailed merger simulations. The challenge for antitrust agencies is to determine the simplest available method that can provide an accurate evaluation of the

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[91]   For a survey of the literature on the price effects of horizontal mergers, finding that most mergers tend to increase the prices of both the merging parties and the other firms in the market, see Matthew Weinberg, "The Price Effects of Horizontal Mergers," *Journal of Competition Law and Economics*, Vol. 4, 2008.

[92]   For such a treatment, see Joseph Farrell and Carl Shapiro, "Antitrust Evaluation of Horizontal Mergers: An Economic Alternative to Market Definition," *B.E. Journal of Theoretical Economics: Policies and Perspectives*, Vol. 10, 2010.

impact of a merger. The desired accuracy of this evaluation depends on the stage of the merger review. In most jurisdictions, the antitrust agency needs to make a first evaluation of whether to further investigate a merger in a very short amount of time. At this early stage, the agency may more readily employ empirical methods that are imprecise but easy to apply. These can be viewed as screens; their results are not meant to provide proof of potential harm to competition, but rather can serve as an indicator of potential harm and serve to flag the merger for further and closer inquiry. The agency may turn to more complicated methods in the later stages of merger review. By that point the agency likely has access to more data and information, allowing for more careful modeling. Below we discuss a number of methods that can be employed by interested parties and the antitrust agencies.

A. Market concentration and the HHI

A powerful intuition that motivates merger review is that, everything else being equal, concentrated industries are likely to be less competitive than unconcentrated industries.[93] An analysis of how a proposed merger will change market concentration can therefore provide a simple and easy to apply early screen to determine whether to scrutinize the merger in greater detail. The challenge is that arguments about market concentration hinge critically on market definition, as we explain below.

Market concentration is a function of the number of firms and their respective shares of total production in a relevant market. The most commonly used concentration measure is the Herfindal-Hirshman Index ("HHI"). The HHI is calculated by summing the squares of the individual market shares of each firm in the market and multiplying the result by 10,000.[94] By design the HHI provides information not just on the number of firms in a market, but also on the distribution of market shares across these firms. Because the shares are squared, an industry with a large number of firms but one or two dominant firms may have a higher HHI than an industry with a smaller number of similarly-sized firms.[95]

The HHI can provide a quick screen to determine whether a proposed merger should be evaluated further. For example, the U.S. Guidelines characterize markets with HHI below 1,500 as generally unconcentrated and markets with HHI above 2,500 as generally highly concentrated.[96] Furthermore, they state that mergers that lead to moderately or highly concentrated markets and that increase HHI by over 100 or 200 will be presumed to increase market power.[97] Nevertheless, the guidelines also suggest that a presumption of

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[93] For example, they may be more likely to impose higher prices and reap higher profit margins; they may not compete on product quality as much; or they may not feel the need to innovate as much.

[94] Therefore, in a market with three competitors with 20%, 30%, and 50% of the market respectively, the HHI would be 3,800, or the sum of 400 (= 20 x 20), 900 (= 30 x 30), and 2,500 (= 50 x 50).

[95] For example, an industry with one firm with 91% of the market and 9 other firms, each with 1% of the market would have an HHI of 8,290 (= 91 x 91 + 9 x 1 x 1), while an industry with four firms each with a quarter of the market would have an HHI of 2,500 (= 4 x 25 x 25).

[96] See U.S. Guidelines at § 5.3.

[97] This suggests a safe harbor: mergers that do not increase industry HHI by more than 100 points or to above an HHI of 1,500 are less likely to be challenged by the U.S. antitrust agencies. Safe harbors can reduce regulatory uncertainty and help more efficiently approve less controversial mergers. The U.K. Office of Fair Trading uses similar thresholds; it considers a market with HHI of over 1,000 as concentrated and a market with HHI over 2,000 as highly concentrated. Furthermore it considers an increase in HHI of less than 250 in a concentrated market and less than 150 in a highly concentrated market as unlikely to give cause for concern. It notes, however, that this guidance "may be most informative

harm "may be rebutted by persuasive evidence showing that the merger is unlikely to enhance market power."[98]

Similarly, the Mexican Federal Competition Commission considers that a merger is unlikely to affect competition when the HHI is calculated to be below 2000, or where the merger increases the HHI by less than 75 points.[99] Furthermore, the Commission also considers a Dominance Index ("DI"). This index is related to the HHI but focuses, as its name implies, on whether the industry is dominated by a small number of firms. Specifically, the DI is calculated by summing the squares of each firm's contribution to the HHI as a share of the total HHI and multiplying the result by 10,000.[100] The more an industry's HHI is driven by a small number of firms, the greater the DI for the industry. As a result, a merger could actually decrease the DI if it is between two of the smaller firms in industry. The Commission considers that a merger is unlikely to affect competition when the estimated DI decreases as a result of the merger or when the industry's DI is below 2,500. Nevertheless, the Commission cautions that a merger may still investigate the competitive effects of a merger if the merging parties have participated in previous mergers in the same relevant market, if they have substantial market power in related relevant markets, or if there are other valid competitive concerns.[101]

The caveats that both agencies provide regarding these screens are important. Market concentration is a simple metric that does not directly measure either unilateral or coordinated effects.[102] It ignores dynamic effects such as entry and exit in the market, changes in demand patterns, and shifts in technology. This suggests that conclusions drawn based on market concentration alone may be less reliable when market shares have not historically been stable, indicating the presence of such dynamic shifts.[103] Accordingly, it is important for any conclusions that are drawn from observations about market concentration to be consistent with other evidence in the particular case. Moreover, unless the market concentration evidence is overwhelming,[104] market concentration measures will likely be useful primarily as an initial screen, but not as the basis for a final decision on whether the merger would in fact be harmful to consumers. For example, in a case like *Whole Foods-*

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for mergers in a market where the product is *undifferentiated* and where competition between firms involves firms choosing what volume to supply to the market. In other cases the significance of these thresholds will be less." (Emphasis added.) See U.K. Competition Commission and Office of Fair Trading, *Merger Assessment Guidelines*, 2010 at ¶ 5.3.5.

[98] See U.S. Guidelines at § 5.3.

[99] See *Mexican Official Gazette*, July 24, 1998.

[100] Consider our previous example of a market with three competitors with 20%, 30%, and 50% of the market respectively. The calculated HHI would be 3,800, or the sum of 400 (= 20 x 20), 900 (= 30 x 30), and 2,500 (= 50 x 50). Thus the three firms contribute roughly 10.5% (= 400 / 3,800), 23.7% (= 900 / 3,800), and 65.8% (= 2,500 / 3,800) of the HHI respectively. The DI is would then be roughly 5,002, or the sum of 110 (= 10.5 x 10.5), 562 (= 23.7 x 23.7), and 4,330 (= 65.8 x 65.8).

[101] See *Mexican Official Gazette*, July 24, 1998.

[102] For a discussion of the decades old empirical literature that empirically estimated Structure-Conduct-Performance models and attempted to relate industry concentration to industry profitability, see Peter Davis and Eliana Garces, *Quantitative Techniques for Competition and Antitrust Analysis*, Princeton University Press, 2010 at pp. 292–300.

[103] See Peter Davis and Eliana Garces, *Quantitative Techniques for Competition and Antitrust Analysis*, Princeton University Press, 2010 at pp. 400–401. The question of whether merger review can appropriately account for the likely effects on innovation and change is a complicated and important one. For an extensive discussion, see Michael L. Katz and Howard A. Shelanski, "Mergers and Innovation," *Antitrust Law Journal*, Vol. 74, 2007.

[104] For example, when the proposed merger would reflect a merger to monopoly.

Wild Oats, it would be reasonable for the agency in the early stages of the merger to argue that organic supermarkets possibly form a market and request further examination of the merger based on the increase in concentration the merger would cause in that market. In the later stages of merger review, however, more analysis will be required to convincingly support arguments on whether the market has been defined correctly and whether the merger will harm competition.

This is because even if the market concentration evidence is overwhelming, the calculation critically depends on *market definition*. Without clear identification of the appropriate market, "market shares" are of limited value.. For example, consider the *Whole Foods-Wild Oats* merger.[105] Given the government's proposed narrow market of premium natural and organic supermarkets, the market was shown to be concentrated and the proposed merger shown to increase concentration dramatically, leading to a monopoly in many local areas. However, given the merging parties' proposed broader market of all supermarkets, the market was much less concentrated and the merger would not have resulted in as large of an increase on concentration. Notice that there is no straightforward way to reconcile these two very different conclusions if relying only on analysis of market concentration as each depends directly on market definition.

In reality, market boundaries are frequently not defined this starkly, especially in an industry with differentiated products. In such industries, products may compete within a larger market, but individual products may compete much more strongly with one another than with most of their other competitors.[106] *Market definition (and, by extension, market concentration) presents an in-or-out choice that does not flexibly allow for this concept of closeness of competition.* Consider the hypothetical case of automobiles. A merger between BMW and Mercedes may be of competitive concern because the two are likely very close competitors in the submarket for German luxury cars. But even a market defined as luxury cars, much less German luxury cars, could be challenged as unrealistically narrow because luxury cars do compete with other cars.

This only reinforces the idea that market concentration measures without other support do not alone provide convincing predictions of the effects of the merger. They are only as useful as the market definition that underlies them. Thus careful analysis of market definition or more direct analysis of the merger's likely effects on prices is an important step in the evaluation. We now turn to one such direct analysis of price effects.

B. Price-concentration analysis

When industries feature different *local* marketplaces, for example in retail sales where customers are local, a price-concentration analysis can examine the relationship between price and the level of concentration in each of these local areas. In particular, economists can use a regression framework to evaluate how prices react to *changes* in the structure of each local geographic marketplace. Echoing the preceding discussion of HHI, this type of analysis relies on the intuition that, everything else being equal, higher concentration is associated with greater market power, which is in turn associated with higher prices.

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[105] For more details and citations, see the discussion in the market definition section above.

[106] In *Whole Foods-Wild Oats*, one could argue that even if supermarkets all competed with one another, differentiation may lead premium natural and organic supermarkets to compete much more closely with one another.

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Unlike market concentration measures, a price-concentration analysis can go beyond this simple intuition and attempt to quantify the actual effect that changes in market structure have on prices.

Staples-Office Depot provides an example of price-concentration analysis, described in more detail in the market definition section above. To recap, the analysis used data for multiple local markets over multiple years (a so-called panel data structure) to study the effect of the entry and exit of office-supply superstore ("OSS") competitors on average prices at Staples stores in a local market. The antitrust agency's analysis showed that prices were higher when fewer OSS stores were present in each area. The estimated effect of changes in the number of local OSS competitors was then used to predict the expected post-merger price increase in areas that contained both Staples and Office Depot stores. For example, in a local area where the merging parties faced no other OSS competition, the model predicted that prices would increase to the typical level observed in other areas where there was only a single OSS store. Under the theory of anticompetitive harm of the case, no change would occur in local areas where only one of the merging parties was present.

Observe that the above analysis required information on multiple geographic areas, so it may not always be applicable. Moreover, it required a *natural experiment*, in particular that we observe entry or exit of OSS and non-OSS competitors in multiple markets. If no entry or exit of OSS stores (or non-OSS stores) was observed, the analysis would need to rely on cross-sectional comparisons of price levels across geographic areas, rather than changes over time within the same geographic area. Such cross-sectional comparisons are more likely to be confounded by legitimate economic differences across geographic areas that are not controlled for in the model. For example, if urban areas were more likely to have higher prices due to general supply and demand conditions, and were also more likely to be large enough to support having multiple OSS stores, it might even appear that the existence of more OSS stores led to higher prices. Obviously this would be confounding the "urban" effect with the impact of competition between OSS stores when multiple of them exist.

When based on a reliable regression model, price concentration analysis can provide an actual estimate of price effects. Thus it can be used not just as an initial screen, but for more comprehensive analysis of a merger. The regression framework allows for extensive sensitivity analysis that can establish whether the price-concentration results are robust and how much weight should be given to its estimate of the likely effects of the merger. Importantly, the estimated price effects do not necessarily depend on a definitive market definition, which can help when evaluating mergers in settings with differentiated products.[107] Rather it allows one to test the relative impact of the existence of many different potential market participants. Another advantage is that the price-concentration test is relatively straightforward conceptually compared to other comprehensive merger evaluation analyses. It relies on the basic intuition that higher concentration may lead to

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[107] For example, the test can control for whether multiple types of competitors are present in the local area. Like in *Staples-Office Depot*, a finding that prices react significantly to the presence of one type of competitor but not to another can help inform market definition, but market definition considerations need not lead to a change in the model. See the earlier market definition section for an extended discussion of *Staples-Office Depot* and how the price-concentration analysis was used to support a narrower market.

higher prices, as opposed to explicit estimation of specific economic models of competition. This helps avoid assumptions that may seem arbitrary to non-economists and may be estimated using relatively simple regression methods. On the other hand, it is still necessary to consider the economic features of the marketplace as they may affect the reliability of the estimates.[108] Therefore, in settings where price-concentration analysis is applicable, it may be more convincing to judges and policy makers than approaches that depend on more theoretical assumptions and complex formulas, but may also be rebutted by careful analysis of that type. We now turn to a discussion of upward pricing pressure and then follow this with a discussion of merger simulation techniques.

C.   Upward pricing pressure

Upward pricing pressure ("UPP") is an alternative initial screen that can be easy to implement, easy to perform sensitivity analysis on, and that can be especially relevant in a differentiated products context, as it does not rely on explicit market definition but instead relies on measures of product substitution. Although UPP is relatively recent in its current formulation compared to other methodologies,[109] it is based on well-established industrial organization concepts,[110] has been discussed, extended, and supported by others,[111] and has been incorporated in the latest version of the U.S. Guidelines.[112]

As described above, a merged entity of product A and B can find that post-merger the marginal cost of selling more of product A is now higher then pre-merger because it must now consider any potential losses in sales of product B. UPP examines the likely unilateral effects of a merger in a differentiated products market by evaluating the pricing incentives faced by the merged entity. In particular, it interprets the cannibalization between the merged firm's two products as an increase in the marginal cost of each product (reflecting that if more quantity of product A is sold, a "cost" is associated with each marginal unit that was cannibalized from product B's sales). UPP then compares this increase in marginal cost to the reduction of marginal costs that might be expected due to any efficiencies resulting from the merger. Everything else being equal, a net increase in marginal costs will lead to an increase in prices, while a net decline would lead to a decrease in prices. This leads to the following test for upward pricing pressure,

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[108] For example, a discussion of potential endogeneity problems in price-concentration regressions, as well as some additional discussion of *Staples-Office Depot*, can be found in Peter Davis and Eliana Garces, *Quantitative Techniques for Competition and Antitrust Analysis*, Princeton University Press, 2010 at pp. 246–253.

[109] See Farrell and Shapiro, "Antitrust Evaluation of Horizontal Mergers: An Economic Alternative to Market Definition," *B.E. Journal of Theoretical Economics*, Vol. 10, 2010.

[110] For example, see Gregory Werden, "A Robust Test for Consumer Welfare Enhancing Mergers Among Sellers of Differentiated Products," *Journal of Industrial Economics*, Vol. 44, 1996.

[111] For example, see Richard Schmalensee, "Should New Merger Guidelines Give UPP Market Definition?" *Global Competition Policy*, 2009; and Jerry Hausman, Serge Moresi, and Mark Rainey, "Unilateral Effects of Mergers with General Linear Demand," 2010 at http://crai.com/uploadedFiles/Publications/Unilateral%20Effects-of-Mergers-with-General-Linear-Demand-Hausman-Moresi-Rainey.pdf; and Joseph Farrell and Carl Shapiro, "Upward Pricing Pressure and Critical Loss Analysis: Response," *Competition Policy International Antitrust Journal*, 2010.

[112] See U.S. Guidelines at § 6.1 and p. 21 ("In some cases, where sufficient information is available, the Agencies assess the value of diverted sales, which can serve as an indicator of the upward pricing pressure on the first product resulting from the merger. Diagnosing unilateral price effects based on the value of diverted sales need not rely on market definition or the calculation of market shares and concentration. The Agencies rely much more on the value of diverted sales than on the level of the HHI for diagnosing unilateral price effects in markets with differentiated products. If the value of diverted sales is proportionately small, significant unilateral price effects are unlikely.").

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$$D_{AB} (P_B - C_B) > E_A C_A$$

where D_{AB} represents the diversion ratio from product A to product B, P_B the pre-merger price of product B, C_A and C_B the pre-merger marginal cost of products A and B respectively, and E_A the fractional reduction of product A's marginal cost as a result of efficiencies as a result of the merger.

This test can be interpreted as follows. The higher the efficiencies expected as a result of the merger (the higher E_A is), the less likely it is that the merger will lead to upward pricing pressure.[113] But the higher the margin on product B and the higher the diversion from product A to B (thus, the more costly the cannibalization of B by A), then the more likely it is that the merger will lead to upward pricing pressure.

To illustrate the usefulness of the UPP consider how the test might be applied in practice. In particular, consider the likely quality of the estimates of each input to the UPP test: price, marginal costs for both products, efficiencies for one product, and the diversion ratio.[114] Accurate measures of pre-merger prices should generally be readily available. But the other inputs necessary to calculate an effective UPP are harder to determine. As previously discussed, estimates of pre-merger marginal costs for the two products can be challenging to estimate.[115] That said, information on marginal costs is necessary for many other empirical methods relevant to merger review,[116] so this is not an burden specific to the UPP test. Furthermore, the simple functional form of the UPP test makes sensitivity analysis straightforward, which can make the bottom line conclusion of the UPP test relatively more useful than other methods even when there is lack of confidence about the precise value of marginal cost.[117] Efficiencies are similarly hard to predict, especially in the early stages of merger review,[118] but in some cases it may be possible to determine a reasonable upper bound.[119] In fact, one of the advantages of the UPP test is that unlike

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[113] Strictly speaking, one could take efficiencies for product B into account as well. Post-merger, higher efficiencies for product B will cause product B's margin to rise, making cannibalization of B by A more costly. This can be expressed by replacing pre-merger marginal cost C_B in the formula with $(1 - E_B) C_B$, the marginal cost of B after efficiencies have been applied. However, this has the unattractive property of penalizing a merger for creating greater efficiencies and is best avoided. See Farrell and Shapiro, "Antitrust Evaluation of Horizontal Mergers: An Economic Alternative to Market Definition," *B.E. Journal of Theoretical Economics*, Vol. 10, 2010 at pp. 11–12; and Joseph Farrell and Carl Shapiro, "Upward Pricing Pressure and Critical Loss Analysis: Response," *Competition Policy International Antitrust Journal*, 2010 at p. 3.

[114] See also Farrell and Shapiro, "Antitrust Evaluation of Horizontal Mergers: An Economic Alternative to Market Definition," *B.E. Journal of Theoretical Economics*, Vol. 10, 2010 at pp. 17–19.

[115] See the earlier discussion in the best practices section. See also Peter Davis and Eliana Garces, *Quantitative Techniques for Competition and Antitrust Analysis*, Princeton University Press, 2010 at pp. 125–130.

[116] For example, information on margins is necessary to calculate the critical loss and the actual loss central to evaluating whether a SSNIP is profitable.

[117] For example, the test can be evaluated at multiple estimates for marginal costs. Or we can use the formula to calculate threshold values for marginal cost, i.e., the lowest values for C_A and C_B that would still not lead to upward pricing pressure, holding all other parameters constant. Even if estimates of marginal cost are very noisy, it may be clear that marginal costs are above or below these thresholds.

[118] For example, merging parties will typically generate some estimate of likely merger efficiencies during their own internal evaluation of the proposed deal, for instance in the materials presented to the board of directors to help them decide whether to approve the deal or not. Course of business documents must generally be interpreted carefully. In the case for merger efficiencies, for example, the organizations may be unreasonably optimistic about the potential efficiencies. Moreover, antitrust agencies may not characterize as efficiencies everything that the merging firms describe as a benefit of the merger.

[119] For example, other mergers in the same or similar industries may provide guidance for whether efficiencies may be approximately 1%, 5%, 10%, or 20%. Given values for the other parameters in the test, one can calculate a threshold

other tests it explicitly incorporates at least the potential of proposed efficiencies from the merger and thus allows for sensitivity analysis on the effect of those efficiencies.[120] Finally, the diversion ratio may also be difficult to estimate robustly, as discussed in more detail in the earlier market definition section. But general guidance on its value may be provided by business documents, industry experts and analyst reports, and consumer surveys. To summarize, then, given the UPP test's straightforward functional form, one can apply it using a number of estimated or assumed values of each of the relevant inputs, enabling extensive sensitivity analyses. This allows great flexibility in the use of the test and suggests that it may be a valuable tool when there is limited time to make an initial determination about whether to more closely scrutinize a proposed merger.[121]

Note that a finding of upward pricing pressure does not provide a prediction on *how* much prices will rise. A finding of upward pricing pressure may not be of competitive concern if the price increase it implies is in fact small. To determine the predicted magnitude of the price increase, extend the UPP test as follows. Recall the intuition that the cannibalization of product B by product A can be thought of as an increase in the marginal cost of product A. This marginal cost increase was calculated as $D_{AB} (P_B - C_B)$. If firms compete by setting prices rather than quantity, as they likely do in a differentiated products context, consider a measure of the pass-through rate of firm-specific costs R_A.[122] This measure may be difficult to calculate, especially at the initial screening stage. Nevertheless, a proxy may be used,[123] or sensitivity analysis may be performed to test for the effect of different values. Given this pass-through rate, the estimated price increase would be equal to $R_A D_{AB} (P_B - C_B)$. This price increase could then be compared to any threshold price increase that might be considered substantial.[124]

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efficiency value, below which there is upwards pricing pressure. That threshold may be clearly higher or lower than most reasonable estimates of likely efficiencies.

[120] For a discussion of the role of efficiencies in merger review and the benefits to a more explicit framework within which to consider such efficiencies, see Robert Pitofsky, "Efficiencies in Defense of Mergers: 18 Months After; Remarks by Robert Pitofsky, Chairman Federal Trade Commission," *George Mason Law Review Antitrust Symposium*, 1998 at http://www.ftc.gov/speeches/pitofsky/pitofeff.shtm.

[121] Consider an example where the markup for product B (price less marginal cost) is $2, the marginal cost of product A is $10, and the expected efficiencies on product A's marginal cost are 10%. Given the UPP formula, $D_{AB} (P_B - C_B) > E_A C_A$ the test is then whether $D_{AB} > 0.5$. Post-merger, the firm is enjoying the $1 of efficiencies for each unit of product A it sells, making sales of A more profitable than they were pre-merger. But every sale of product A also cannibalizes D_{AB} sales of product B, which sales would have enjoyed a margin of $2, which represents the cannibalization marginal cost that the merged firm associates with product A. Whether the firm faces upward pricing pressure after the merger or not depends on whether its marginal costs have increased or not. If $D_{AB} > 0.5$, then the increase in marginal cost due to the cannibalization of product B is higher than the reduction in marginal cost due to efficiencies in the production of A. Facing higher marginal costs, the firm will be pressured to increase prices post-merger. In contrast, if $D_{AB} < 0.5$, then the efficiencies outweigh the effect cannibalization has on marginal costs, leading to lower overall marginal costs and no upward pricing pressure.

[122] In other words, if the firm-specific costs of the firm producing product A increase by Δ, the price of A would increase by $R_A\Delta$. This pass-through rate is different than the pass-through rate of industry-wide costs. Industry-wide cost increase may be more likely to be passed through because every firm will have incentives to raise their product's price, whereas a firm-specific cost may be less likely to be passed through because competing products' prices are not changing, leading to a greater competitive effect.

[123] Farrell and Shapiro (2010) suggest using a firm-specific pass-through rate of 50%. They argue that 50% would be the rate implied by linear demand, while convex demand would lead to even higher rates. Moreover, accommodating rivals who also increase prices would lead to even higher pass-through rates. Therefore using 50% may be conservative, as higher pass-through lead to higher post-merger price increases.

[124] For example, in the context of the SSNIP test a price increase of 5% or 10% is frequently used.

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By the later stages of merger review, it might be possible to estimate each of the inputs to the UPP test with greater precision. In that case, the UPP test could go beyond a simple screen and help inform a theory of unilateral effects. For example, based on better inputs and using extensive sensitivity analysis, it could provide evidence for the notion that prices are likely to increase even in a broadly defined market, or conversely against the notion that prices are likely to increase even in a narrowly defined market. Evidence from a UPP test may be weighed against qualitative evidence, market concentration evidence, as well as detailed merger simulation models that are more closely tailored to the particular industry. We now discuss this latter class of models.

D. Merger simulation

Merger simulation refers to the explicit structural modeling of the demand and supply equilibrium in a particular industry.[125] Assuming such a model can be reliably estimated, it can then be used to determine how the proposed merger will affect the incentives of the merging parties and, in turn, how this change in incentives will lead to a change in the market equilibrium.

Three pieces are required to put a merger simulation together. First, the demand curve for each merged product must be specified and its parameters estimated.[126] Second, the cost curve for each merged product must also be specified and its parameters estimated.[127] Third, one must choose the game theoretic model under which the industry is assumed to operate. In the study of industrial organization there are a number of standard models and approaches that have been proposed to represent the way firms interact within a marketplace, including those by Cournot and Bertrand. Frequently Cournot competition is assumed in industries with homogeneous products where firms operate by choosing between different output levels, while Bertrand competition is frequently assumed in industries with differentiated products where firms operate by choosing between different price levels.[128] These theoretical models can be solved under different assumptions,[129]

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[125] This differs from the approach taken in many of the other methodologies we have discussed, which draw inferences about the underlying model based on the data, but tend to do so without explicitly estimating all parameters of the underlying model.

[126] Generally, we can write demand for product j as $D_j(p_j, \cdot)$ to indicate that it depends on its price, p_j, as well as other factors. For example, consider the demand for a particular automobile, say the Volkswagen Touareg sports utility vehicle. Its demand may depend on a variety of factors beyond price, including non-price characteristics of the product (such as horsepower, torque, fuel efficiency, and design), the price and non-price characteristics of direct competitors (such as other sports utility vehicles and other types of automobiles), the price and non-price characteristics of more distant competitors (such as public transportation or taxis), as well as market and consumer characteristics (e.g., sports utility vehicles may be in higher demand in more rural geographies or in geographies with a larger proportion of families with young children).

[127] Like the demand curve, the cost curve will depend on the quantity of a product produced, but also on a host of other factors. For example, the cost curve may have a complicated relationship to the prices of all potential inputs if those inputs do not need to enter the production process in fixed proportions.

[128] For an extended discussion of these models, see, e.g., Peter Davis and Eliana Garces, *Quantitative Techniques for Competition and Antitrust Analysis*, Princeton University Press, 2010 at pp. 38–56.

[129] Economists typically assume that firms are maximizing profits. We also make this assumption here and, accordingly, assume the usual treatment of Cournot and Bertrand models of competition, based on firms making choices with the objective to maximize their profits. In principle, one could change these models to assume that firms are actually maximizing some other objective, for example some combination of profit and market share. However, even if internal company documents indicate that firms may not be making decisions purely driven by maximizing short-term profits, such behavior is not necessarily inconsistent with maximization of long term profits. For discussions of behavioral economics as they apply to profit maximization and antitrust, see, e.g., Elizabeth M. Bailey, "Behavioral Economics:

including an assumption on whether different firms compete or collude. This latter assumption can be used to examine the post-merger equilibrium, where the joint entity maximizes its total profits taking cannibalization between the two products into account. Merger simulation involves solving the chosen theoretical model for the post-merger equilibrium, and then plugging in reliable estimates for demand curves and cost curves to determine the predicted prices and quantities.

To better understand the counterfactual exercise, consider an industry with differentiated products and single-product firms that set prices. If the firms are *competing* with each other, each firm wants to maximize it's own profit. Given any set of prices for its competitors' products, the firm can choose the price that will maximize its own profit. This price is known as its best response to the other firms' prices. If the firm increases its price above its best response, the incremental profit due to higher margins is not enough to offset the decrease in profit due to loss of market share. Conversely, if the firm decreases the price below its best response, the decrease in profits due to lower margins will offset any increase in profit due to higher market share. The equilibrium of the model is then defined as the set of prices where every firm's price is equal to its best response given every other firm's price. This set of prices should correspond to the pre-merger observed prices, assuming pre-merger the market is at the competitive equilibrium.

However, the game could also be solved assuming the firms are colluding. In that case, each firm does not try to maximize its individual profit, but rather firms try to pick a set of prices that will maximize their *joint* profits. In determining its best response, each firm will now take into account the effect that a price increase or decrease will have on the profits of their competitors. In particular, if each firm raises its price a little bit, some of the demand it loses will shift to its competitors. If they all raise their prices together, they will each lose some demand, but not as much as they would have lost if they had increased price by the same amount unilaterally. The equilibrium will therefore tend to be at higher prices and lower quantities than the competitive equilibrium.

Similarly, the game could also be solved assuming that the merger takes place. This is, in a sense, a combination of the two prior examples. Firms other than the merging parties once again care only about their own profits and act independently. But the post-merger joint entity will no longer set the price of its two products to maximize the profit of each product individually; rather, it will set prices for both products so as to maximize the *total* profits across both products. In doing so, the joint entity recognizes that decreasing the price of one product may increase that product's sales, but these increased sales will, at least in part, come through cannibalization of the second product.[130] Everything else being equal, the merged firm's best response functions will lead to higher prices.

In merger simulation, after theoretical post-merger response functions have been calculated, the estimated cost and demand parameters are used to also obtain empirical estimates of each firm's post-merger best response functions. The observed market prices of each product are then entered into these best response functions. Per the logic above, everything else being equal, the best response of the merged entity will be to increase the

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Implications for Antitrust Practitioners," *Antitrust Source*, 2010; and Mark Armstrong and Steffen Huck, "Behavioral Economics as Applied to Firms: A Primer," *U.K. Office of Fair Trading Economic Discussion Paper*, 2010.

[130] For more extended discussion of this dynamic, refer to the earlier discussion of Upward Pricing Pressure.

prices of its two products. If this new set of (higher) prices is entered into the other firms' best response functions, it will incent them to also raise their prices, albeit by a smaller amount. In turn, their increased prices will incent the merged firm to raise its own prices yet again, albeit by a smaller amount still. This process can be repeated until convergence to the predicted post-merger equilibrium.

Specific implementation details of comprehensive merger simulation are beyond the scope of this current guide. As suggested by the name, comprehensive analysis of this sort tends to be detailed and in many ways tailored to each particular case. Readers that are interested in further information can review articles discussing the practical advantages and disadvantages of merger simulation,[131] as well as examples that illustrate the judgment calls that were made in particular cases.[132] In brief, comprehensive merger simulation can provide detailed and precise predictions of equilibrium prices, not just for the merging parties but also for their competitors. Moreover, the simulation provides a common framework within which to think about the interactions of demand and supply in the particular market. Undertaking such detailed analysis can therefore aid in the understanding of both the industry and the limitations of the available data.

In practice, comprehensive merger simulation can be time consuming and complicated. First, we have explained earlier that it can be difficult to properly estimate demand.[133] This is especially true if we are interested not just in obtaining a rough measure of elasticity, but a model that is meant to accurately replicate currently observed shares and to accurately predict counterfactual shares under different market conditions. Second, we have previously discussed how obtaining reliable information on marginal cost might be difficult. While it may be possible to obtain such information for the merging parties, it may be more difficult to obtain it for other industry participants, particularly in industries where different firms face different types of costs. It may possible to estimate marginal costs for these firms using a combination of economic theory and the demand estimates.[134] However, these estimates will be most useful in the counterfactual exercise if they can be linked to a more detailed model of cost, for example one that can allow for economies of scale; going beyond simplified models of constant marginal cost and estimating detailed cost functions involves its own challenges.[135] Third, this type of detailed structural modeling requires multiple assumptions about structural form. These assumptions cannot

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[131] For example, see Jonathan B. Baker, "Merger Simulation in an Administrative Context," *Antitrust Law Journal*, Vol. 77, 2011; and Oliver Budzinski and Isabel Ruhmer, "Merger Simulation in Competition Policy: A Survey," *MAGKS Joint Discussion Paper*, 2008 at http://ssrn.com/abstract=1138682.

[132] See Gregory J. Werden and Luke M. Froeb, "Unilateral Competitive Effects of Horizontal Mergers," *Handbook of Antitrust Economics*, ed. Paolo Buccirossi, 2008; and Peter Davis and Eliana Garces, *Quantitative Techniques for Competition and Antitrust Analysis*, Princeton University Press, 2010 at pp. 419–426.

[133] See the discussion of general best practices and market definition sections. For a more extended discussion of estimating demand in an antitrust context, see Peter Davis and Eliana Garces, *Quantitative Techniques for Competition and Antitrust Analysis*, Princeton University Press, 2010 at Chapter 9.

[134] For example, frequently in equilibrium the Lerner equation shows that the price-cost margin is equal to the inverse of the own-price elasticity. Given a good estimate of demand, we can use the observed pre-merger prices to recover an estimate of marginal cost. The quality of this estimate depends on the quality of our elasticity estimate and on the validity of the assumption that, pre-merger, the market was in equilibrium and the firms did not tacitly or explicitly collude. If the marginal cost estimates that are recovered seem unreasonable, it may be evidence that either the inputs to the calculation or the assumptions that underlie it may be questionable.

[135] For a discussion of estimating demand in an antitrust context, see Peter Davis and Eliana Garces, *Quantitative Techniques for Competition and Antitrust Analysis*, Princeton University Press, 2010 at Chapter 3.

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be made lightly, as they frequently have large influence on the results of the simulation.[136] It is therefore critical that merger simulation analysis be accompanied by extensive sensitivity analysis.[137] Finally, understanding the mechanics of merger simulation and the justifications for all the assumptions involved can be difficult, particularly for non-experts, which may limit the likely return of the modeling exercise within an administrative and legislation context. All these factors combine to make comprehensive merger simulation difficult to implement in merger review cases that do not go into the later stages of detailed investigation. Even at that stage, merger simulation cannot be relied upon exclusively, but will be more persuasive when its conclusions are also supported by other evidence.

E.   Identifying mavericks

Most of the preceding merger review discussion has focused on the analysis of unilateral effects. An analysis of coordinated effects instead may frequently revolve around the identification of a "maverick" firm. Mavericks are identified in antitrust authorities' guidelines as a potential force against the emergence of the types of horizontal collusion that can happen in concentrated, or oligopolistic, industries.[138] They are firms which, for a variety of reasons, are less likely to participate in collusive schemes. The key to price fixing collusion, whether tacit or explicit, is that it requires participation of the vast majority of players in the marketplace in order to be successful. The threat that the maverick is unlikely to go along with a price increase or a quantity decrease can make the other firms in the market less likely to jointly attempt such moves in the first place.

Mavericks are more likely to exist, and collusion is less likely be successful, under certain economic conditions. For example, collusion is less likely to succeed the greater the marginal cost differences between competitors, e.g., a firm with a relatively low marginal cost will prefer a lower collusive price and higher industry sales, but this lower price may not be profitable for a rival with higher marginal cost. Collusion is also less likely to succeed if it is not as easy to punish cheaters, e.g., firms with little excess capacity may have difficulty punishing cheaters, while firms with a lot of excess capacity can gain significantly from cheating. Generally, differences between competitors will lead to differential incentives to participate in tacit or explicit collusion. The industry maverick can be thought of as the firm that is almost indifferent between participating and cheating, and thus constrains others from increasing their prices. Mavericks must be evaluated in a case-by-case basis. Further discussion and examples are available in the academic literature.[139]

Following the above logic, in an industry in which mavericks exist, if the merger does not involve the maverick then it may be less likely to lead to coordinated effects, while a

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[136] For example, Froeb et al (2004) illustrate that a merger simulation of the *WorldCom-Sprint* proposed merger finds predicted price increases anywhere from 2% to 16% depending on the assumption that is made regarding the functional form the demand equation. See Luke M. Froeb, Steven Tschantz, and Gregory J. Werden, "Pass-Through Rates and the Price Effects of Mergers," *Working Paper*, 2003 at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=274848.

[137] See Gregory J. Werden, Luke M. Froeb, and David T. Scheffman, "A *Daubert* Discipline for Merger Simulation," *Working Paper*, 2004 at http://www.ftc.gov/be/daubertdiscipline.pdf.

[138] See U.S. Guidelines at § 2.1.5; and U.K. Competition Commission and Office of Fair Trading, *Merger Assessment Guidelines*, 2010 at ¶ 5.5.18.

[139] See, e.g., Jonathan B. Baker, "Mavericks, Mergers, and Exclusion: Proving Coordinated Competitive Effects Under the Antitrust Laws," *New York University Law Review*, Vol. 77, 2002.

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merger that did involve a maverick might draw additional scrutiny to ascertain whether the merger would change the maverick's incentives. In either case, evaluating the possibility of competitive effects one must first *identify* the industry maverick. There are a few different ways to do that. First, direct evidence, either in the public domain or in internal documents, may suggest that a particular firm is a maverick, e.g., it may be the only firm not to follow others' price increases, or it may lead in price wars and price deductions.[140] Second, empirical estimation of pass-through rates may help identify a maverick. Observations of cost changes for a particular firm are passed through at a greater rate than other firms may be indication of a maverick. Third, economic theory may be used to determine firm characteristics that would make a firm more likely to compete more vigorously and less likely to join a conspiracy. For example, consider an industry where marginal costs are equal across the different firms, but where all firms but one are close to capacity constrained; competitors have little capacity available to discipline this single firm, while the firm has a large incentive to cheat on any tacit or explicit collusion, making it a force holding the other firms back from increasing prices.[141] Alternatively, a firm with more elastic demand or lower marginal costs will, everything else being equal, be more likely to be the industry maverick. Qualitative and quantitative analysis can therefore help identify any mavericks.

Once a maverick has been identified, quantitative techniques can potentially be employed to understand and model the incentives of the maverick, which can then help determine what the likely effects of the proposed merger will be on the maverick's behavior. The specific techniques to be employed will depend on the industry and the particular circumstances of the maverick and the merging parties.

Merger enforcement: key takeaways

- Merger analysis tries to determine the likely unilateral and coordinated effects

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[140] Consider the example of Northwest Airlines. Twice all other airlines (except for Southwest) followed a price increase led by Continental Airlines, but then rescinded their price increases once Northwest did not follow. When Northwest subsequently led with a similar price increase, all airlines (again, except Southwest) followed the increase, and the higher price stuck. See Jonathan B. Baker, "Mavericks, Mergers, and Exclusion: Proving Coordinated Competitive Effects Under the Antitrust Laws," *New York University Law Review*, Vol. 77, 2002 at 166–169.

[141] See Olivier Compte, Frederic Jenny, and Patrick Rey, "Capacity Constraints, Mergers, and Collusion," *European Economic Review*, Vol. 46, 2002; and Jonathan B. Baker, "Mavericks, Mergers, and Exclusion: Proving Coordinated Competitive Effects Under the Antitrust Laws," *New York University Law Review*, Vol. 77, 2002 at 175–177.

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of a proposed merger.

- Given the time constraints frequently associated with the early stages of merger analysis, antitrust agencies frequently employ a number of imprecise but easy to apply screens as one of the tools they use to reach their initial determination.

- Market concentration is one such easy to apply screen. Because it relies on an in or out concept of market definition, it does not allow for the concept of closeness of competition.   Therefore conclusions based on market concentration are only as good as the underlying market definition analysis and must be interpreted accordingly.

- Price-concentration analysis can be used when data is available and marketplaces are local. It can be relatively straightforward conceptually relative to other merger evaluation analyses, avoids assumptions that may seem arbitrary to economists, and is relatively easy to estimate.

- Upward pricing pressure is a helpful initial screen. Some of the inputs it requires may be difficult to accurately estimate in the early stages of merger review. However, given the simplicity of the upward pricing pressure formula, it is easy to undertake comprehensive sensitivity tests for different values that these inputs might take and weigh the different results accordingly.

- By the later stages of merger review, when more time and data may be available, industry knowledge and economic theory can be used to tailor a more thorough merger simulation model to the particular case. These detailed merger simulation models will vary from case to case and can be time consuming and complicated. However, if supported by other evidence and robust to sensitivity analyses, they can provide compelling economic evidence of the likely effects of the proposed merger.

- In situations where coordinated effects are a concern, one should consider whether any maverick firms exist and identify the maverick's post-merger incentives using direct qualitative or quantitative evidence consisted with economic theory and industry knowledge.

V.   Horizontal conspiracies

In many jurisdictions, horizontal conspiracies are considered *per se* illegal.[142] In some cases, direct documentary evidence suggesting the existence of such conspiracies is available (so-called "smoking gun" evidence). If this evidence is particularly strong, an antitrust agency investigating such conduct may feel that its resources are better spent building a case around this qualitative evidence alone, suggesting a limited role for empirical analysis. However, documentary evidence is not always conclusive. It may not shed light on the frequency, duration, success or impact of any alleged agreement. It may also be interpreted differently by different parties and hence not offer uncontroversial evidence of the existence of a conspiratorial agreement. Economic analysis of the industry based on the Consensus-Detection-Punishment paradigm can help evaluate the plausibility of an alleged conspiracy.[143] This analysis may suggest specific marketplace outcomes that would be expected to occur as a result of the conspiracy. An empirical investigation of these outcomes can then corroborate or cast doubt on a particular interpretation of the documentary evidence at hand.

In this section we discuss some of the marketplace outcomes that may be predicted by economic theory in certain circumstances of horizontal conspiracy and how one might go about testing for them empirically. These methods can be used when evaluating a specific alleged conspiracy that has been identified through other evidence, but they can also be used as screens in an effort to check for potential signs of collusion in different industries.

A.   Potential marketplace outcomes of horizontal conspiracies

Conspiracies may operate in a variety of different ways. Consider a conspiracy among the sellers of a product that aims to increase market prices. The conspirators could achieve their goal by agreeing to set price levels directly, by agreeing to follow prices set by a leader, by agreeing to constrain their volume or capacity,or by agreeing to allocate geographic regions or customers. Different alleged mechanisms of collusion will point to different relevant empirical methods and can result in different patterns in the data.

Higher prices. Regardless of the direct mechanism through which the conspiracy is alleged to have operated, economic theory tells us that the ultimate effect of a conspiracy of

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[142] See "Price Fixing, Bid Rigging, and Market Allocation Schemes: What They Are and What to Look For," *U.S. Department of Justice*, at http://www.justice.gov/atr/public/guidelines/211578.pdf ("Under the law, price-fixing and bid-rigging schemes are *per se* violations of the Sherman Act. This means that where such a collusive scheme has been established, it cannot be justified under the law by arguments or evidence that, for example, the agreed-upon prices were reasonable, the agreement was necessary to prevent or eliminate price cutting or ruinous competition, or the conspirators were merely trying to make sure that each got a fair share of the market.").

[143] For discussion of the conditions under which conspiracies are more or less likely to be successful, see, for example, Alexis Jacquemin and Margaret E. Slade, "Cartel, Collusion, and Horizontal Merger," *Handbook of Industrial Organization*, eds. Richard Schmalensee and Robert D. Willig, p. 417 ("Whether firms collude tacitly or overtly, legally or illegally, they face many problems. First, an agreement must be reached. Second, as soon as price is raised above the noncooperative level, firms have an incentive to cheat on the collusive arrangement. And finally, once cheating is detected it must be punished."); Simon J. Evenett and Valerie Y. Suslow, "Preconditions for Private Restraints on Market Access and International Cartels," *Journal of International Economic Law*, Vol. 3, 2000, pp. 593–631; Margaret C. Levenstein and Valerie Y. Suslow, "What Determines Cartel Success," *Journal of Economic Literature*, Vol. 44, 2006; Andrew R. Dick, "When Are Cartels Stable Contracts?" *Journal of Law and Economics*, Vol. 39, 1996; and Robert H. Porter and J. Douglas Zona, "Collusion," *Antitrust Law Journal*, Vol. 2, 2008.

buyers, if it were successful, would be to increase prices and lower quantity, everything else being equal. Regression methods can be used to test for this, comparing prices across geographic regions and/or time periods. In particular, were prices in the allegedly conspiratorial geographic region and time period indeed higher, everything else being equal? As discussed in the best practices section above, for the results of the model to be accurate and reliable, it is very important for the model to include appropriate controls and to use an appropriate benchmark. In and of itself, a finding that price levels increased and volume fell is meaningless. For such a finding to suggest the effect of a conspiracy, it must be that these changes cannot instead be explained by shifts in demand (such as changes in income) and supply (such as changes in costs). Similar methods can be used to evaluate volume changes.

Higher prices downstream. In a vertical industry, a conspiracy that has the effect of restricting volume and increasing the price of an upstream product A will increase the costs of any downstream product B. The increased costs will tend to lower the production of B and, if its producers sufficiently pass-through its costs to consumers, will tend to increase its price. In certain situations, data may be more readily available on the downstream rather than upstream product. One can then test prices in the downstream market to see whether they increased for no apparent demand and supply reason. As discussed above, this test is only useful when relevant shifts in demand and supply have been accounted for.

Reduced price variation, increased margin variation. Beyond increasing prices, a conspiracy to fix prices may also result in other patterns in the data. A conspiracy to set common prices may lead to reduced variation in prices. As a result it may also weaken the relationship between cost and price, leading to increased variation in margins. This pattern was observed in a conspiracy to fix the price of frozen perch sold to the U.S. military in the late 1980s. After the U.S. Department of Justice initiated an investigation into the alleged price fixing, prices in frozen perch fell significantly in a short period of time as the collusive scheme fell apart. Comparing the prices after the drop to the prices before, it is apparent that price fluctuated a lot more during the competitive period.[144] Additionally, the fluctuation in cost was similar between the two time periods. Thus, empirical evidence suggested that price was more disconnected from cost during the alleged collusive price period.[145] This pattern need not generalize to every industry, nor is a finding of reduced price variation during a time period conclusive proof of the existence of a conspiracy. Alternative explanations for any such patterns can exist and must be thoroughly considered. Moreover, like all other empirical evidence, any such findings are more convincing when they are consistent with qualitative evidence in the case.

Price leadership. A conspiracy may be implemented by having one conspirator lead with a publicly announced price increase, with the co-conspirators then matching that

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[144] If the pattern is stark enough, such a conclusion may be drawn informally by plotting the data, but it might also be evaluated through formal statistics during proposed collusive and competitive periods.

[145] See Rosa M. Abrantes-Metz, Luke M. Froeb, John F. Geweke, and Christopher T. Taylor, "A variance screen for collusion," *International Journal of Industrial Organization*, Vol. 24, 2006, pp. 467–486. The conclusion that the relationship between cost and price was different in the proposed collusive and competitive period could also be evaluated in a regression context by testing for a structural break between the two periods.

increase.[146] Given assurances that the co-conspirators will follow, the leader can afford to increase the price above the competitive level. Such a conspiracy may not quantitatively look very different than tacit collusion, which involves no explicit agreement or communication between firms and is thus typically not illegal.[147] As a result, evidence of price leadership is not conclusive proof of conspiratorial agreement without additional and more direct evidence of communication, even though certain patterns of price leadership may be more suspicious than others.[148]

Capacity constraints. A horizontal conspiracy that operates through a reduction in volume may result in either unutilized or reduced production capacity. It is sometimes suggested that conspirators may hold excess capacity in order to more easily punish those who cheat on the conspiracy, or they may commit to eliminating some of their capacity as a way to reduce the potential for cheating and facilitate collusion.[149] On the other hand were a conspiracy to operate through restraining capacity and capacity growth, once would expect to see higher utilization and lower excess capacity. Thus, while changes in capacity and capacity utilization can provide evidence for or against a particular conspiracy theory, it depends directly on the type of conspiracy being alleged.   It also is generally inappropriate to draw conclusions about collusion based on observations of capacity utilization without additional corroborative evidence. Utilization may vary significantly across industries and in some cases geographic regions for a number of reasons unrelated to collusion.[150] It is important to consider any such alternative explanations before drawing conclusions. On the other hand, it may warrant further investigation when there are notable changes in behavior, for example, a finding that substantial spare capacity was suddenly put to use and an apparent price war broke out.[151]

Stable market shares. A conspiracy that acts by allocating geographies or customers, or one that acts by setting explicit volume targets, may lead to more stable market shares. This could happen regionally, for example, or within certain large customer accounts. A finding of relatively stable market shares in a particular industry is not generally

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[146] See, e.g., a discussion of price leadership in the European Commission's decision regarding the *Vitamins* case: "The parties normally agreed that one producer should first 'announce' the increase, either in a trade journal or in direct communication with major customers. Once the price increase was announced by one cartel member, the others would generally follow suit. In this way the concerted price increases could be passed off, if challenged, as the result of price leadership in an oligopolistic market." See 2003/2/EC: Commission Decision of 21 November 2001 relating to a proceeding pursuant to Article 81 of the EC Treaty and Article 53 of the EEA Agreement (Case COMP/E-1/37.512 — Vitamins).

[147] For an extended discussion of tacit collusion, see Marc Ivaldi, Bruno Jullien, Patrick Rey, Paul Seabright, and Jean Tirole, "The Economics of Tacit Collusion," *Report for DG Competition, European Commission*, 2003 at http://ec.europa.eu/competition/mergers/studies_reports/the_economics_of_tacit_collusion_en.pdf.

[148] Tacit collusion is by definition uncoordinated. In many industries, changing prices requires some preparation. Even if competitors are tacitly colluding and following each other, they may not be able to do so immediately or at short notice. A pattern where competitors repeatedly announce identical price increases near simultaneously may be suspicious and warrant further investigation.

[149] See Louis Kaplow, "An Economic Approach to Price Fixing," *Antitrust Law Journal*, Vol. 77, 2011 at pp. 398, 443.

[150] For example, in one industry the production technology may be such that a plant is unprofitable unless it consistently runs near full capacity. In another industry, this may not be the case; moreover, strong seasonal variation in demand may require that the plant include capacity that goes unutilized for much of the year.

[151] For example, in 1955 the quantity of automobiles sold was higher and their price was lower than it was in either 1954 or 1956, which may indicate the breakdown of either explicit or tacit collusion among car manufacturers. See Timothy F. Bresnahan, "Competition and Collusion in the American Automobile Market: The 1955 Price War," *Journal of Industrial Economics*, Vol. 35, 1987.

informative on its own; market shares may be relatively stable even in highly competitive industries. In contrast, finding that the pattern of market share variation *changed* at the same time that other evidence indicates a conspiracy began or ended could be interpreted as evidence for the existence of the conspiracy. One can measure market share variation of a particular product using the Jacoby index. This index is equal to the coefficient of variation (the standard deviation divided by the average) of each product's market share.[152] A finding that the Jacoby index was significantly lower during the allegedly collusive period than during the competitive period may warrant further investigation. A more formal way to test for a similar effect is by examining each product's market share time series for negative serial correlation; in particular, is this statistical feature of the time series the same during the competitive and allegedly collusive periods? A finding that the market share of a firm has strong negative serial correlation implies that any change in share in one period is likely to be followed by an opposite change in the next period. Such a pattern might be generated by a conspiracy to allocate market shares.[153]

B.   Bid rigging

Bid rigging refers to collusion in a procurement auction context. In general, conspirators may aim to coordinate over a series of such auctions to determine who the winner of each bid will be and to raise the winning bid's price.[154] One could imagine different types of bid rigging conspiracies. For example, conspirators may refuse to bid in certain situations; they may decide on the winner of the auction beforehand; or they may bid pre-determined amounts. The allegations particular to any one case may suggest particular behavioral patterns that could be investigated empirically. The U.S. Department of Justice has provided a set of bidding behaviors that could suggest different types of collusion in procurement auctions, even though it warns that they should not be considered conclusive on their own. For example, do the same suppliers always submit bids together and appear to be taking turns being the winner? Do companies bid much higher for some bids than others, even though there are no apparent cost differences between the two bids? Do bid prices drop whenever an infrequent bidder (who may not be part of the conspiracy) submits a bid?[155] Are losing bids unrealistically similar?[156]

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[152] See Neil H. Jacoby, "The Relative Stability of Market Shares: A Theory and Evidence from Several Industries," *Journal of Industrial Economics*, Vol. 12, 1964, pp. 83–107.

[153] For example, conspirators may meet on occasion to share price and quantity information and ensure that no one is cheating on the agreement. If small deviations are observed but the agreement does not break down, the conspirators may decide to allow the party who lost share to lower prices or bid competitively for some additional business to make for their previous loss.

[154] For example, see U.S. Department of Justice, "Former Employee of a National Bank Pleads Guilty for Role in Bid-rigging and Fraud Conspiracies Involving Proceeds of Municipal Bonds," *Press Release*, 2010 at http://www.justice.gov/opa/pr/2010/September/10-at-1008.html.

[155] See "Price Fixing, Bid Rigging, and Market Allocation Schemes: What They Are and What to Look For," *U.S. Department of Justice*, at http://www.justice.gov/atr/public/guidelines/211578.pdf. They also indicate a number of suspicious statements or behavior that they claim have each led to a successful antitrust prosecution, such as a company bringing multiple bids to a procurement auction and submitting its bid only after determining who else is bidding.

[156] For example, see Rosa M. Abrantes-Metz and Patrick Bajari, "Screening for Conspiracies: Applications for Litigation, Pre-Litigation, Regulation, and Internal Monitoring," *SSRN Working Papers*, 2009, at p. 5, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1357862 ("A famous example is bids received by the Tennessee Valley Authority to install conductor cables in the 1950s. Seven firms submitted identical bids of $198,438.24. This is analogous to a gambler making 20 winning bets in a row at the roulette wheel. The chances of 7 bidders, acting

Suspicions of a cartel among a certain set of firms that bid on procurement auctions can be investigated quantitatively. The allegations particular to each case can be used to determine empirical patterns that would be observed if the allegations were true, and to test for the existence of those patterns. Consider a particular example where competitors take turns submitting the winning bid. Using regression methods, one could calculate the relationship between the bids a firm submits and the costs of both that firm and its rivals.[157] The results of such regressions using data from groups of competing firms can then be contrasted against the results using groups of allegedly colluding firms. When firms compete, the model should lead to expected competitive results; a firm with higher costs should submit higher bids and the firm with the lower costs should generally win each auction, while firms should on average offer lower (more competitive) bids when bidding against low-cost firms. However, the same may not be true in the presence of a conspiracy to allocate winners; in that case, the firm whose turn it is to win (and which will submit the lowest bid) may not be the firm with the lowest costs for the particular project. Thus in the presence of the conspiracy the relationship between costs and bids will not be as close as in the competitive case, everything else being equal. Moreover, in the presence of a conspiracy a firm facing low-cost competitors will not feel the need to lower its bid to compete with them if these competitors are within the cartel. As a result, if the conspiracy were present the regression might provide nonsensical results; for example, a firm's distance from the site of a project, which we would expect to raise costs and thus raise bids, may in fact be estimated to *reduce* bids. The difference between the two groups can be formally tested using a Chow test.[158] Moreover, the residuals from the regression are more likely to be correlated for the colluding firms. On the other hand, if sufficient controls for costs are included, the residuals for the competitive firms are more likely to appear to be random. The economic literature includes studies that investigated *known* cases of bid rigging and found such patterns of nonsensical bid-cost regression results and correlated residuals.[159]

Because rich data on government procurement auctions is more likely to be readily available to the antitrust authority compared to data on any private industry, bid rigging can also be an attractive target for *proactive* investigation of horizontal conspiracies. Screens designed to identify behavior observed in former bid-rigging conspiracies may provide early indication of suspect behavior. Given such evidence, the antitrust agency can formulate and test for a more specific theory of suspected anticompetitive behavior. We

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independently, arriving at bids that agree to 8 significant digits is almost zero and a very strong signal that firms have explicitly or implicitly arrived at a mechanism for coordinating bids.").

[157] For example, consider a model the regresses a firm's bid on an external estimate of the cost of the project, the distance between the firm and the location of the project, the minimum of such distances for the other firms bidding on the project, a measure of the firm's unutilized capacity at the time of the bidding, the maximum of this measure for the other firms bidding on the project, and firm and project fixed effects. See Patrick Bajari and Garrett Summers, "Detecting Collusion in Procurement Auctions," *Antitrust Law Journal*, Vol. 70, 2002.

[158] See Jan Kmenta, *Elements of Econometrics*, Second Edition, 1986 at pp. 421–422, 576.

[159] For example, see Robert H. Porter and J. Douglas Zona, "Detection of Bid-rigging in Procurement Auctions," *Journal of Political Economy*, Vol. 101, 1993; Robert H. Porter and J. Douglas Zona, "Ohio School Milk Markets: An Analysis of Bidding," *RAND Journal of Economics*, Vol. 30, 1999; and Martin Pesendorfer, "A Study of Collusion in First-Price Auctions," *Review of Economic Studies*, Vol. 67, 2000.

discuss here screens for conditional independence and exchangeability, suggested in the economic literature based on investigations of known bid rigging cartels.[160]

Using a cost-bid regression model like the one discussed above, the test for conditional independence checks whether the bids that each pair of firms submitted are correlated after controlling for all observable costs.[161] In a competitive environment, the two firms' bidding behavior should not jointly deviate from the behavior expected based on their own and their competitors' cost data. If the residuals of the two firms are not independent but are instead correlated, this indicates that something is jointly impacting their bidding behavior. It is premature to assume an agreement between the firms as this could also be caused by other common economic factors, for example, common cost shocks that have not been included in the model. Similarly, the exchangeability test examines whether each firm bids in a similar way when faced with the same costs for itself and its competitors. A finding that the coefficients in each firm's equation are different may indicate that bids are separated from the underlying cost data. These tests are suggestive. They should not be interpreted as conclusive evidence, but rather may raise a warning flag that can lead to further inquiry.

Horizontal conspiracies: key takeaways

- Even if horizontal conspiracies are *per se* illegal in a jurisdiction, quantitative analysis can help evaluate the plausibility of an alleged conspiracy in situations where the documentary evidence is not conclusive.

- Economic theory, combined with industry knowledge, can suggest a number of marketplace outcomes that in particular cases may be consistent with the existence of an alleged horizontal conspiracy. For example, higher prices, reduced price variation, increased margin variation, unutilized or reduced production capacity, or stable market shares. Such evidence is not conclusive in and of itself, but it can corroborate or cast doubt on other available evidence.

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[160] See Patrick Bajari and Garrett Summers, "Detecting Collusion in Procurement Auctions," *Antitrust Law Journal*, Vol. 70, 2002; and Patrick Bajari and Lixin Ye, "Deciding Between Competition and Collusion," *Review of Economics and Statistics*, Vol. 85, 2003.

[161] Specifically, we compare the model's predicted bids for firm A to the actual bids of firm A to calculate the residuals for firm A, and repeat the process for firm B. We then identify any procurement auctions where both firm A and B participated, and calculate the correlation coefficient between the two series of overlapping residuals, testing for statistical significance.

VI. Market power and monopolization

Previously we reviewed quantitative techniques that can aid in the prospective evaluation of market power that might result from a merger. In this section we focus on antitrust investigations that *retrospectively* attempt to evaluate whether a single dominant firm unilaterally exercised market power and monopolized the market it operates in.[162] Many of the techniques that were previously used in the context of merger evaluation can also inform investigations of monopolization. However these techniques must be applied with care because of the retrospective character of a monopolization investigation. In particular, the *Cellophane* fallacy illustrates that a suspected monopolist's market power should be evaluated not by its ability to raise price from observed market prices (which would be already inflated if the firm had already successfuly monopolized its market), but rather by whether it has raised prices from their competitive levels.

It is important to note that in many jurisdictions, ruling monopolization anticompetitive is about *conduct* rather than pricing. That is, it is legal to be a monopoly as long as monopoly power was obtained and maintained without the use of anticompetitive conduct. .[163] For example, one could become a monopolist by simply having costs that are well below the competition. In this case the firm could price well above its own marginal cost, but just below that of the costs of other firms. It follows that the prospect of charging monopoly prices, even for a short time, can incentivize innovation, cost reduction and economic growth, with the short-term loss in consumer welfare resulting from monopoly pricing being a reasonable tradeoff for the long-term dynamic benefits of innovation. On the other hand, monopolization maintained through anticompetitive conduct can reduce the incentives of other firms to innovate.[164] In any case, the law may require that an empirical finding of market power be tied to some type of anticompetitive conduct in order to raise antitrust concerns. The investigation of such conduct can also be informed by careful analysis of the barriers to entry in the particular industry.[165]

A. The *Cellophane* fallacy

Because the evaluation of monopolization is retrospective, one must carefully consider what the allegations particular to each case imply for the marketplace outcomes that would be observe if monopolization had indeed taken place. This exercise involves combining economic theory, industry knowledge, and the particular theory of the harm being investigated to determine empirical marketplace outcomes that would serve as evidence of the suspected conduct. In this sense, this exercise is similar to the investigation of

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[162] The discussion here is also applicable to cases where a dominant firm may have monopsonized the market it operates in.

[163] This line of argument is credited to Schumpeter; see Joseph A. Schumpeter, *The Theory of Economic Development*, Oxford University Press: 1934. See also David S. Evans and Keith N. Hylton, "The Lawful Acquisition of Monopoly Power and its Implications for the Objectives of Antitrust," *Competition Policy International*, Vol. 4, 2008.

[164] See Jonathan B. Baker, "Dynamic Competition Does Not Excuse Monopolization," *Competition Policy International*, Vol. 4, 2008.

[165] For example, see David Harbord and Tom Hoehn, "Barriers to Entry and Exit in European Competition Policy," *International Review of Law and Economics*, Vol. 14, 1994.

marketplace outcomes proposed in the earlier discussion of horizontal conspiracy investigations.

A key intuition while considering what marketplace outcomes may be evidence of monopolization is that of the *Cellophane* fallacy.[166] Empirical tests of monopolization must keep in mind that, if the market is monopolized, observed market prices are already marked up above their competitive levels. For example, a market is more likely to be monopolized if there are few substitutes for the product. However, the monopolist will continue increasing the price until it reaches its profit maximizing level, where further increases lead to sufficient substitution to offset the increase in profit due to the higher price. As a result, if one evaluates the substitutability of the product at *observed* market prices, they may mistakenly conclude that the product has substitutes and that the monopolist faces an elastic demand. But this finding would only be an artifact of the fact that the monopolist is already exercising market power. We now discuss how this intuition can inform previously discussed techniques.

B. Market definition and market concentration

It is natural to consider market concentration when examining whether an industry is being monopolized. Is there a single (dominant) firm in the market? However, as we have seen in the earlier discussion of merger evaluation, the conclusions to be gained from market concentration analysis critically depend on market definition. The *Cellophane* fallacy suggests that many market definition techniques may find a broader market than they would have found had the prevailing prices in the true antitrust market of interest been more competitive. For example, a direct examination of the monopolist's demand elasticity may yield high elasticities that could suggest a broader market. Similarly, the hypothetical monopolist test may find a SSNIP to be unprofitable; but the question should not be whether the monopolist can raise prices above its *current* price, which *is* the profit-maximizing price, but rather whether it has the power to raise them above some "competitive" level.[167] The challenge in the application of this test is to identify what that "competitive" level should be. Perfect competition (i.e. price = marginal cost) is unlikely to be appropriate in most market settings, as is shown in the discussion below on price-cost margins.

C. Price-cost margins

High price-cost margins are sometimes offered as potential evidence of anticompetitive monopolization. This follows the economic theory that suggests that in a simple model with no fixed costs competition should bring prices toward marginal cost. But this simple model frequently does not match the real world. Consider a few examples. First, a monopolist who does not face close competitors is more likely to have endogenously high

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[166] See Donald F. Turner, "Antitrust Policy and the Cellophane Case," *Harvard Law Review*, Vol. 70, 1956; and George W. Stocking and Willard F. Mueller, "The *Cellophane* Case and the New Competition," *American Economic Review*, Vol. 45, 1955.

[167] For a discussion of various challenges facing market definition in the context of monopolization, see Lawrence J. White, "Market Power and Market Definition in Monopolization Cases," *Issues in Competition Law and Policy*, Vol. 2, American Bar Association: 2008.

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costs.[168] Second, a monopolistic firm that maintains its position through predatory pricing may be found to have low price-cost margins.[169] Third, a firm that is a multi-product monopolist may enjoy higher margins due to the differentiation of its product portfolio rather than due to any type of anticompetitive behavior.[170] Fourth, in industries with significant seasonal variance in production, firms need to recover large fixed costs over the course of operation. Thus, it may be inaccurate to investigate price-cost margins by narrowly focusing on average variable operating costs. For example, consider the electricity market. Demand for electricity fluctuates significantly during the day and over the year. Marginal generators of electricity must recover large capital costs during short periods of operation and thus their prices will need to cover both average variable costs and start-up and shutdown costs of operation.[171] Lastly, in industries in which high fixed costs are necessary in order to enter (for example, those characterized by large R&D efforts), competition and innovation requires the potential of recouping those fixed costs through earning profits above marginal cost once a successful product has been identified and developed.[172]

These examples illustrate that no single test based on price-cost margins is likely to provide evidence of anticompetitive monopolization. Rather, the allegations of the particular case must inform the test to be applied and such analysis must be carefully implemented.

Market power and monopolization: key takeaways

- Many market definition and merger review methods can also be used to retrospectively evaluate monopolization claims. However, it is important to be aware of the different context and to interpret any results accordingly to avoid misleading conclusions.

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[168] See Damien J. Neven, Lars-Hendrik Roller, and Zhentang Zhang, "Endogenous Costs and Price-Cost Margins: An Application to the European Airline Industry," *Journal of Industrial Economics*, Vol. 54, 2006.

[169] See Massimo Motta, *Competition Policy*, Cambridge University Press: 2004 at p. 116.

[170] Nevo (2001) investigates the ready-to-eat cereal industry, which traditionally has enjoyed high price-cost margins which were speculated to be the result of tacit or explicit collusion. Using a structural model of demand and supply, coupled with techniques similar to merger simulation, the paper separated these margins into each product's independent market power due to its differentiation from other products; the "portfolio effect" of a multi-product firm avoiding cannibalization among its products; and the potential effect of tacit or explicit collusion. It found that the first two effects could explain the majority of the observed price-cost margins. See Aviv Nevo, "Measuring Market Power in the Ready-to-Eat Cereal Industry," *Econometrica*, Vol. 69, 2001. Similarly, a monopolist's margins may be driven largely by the differentiation of its products.

[171] See Timothy Brennan, "Mismeasuring Electricity Market Power," *Regulation*, 2003. See also Severin Borenstein and James Bushnell, "An Empirical Analysis of the Potential for Market Power in California's Electricity Market," *Journal of Industrial Economics*, Vol. 47, 1999.

[172] See, e.g., "Looking for Mr. Schumpeter: Where Are We in the Competition-Innovation Debate?," in Adam B. Jaffe, Josh Lerner, and Scott Stern (eds.), *Innovation Policy and the Economy*, National Bureau of Economic Research, 2006.

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