Economic models in the courtroom: a methodological approach

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Abstract

When it comes to finding whether a firm has violated antitrust law, economists are often called upon as expert witnesses by the parties involved in litigation. This paper focuses on a challenge that economists may face when appearing as expert witnesses in US federal courts, namely to comply with the so-called *Daubert* standard of admissibility of expert testimony. I propose a new framework for analysing the interplay between model applicability and admissibility standard in courtrooms. The framework distinguishes between weak applicability claims, stating that a model's critical assumptions are shared by the target, and strong applicability claims, connecting empirical models and specific market features. I use this distinction to examine a recent antitrust case where an expert testimony based on economic models has been assessed following the *Daubert* standard.

Keywords: models, antitrust, *Daubert*, model applicability, model selection

1 Introduction

Antitrust litigation is becoming increasingly dominated by the judicial evaluation of economic and econometric analysis (Lopatka, 2016, Shapiro 2021a). This is hardly surprising as antitrust statutes are grounded in economic concepts such as monopolization, restraint of trade, and lessening of competition. For this reason, when it comes to finding whether a firm has engaged in anticompetitive behaviour and violated antitrust law, economists are often called upon as expert witnesses by the parties in litigation (Posner, 1999). When appearing as expert witnesses in US federal courts

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economists must comply with the current standard of admissibility of scientific testimony, the so-called *Daubert* standard.[1] This paper examines how economic expert witnesses use models in antitrust litigation and how testimonies based on these models are assessed following the *Daubert* standard. Why do economic expert witnesses use models? How are certain modelling choices justified? How do *Daubert* challenges work when models are at stake? In what follows I will answer these questions by providing a conceptual framework to analyse the problem of model applicability in the context of antitrust litigation.

My framework portrays economic experts testifying in antitrust cases as making two applicability claims. The first one is a *weak applicability claim* where evidence is advanced to show that some critical assumptions of a theoretical model M are shared by the intended target T. The second one is a s*trong applicability claim* where an empirical model M' is designed and different sources of evidence are used to show that M' describes accurately some features of the target T. The notions of *critical assumption* and *empirical model,* which I use to identify the two claims, will be defined in the paper. Furthermore, I will clarify the different types of evidence that are commonly provided by economic experts in the two applicability claims.

This framework is helpful for three main reasons. First, it explicates the *fit requirement* (prescribing that a model must be tailored to the facts of the case) that has been previously employed to describe what economic expert witnesses should do when using models in the courtroom (Coate and Fischer, 2001, 2012; Giocoli*,* 2020; Hovenkamp, 2005; Werden, 2008; Werden et al., 2004). Second, it makes clear that most of *Daubert* challenges concern the strength of the evidence that the expert witness has put forward to justify the two applicability claims. Third, it furnishes a key to

[1] The name originates from *Daubert v. Merrell Dow Pharm. Inc.*, 509 US 579 (1993). See below, Section 2.

interpret antitrust cases where *Daubert* challenges concern the (mis)use of economic models. I will check my framework against the scientific practice of expert witnesses by performing a detailed review of a recent antitrust case *Castro v. Sanofi Pasteur Inc.* (2015),[2] where scientific testimony based on economic models was challenged and assessed under the *Daubert* standard.

This paper serves two main purposes. The first is to study the problem of model applicability in a context that has been neglected by philosophers of economics, namely the use of models by economic expert witnesses in the courtroom. In this regard, my work contributes to the wide literature concerning how economic models are (and ought to be) employed for explanatory, predictive, or policy purposes (e.g. Aydinonat, 2018; Gibbard and Varian, 1978; Mäki, 2018; Rodrik, 2015). The second is to advance a methodological approach to the ongoing discussion on the relationship between economic theory, expert economic evidence, and antitrust enforcement. In recent years many prominent economists have questioned the strenghts and limitations of economic theory aiming at better antitrust enforcement (Björnerstedt and Verboven, 2016; Salop, 2021; Shapiro, 2021a, 2021b). However, a genuine methodological reflection that makes use of insights from the philosophy of economics is still absent. This paper aims to fill this gap in the literature.

I proceed as follows. In Section 2, I survey the role of economic expert witnesses in US antitrust litigation and how the *Daubert* admissibility standard works when economic models are at stake. Section 3 introduces some notions from the methodological debate on model applicability, especially concerning critical assumptions and model selection. These notions will be used in Section 4 to develop a framework of model applicability in the context of antitrust litigation. Section 5 applies

[2] *Castro v. Sanofi Pasteur Inc.*, 134 F. Supp. 3D 820 (D.N.J. 2015).

the framework to review a recent US antitrust case where economic modelling is at the heart of a *Daubert* challenge. Section 6 concludes the paper.

2 *Daubert* standard and the economic expert witness

The law governing the admissibility of expert witnesses in federal courts, set forth in the Rule 702 of the Federal Rules of Evidence, reflects the standard articulated by the Supreme Court in *Daubert v. Merrell Dow Pharm. Inc.* (1993) and then refined in a series of rulings – known as the *Daubert* trilogy – taken between 1993 and 1999. In the legal jargon, the *Daubert* standard and the ensuing Rule 702 have assigned courts the role of *gatekeepers* for the admission of scientific experts – a role they must perform by ensuring that 'any and all scientific testimony or evidence admitted is not only relevant, but reliable.' (*Daubert*, p. 589). More specifically, the Rule 702 states that trial judges serve a gatekeeping role to determine whether

(1) the expert's scientific, technical, or other specialized knowledge will help the trier of fact to understand the evidence or to determine a fact in issue;

(2) the testimony is based on sufficient facts or data;

(3) the testimony is the product of reliable principles and methods; and

(4) the expert has reliably applied the principles and methods to the facts of the case.[3]

The introduction of the *Daubert* standard represents a major turning point in the interaction between the judge and the expert witness because it asks the court to determine whether the expert testimony can be admitted on grounds that it is the result

[3] Rule 702 – Testimony by Expert Witness. Retrieved from https://www.law.cornell.edu/rules/fre/rule_702.

of *scientific* methodology. Rule 702 demands courts to delve into the methodology that an expert uses in arriving at certain conclusions, without questioning such conclusions per se. An important legacy of *Daubert* has been the emergence and spread of the so-called *Daubert* challenge, a special motion made to the judge before or during litigation in order to exclude the introduction of unqualified expert witness testimony to the judge or jury during trial. *Daubert* challenges enriched the tools in a litigator's belt because a successful exclusion of the opposing party's expert testimony can potentially change the outcome of the case.

Although the *Daubert* standard aimed to be 'a vital weapon in the mounting war against "Junk science" in the courts' (Gavil, 2001, p. 6), many concerns have been expressed from both law scholars and philosophers of science (e.g. Haack, 2005, 2015; Martini 2015). Here I will take the *Daubert* standard at face value and focus on how economic expert witnesses deal with it when using economic models in the courtroom.

The empirical evidence on the effect of the adoption of the *Daubert* standard on economic expert witnesses is rather consistent. Three results, which are robust across different empirical studies, are particularly telling (Langenfeld and Alexander, 2011; Giocoli, 2020).[4] First, *Daubert* challenges are successful in excluding, totally or partially, the testimonies of economic experts in around 45% of cases. Second, economists receive a relatively higher percentage of *Daubert* challenges in antitrust cases compared to other areas of law where economists testify as experts. Third, plaintiffs' economic experts appear to be excluded more easily than those of defendants. Although a comparative analysis on the number of challenges and exclusion rate of economists compared to other scientific disciplines is still missing, these results suggest

[4] These findings should however be taken with a certain degree of caution for it is extremely hard to build a dataset containing *all and only Daubert*-related challenges (see Langenfeld and Alexander, 2011, Appendix).

that complying with the *Daubert* standard is a critical task facing antitrust economists in US courts.[5]

This paper concentrates on economic experts that make explicit use of theoretical models within their testimonies in antitrust litigation. In many antitrust cases economic experts need to model a counterfactual scenario of what would have happened in the absence of the anticompetitive conduct. This counterfactual world is usually called the but-for world to indicate that it is the world that one should expect to exist *but for* the alleged anticompetitive behavior. Ideally, the comparison between the actual world and the but-for world demonstrates the effect of the antitrust violation.

Economists mostly use theoretical models from industrial organization to describe the counterfactual world. A notable example of but-for modelling is merger assessment in concentrated industries, where game-theoretic models of oligopolistic markets are employed to describe what would happen to prices in the relevant market if the merger were allowed.[6] A second example is antitrust damage calculation, where economic experts are asked to quantify damages that result from anticompetitive conduct.

How are models evaluated in antitrust litigation under the *Daubert* standard? We have seen that Rule 702 requires the expert to rely on sufficient facts or data and reliably apply her theory and methods to the facts of the case. This requirement is usually referred to as the *fit requirement* in the literature on economic experts in

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[5] The *Daubert* Tracker website (https://www.dauberttracker.com/index.cfm) reports that economics ranks fourth among the most challenged discipline under *Daubert*/Rule 702 after medicine, engineering, and psychology.

[6] This method, known as *merger simulation analysis*, has been introduced as a methodology for antitrust enforcement in the mid-1990s and it is now considered a standard tool by antitrust authorities (Budzinski and Ruhmer, 2010).

antitrust. Gregory Werden, a leading antitrust scholar, explains the fit requirement as follows:

> Economic modeling of the sort that may be relied on by an expert in an antitrust case entails choices made by the expert, and most choices should be justified on the basis that they are consistent with the facts of the case. Evaluating the fit of an economic model draws on the full array of qualitative and quantitative evidence developed in the case. Courts have excluded economic testimony in antitrust cases premised on models not sufficiently grounded in the facts. […] An empirical model used to make predictions or disentangle effects also must be tailored to the facts of the case. (Werden, 2008, p. 811)

Two remarks are in order. On the one hand, the fit requirement is undoubtedly a good summary of what courts and judges typically expect from an economic expert under the *Daubert* standard when she uses a model in her testimony. In fact, failure to fit the particular facts of the case has been among the main reasons for excluding economic expert testimonies in antitrust cases following a *Daubert* challenge and a great deal of discussion has taken place as to whether this requirement is appropriate to assess the admissibility of economic testimonies (Coate and Fischer, 2001, 2012; Giocoli, 2020; Hovenkamp, 2005; Lopatka, 2016; Werden, 2008; Werden et al., 2004). On the other hand, the fit requirement is couched in rather vague terms and leaves many questions unanswered. What does it mean to apply an economic model in the courtroom? How are certain modelling choices justified? How do *Daubert* challenges work when models are at stake? In what follows I will answer these questions by providing a conceptual framework to analyse the problem of model applicability in the context of antitrust litigation. As I show in Section 4, my framework gives an explication of the fit requirement that draws on notions from the philosophy of science in general, and of economics in particular.

3 Model applicability, critical assumptions and model selection

We saw that the *Daubert* standard requires the expert to reliably apply her theory and methods to the facts of the case. When theoretical models are employed, the *Daubert* standard asks to the expert to convince the judge of the applicability of her selected model to the intended target given a certain purpose. The issue of what does it mean to apply a model to a real-world target is a traditional one in the philosophy of science and economics. Weisberg (2004) defines model applicability as follows: 'A model applies to a target system when it accurately describes the structure and dynamics of the system according to the standards set by the model builder or model user' (p. 1076). Classical work in the philosophy of economics expresses a consonant view speaking of similarity relations between model assumptions and properties of the target (e.g. Gibbard and Varian, 1978; Hausman, 1992).

In a more recent twist in this debate, Rodrik's *Economics Rules* (2015) has emphasized several issues involved in model applicability from the point of view of a practitioner. His starting point is the criticism that economic models are riddled with assumptions that are falsehoods when interpreted in terms of a real situation (for this reason they are called 'unrealistic': Hindriks, 2006; Mäki, 2000) and, therefore, that such models cannot be properly applied for explanatory or policy tasks.[7] Rodrik replies that the applicability of a model depends not only on model-target resemblance but rather on the purpose of the modeller, the context of the application, and the audience being addressed. This is because purpose, context, and audience, determine which assumptions are *critical* in the given model application and – as he contends – 'what matters to the empirical relevance of a model is the realism of its critical assumptions'

[7] The classical reference on the topic of the realism of assumptions in economics is Friedman (1953) and the vast debate following it (see Mäki, 2009).

(Rodrik, 2015, p. 94). Rodrik's own example of the perfectly competitive market model clarifies this point (pp. 28-29).

Suppose an economist wants to apply the perfectly competitive market model in order to advise the government about the effect of imposing price controls on the cigarette industry. In the perfectly competitive market model, a price control leads to a decrease in the supply of cigarettes. Given the purpose, context, and audience of the modeller, the assumption that firms have no market power is critical because a modification of that assumption would produce an extremely different result (for instance, a price cap in a monopolized market would induce the firm to increase its output). At the same time, other assumptions concerning the exact number of firms and the agents' degree of rationality would not affect much the perfectly competitive model's results and, therefore, are not critical for the given application. Given that 'firms have no market power' is a critical assumption for this specific application, economists should attempt to check whether this assumption is approximately satisfied in cigarette industry. Rodrik (2015) summarizes this point as follows: 'The applicability of a model depends on how closely critical assumptions approximate the real world. And what makes an assumption critical depends in part on what the model is used for' (p. 29).

Mäki (2018) proposes to define Rodrik's critical assumptions in terms of negligibility:

> An assumption is critical if its unrealisticness (of some sort and degree) is not negligible for the conclusion drawn. And an assumption is not critical if its unrealisticness is negligible. Critical assumptions therefore had better be realistic, that is, realistic enough. (Mäki, 2018, p. 228).

For example, the assumption about the market power of firms is critical because its unrealisticness is not negligible for predicting the effect of price control on cigarettes. Echoing Rodrik, Mäki (2018) contends that 'claims about negligibility had better be true, and checking them for their truth is part of good modelling practice' (p. 228). Moreover, regardless how critical assumptions are properly defined, Mäki agrees with Rodrik that whether an assumption is critical or not can only be judged given the purpose of the modeller (see also Aydinonat, 2018).

The above discussion on model applicability is strictly related to a further topic that has been widely debated by philosophers of economics, namely model selection. Following Aydinonat (2018), model selection can be understood in two ways. On the one hand, model selection boils down to choosing from a model library a single appropriate model for a specific target T for a particular purpose P. On the other hand, model selection may refer to a procedure that is employed to select from a model library a *set of models* for a specific target T for a particular purpose P. How are the notions of model selection and critical assumption related? To put it simply, candidate (sets of) models are distinguished and selected on the basis of their critical assumptions (Grüne-Yanoff and Marchionni, 2018; Rodrik, 2015). Given the purpose of predicting the effect of price controls on the cigarette industry, the perfectly competitive model can be selected as an applicable one if, among other things, the critical assumption about firms' market power is realistic enough for the given situation. In other words, identifying critical assumptions and judging 'the extent to which they approximate the particular situation to which a model is supposed to apply' are steps of the model selection procedure (Grüne-Yanoff and Marchionni, 2018, p. 3).

The following section will provide a framework to model applicability in the context of antitrust litigation that leverages the notions of critical assumptions and

model selection discussed in this section. This framework will be used in Section 5 to review a 2015 US antitrust case where economic modelling was at the heart of a *Daubert* challenge.

4 Model applicability and *Daubert* challenge: a new framework

What does it mean to apply a model in the context of economic expert witnesses in antitrust litigation? Let us first distinguish two activities performed by the economic expert witness – *model selection* and *model application* – that are associated with two different notions of model applicability.[8] In its simplest form, model selection requires the expert to select a model M for the target T among the set of available models. The aim of model selection is to establish a *weak applicability claim*:

- A theoretical model M is weakly applicable to a target T because there is evidence E_1, …, E_n that some critical assumptions of M are approximately shared by T.[9]

In the context of antitrust cases, the evidence E_1, …, E_n consists mainly of qualitative and informal evidence, with a high degree of subjective judgment by the economic expert. The goal of the expert is to convince the judge that the selected model shares important features with the intended target, usually a very specific market limited in space and time. A toy example will illustrate the point.

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[8] Somebody might say that there are actually three activities, the first one being the very choice to employ a theoretical model rather than purely empirical methods. For reasons of space I leave this further complexity aside.

[9] Following Mäki's (2018) terminology, one can rewrite a weak applicability claim as follows: a theoretical model M is weakly applicable to a target T because there is evidence E_1, …, E_n that some critical assumptions are realistic enough given the target T (and the purpose P). My framework does not depend on how the notion of a critical assumption is defined.

Suppose that the economic expert is required to compute the but-for prices in the Finnish market of fruits in the absence of firm A's anticompetitive conduct. Let us consider the but-for Finnish market for fruits as the target T and assume, for simplicity, that firm A faces a single competing firm B. The first step for the expert is to select a theoretical model M and put forward a weak applicability claim between M and the target T. What is required is to provide evidence E_1, …, E_n that some critical assumptions of M are approximately shared by T. For example, the expert might observe that products sold by the two firms are not close substitutes and that firms have negligible capacity constraints. These two features of the market lead the economic expert to discard models that assume product homogeneity and quantity competition. The economic expert might decide to use a Bertrand model with differentiated goods (henceforth, DB model) and claim that the model is weakly applicable to the target T because evidence exists that some critical assumptions (product differentiation and price competition) are realistic enough given the target T.

Once a theoretical model is chosen, the economic expert still needs to provide evidence that the model describes accurately the particular market to some degree. This activity, which I dub model application, aims at providing a *strong applicability claim*. While weak applicability can be defined solely in terms of theoretical models, strong applicability is to be defined using the notion of *empirical model*. To provide a thorough explication of the notion of empirical model is beyond the scope of this paper. For my purposes, the following working definition will be enough:

- An empirical model M' is the result of a series of activities that provide inputs, modify, and augment the theoretical model M in order to obtain numerical results from it in connection to the expert's goal.[10]

Let us consider again the Finnish market of fruits and suppose that the economic expert chooses to model it using the DB model. The DB model's equilibrium result is a set of first-order conditions that arises from firms' profit maximization. In general terms, first-order conditions determine a relation between three variables: market prices, marginal costs, and demand elasticities. Since the expert's goal is to solve for equilibrium prices of the target market T, she needs to find numerical values for marginal costs and elasticities of demand. When numerical values are substituted for marginal costs and demand elasticities, the economic expert is no longer dealing with the theoretical DB model but rather with an empirical model based on it.

Using the notion of empirical model, I am ready to define a strong applicability claim:

- An empirical model M', based on the theoretical model M, is strongly applicable to the target T because there is evidence E'_1, …, E'_m that M' describes accurately the particular market to some degree.

A strong applicability claim thus involves two intertwined steps, namely the design of an empirical model and the search for evidence that the empirical model describes accurately the particular market. Broadly speaking, antitrust economic experts build empirical models by specifying a functional form of demand, estimating model's coefficients using real-world market data, and adjusting theoretical assumptions to get

[10] Economists sometimes refer to the procedure of building empirical models of such kind as *structural modelling approach* (e.g. Reiss and Wolak, 2007).

closer to the intended target. However, no ready-to-use recipe exists given that every case has its own specificity that depends crucially on the context, purpose and audience. Section 5 will discuss a concrete example of an empirical model designed by the economic expert witness in an antitrust dispute.

The evidence $E'_1, \ldots, E'_m$ used in a strong applicability claim can be partitioned in three groups: direct evidence, indirect evidence, and sensitivity analysis. Direct evidence means that the expert, whenever possible, should compare the numerical results of the empirical model with data available for the target. For example, it is customary to require that empirical models in merger simulation analysis account for the average level of prices over a year in the industry under review (Werden et al., 2004, p. 90). Indirect evidence, by contrast, is suitable whenever the target of the empirical model is a counterfactual but-for world for which no data are available. In such cases economic experts may use indirect evidence from other sources to convince the judge of the reliability of their empirical model's result. Suppose the economic expert's empirical model generates but-for market prices for apples around 10 dollars and that additional evidence exists that the average price of apples in similar markets varies from 8 to 13 dollars. This additional evidence may be brought by the expert to strengthen her strong applicability claim (see Section 5 for an example). Eventually, economic experts may use sensitivity analysis to make clear how alternative choices of functional forms and parameters affect the empirical model's result (Woodward, 2006). A typical example consists in estimating elasticities of demand from the same body of data but using a variety of different assumptions about the functional form for the demand system and seeing how price predictions respond to the change of values for the elasticities of demand.

To sum up, I portrayed economic experts testifying in antitrust cases as making two applicability claims. The first one is a weak applicability claim where evidence is advanced to show that some critical assumptions of a theoretical model M are shared by the intended target T. The second one is a strong applicability claim where an empirical model M' is designed and different sources of evidence are used to show that M' describes accurately some features of the target T. These applicability claims are the products of two activities – model selection and model application – performed by the expert witness.

Why is this framework helpful? First, because it allows a reformulation of the rather vague fit requirement that is supposed to characterize testimonies by experts based on economic models. As we saw in Section 2, the point (4) of Rule 702 states that expert witnesses may testify if they 'reliably applied the principles and methods to the facts of the case'. This point is often interpreted by judges and antitrust scholars as a requirement that the economic model selected by the expert fits the facts of the case. However, given that the notion of fit is not precisely defined, this requirement is either vague or trivially true – since every model can fit a situation to some extent. The distinction between weak applicability and strong applicability clarifies this point: an economic model fits a given target when it is both weakly applicable and strongly applicable to it. Therefore, the fit requirement can be now reformulated as the claim that economic expert witnesses should provide both weak and strong applicability claims. A weak applicability claim is necessary to motivate the selection of a particular theoretical model over alternatives and a strong applicability claim is necessary to argue that an empirical model, based on the theoretical one, accurately describes the properties of the market to some degree.[11]

[11] The clause 'to some degree' is important because it reminds us that a strong applicability claim is always relative to the context, purpose, and audience being addressed. For

Second, my framework makes it clear what most *Daubert* challenges are about, viz. the strength of the evidence that the expert witness puts forward to justify the two applicability claims. Expert witnesses are usually highly qualified and employ models that are generally accepted by the scientific community. However, this does not prevent them from receiving *Daubert* challenges that cast doubt on the evidence E_1, …, E_n and E'_1, …, E'_m that the experts use to put forward the two applicability claims. This can be done either by directly criticizing the evidence offered by the expert witness or by providing alternative evidence. Using our previous example, a *Daubert* challenge might be based on evidence showing that firms have significant capacity constraint, thus implying that the DB model is not weakly applicable to the target. The same challenge could also offer a detailed critique of how marginal costs should have been inferred from accounting data or why demand elasticities are poorly estimated, thus implying that the empirical model based on the DB model is not strongly applicable to the target. More formally, a *Daubert* challenge consists of two main sub-challenges to the opposing party's expert testimony:

- Weak applicability sub-challenge: the evidence E_1, …, E_n is insufficient to justify the weak applicability claim by the expert witness.

- Strong applicability sub-challenge: the evidence E'_1, …, E'_m is insufficient to justify the strong applicability claim by the expert witness.

In this way, the proposed framework connects two expert witness' activities (model selection and model application) associated with two applicability claims (weak

example, judges in different federal courts may have different views on how to evaluate the very same strong applicability claim.

applicability and strong applicability) to two types of sub-challenges (weak applicability sub-challenge and strong applicability sub-challenge).

The first two reasons why my framework is helpful are linked to a third one, namely that this framework can be employed to carry out a detailed review of antitrust cases where *Daubert* challenges are directed against how economic expert witnesses (mis)use economic models. Section 5 will concern such review.

5 Case study: *Castro v. Sanofi Pasteur Inc.* (2015)

Despite the large number of *Daubert* challenges in many areas of law, a detailed analysis of legal cases is often hampered by the absence of complete and easily accessible documentary records. Fortunately, such written documentation is available for some cases. A 2015 antitrust case, *Castro v. Sanofi Pasteur Inc.*, centered around the economic expert testimony and its admissibility under the *Daubert* standard. For this case, direct documentation exists of the report of the plaintiff's expert, the *Daubert* challenge raised by the defendant, and the district court's opinion.[12]

Castro concerns the antitrust action raised by a number of physicians, led by Dr. Adriana Castro, against the bundling of pediatric vaccines by the French multinational pharmaceutical company Sanofi. Plaintiff's expert, renowned antitrust economist and Harvard professor Einer Elhauge, was testifying at the class certification stage, but the defendant raised a motion to exclude his opinion under *Daubert*/Rule 702. The District Court of New Jersey conducted a *Daubert* hearing to evaluate whether to accept or not the challenge. Eventually, the court was convinced that the expert did satisfy the *Daubert* standard and, therefore, could not be excluded from the trial. I will examine this case on the basis of the framework developed in the previous section.

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[12] I accessed the court's opinion, legal briefs, motions, and other unpublished material through the database *NexisUni*.

5.1 Plaintiff's expert report

To understand the purpose and context of Elhauge's testimony, let me briefly summarize the case. Sanofi had for many years monopoly power in the market for the conjugate quadrivalent meningococcal vaccine (MCV4), which is usually inoculated to children against meningitis bacterium. By mid-2009, Sanofi became aware that its own MCV4 vaccine, Menactra, would have soon faced the competition of a new vaccine, Menveo, produced by market entrant Novartis. Sanofi responded to the entry threat by bundling Menactra with its other pediatric vaccines and substantially increasing its prices (*Castro*, p. 826). Only customers who purchased the whole bundle of vaccines were able to receive a 'loyalty discount' that dropped prices back to the level preceding Menveo's entry in the market. All other costumers paid higher prices on all vaccines in the bundle. Plaintiffs were three pediatric physicians who sought to represent a broader class of individuals and firms that were directly damaged by Sanofi's behavior which led to higher prices for vaccines.

Following this antitrust allegation, Elhauge's expert report had to provide evidence about what the prices paid by consumers would have been absent the bundle. In other words, he was required to model a but-for world that should represent the market for MCV4 vaccines in the absence of Sanofi's alleged anticompetitive conduct. He described his task as follows:

> One can estimate how much the Bundle has increased MCV4 prices above but-for levels (i.e., levels that would have prevailed absent the Bundle) by comparing actual MCV4 prices with the Bundle to what an economic model based on actual market data indicates the firms would have charged without the Bundle. (Exhibit 51B, p. 147)[13]

[13] *Castro*, Exhibit 51B. Retrieved from: https://advance.lexis.com/api/document?collection=briefs-pleadings-motions&id=urn:contentItem:5KS1-D4J1-JNCK-21KY-00000-00&context=1516831.

Section VII of his expert's report is devoted to the task of determining the but-for prices and comparing them with actual prices to show that consumers were paying inflated prices as a result of the bundle. The report is divided into different parts:

> Part A below explains that the most appropriate model to use in this market is the "differentiated Bertrand competition" model. [...] Part B describes the quantitative market data used as inputs to the model. Part C calculates but-for profit-maximizing Menactra and Menveo prices by inputting the quantitative market data into the differentiated Bertrand model. (Exhibit 51B, pp. 147-148)

Part A roughly reflects the activity of model selection, while parts B and C correspond to what I have called model application. Let us begin with the former.

Model selection and weak applicability claim

As explained in Section 4, the plaintiff's expert needs to justify the choice of a certain theoretical model over alternatives by appealing to the fact that some critical assumptions of the selected model are shared by the target. In this case, Elhauge chooses to model the but-for world using a Bertrand model with differentiated goods (DB), a standard model of industrial organization theory widely used in the antitrust context.[14] Roughly speaking, the DB model assumes that firms produce differentiated products and compete by setting prices in order to maximize their profits. For this reason, the plaintiff's expert strives to provide evidence that the two MCV4 vaccines – Menactra and Menveo – differ in a significant manner for consumers and that the two firms compete on prices. For example, Elhauge argues that the two vaccines have different chemical properties and are approved for different age groups, thereby prompting some medical providers to prefer one to the other (Exhibit 51B, p. 149). At the same time internal documents show that neither Sanofi nor Novartis have significant

[14] For a textbook treatment of the model see Tirole (1988).

capacity constraint in the MCV4 market. If no capacity constraint is in force, then price competition seems to be more appropriate than quantity competition: firms set prices and are able to sell as much output as demanded by buyers at offered prices (Exhibit 51B, p. 155-156).

In the terminology of Section 4, the economic expert is providing evidence E_1, …, E_n to show that some critical assumptions of the theoretical DB model (product differentiation and price competition) are shared by the intended target, that is, the US market for MCV4 vaccines in the period 2010-2015. Having provided such evidence, Elhauge (Exhibit 51B) concludes that 'market characteristics and market data both indicate that, without the Bundle, Sanofi and Novartis would engage in "differentiated Bertrand competition" in the private segment of the MCV4 market' (p. 148).

Model application and strong applicability claim

The second activity of expert testimony is model application where an empirical model M' is designed and different sources of evidence are used to show that M' describes accurately some features of the target T. In Elhauge's words:

> The next step in estimating the but-for MCV4 prices is to calibrate the differentiated Bertrand competition model to the MCV4 market by obtaining quantitative estimates – based on the actual market data, internal company documents, and other information – of the key factors that determine profit-maximizing MCV4 prices. (Exhibit 51B, p. 168)

We have seen in Section 4, that the DB model's equilibrium result is a set of first-order conditions that arises from firms' profit maximization. The equilibrium conditions describe a relation between three variables: market prices, marginal costs, and demand elasticities. Given the purpose of obtaining numerical values for market prices of the two vaccines (Menactra and Menveo) produced by Sanofi and Novartis respectively, the

economic expert needs to provide numerical inputs for both firms' marginal costs and consumers' demand elasticities.

Researchers and practitioners routinely use a variety of approaches to measure marginal costs. One of these approaches is based on accounting data, that is, to leverage internal firm documents and determine which costs are most likely to stand for the theoretical notion of marginal costs. Elhauge's expert report follows this approach. As often happens in the context of court litigation, some experts' choices are dictated by strategic considerations related to the goal of persuading the judge of the merits of their analysis. In this case, Elhauge decided to consider as marginal all cost categories that Sanofi includes as 'direct cost of good sold' in its balance sheet (Exhibit 51B, p. 171). The choice tends to inflate Sanofi's marginal costs for its vaccine Menactra and generate, ceteris paribus, higher but-for prices. This conservative approach is strategic because it suggests to the judge that the plaintiff's expert is not trying to artificially inflate the difference between actual prices and but-for prices.

Besides marginal costs, Elhauge had to estimate own- and cross-price elasticities for Menactra and Menveo. To explain how antitrust economists model demand systems would require an extensive detour (Björnerstedt and Verboven, 2016; Budzinski and Ruhmer, 2010; Werden et al., 2004). Suffices to say here that in *Castro* Elhauge estimated demand elasticities using a discrete choice logit model and feeding it with actual data from a portion of the MCV4 market unaffected by the challenged conduct. He identified such portion of the market in the Federal Supply Schedule (FSS), viz. long-term contracts with companies that provide access to commercial products and services at regulated prices to the government. As explained by Elhauge (Exhibit 51B), he used data on FSS purchasers because 'FSS customers were not subject to the Bundle and thus their decisions could not be distorted by the Bundle' (p. 190).

Recall that when numerical values are substituted for marginal costs and demand elasticities, the economic expert is no longer dealing with the theoretical DB model but rather with an empirical model based on it. The empirical model is solved and but-for prices are computed. Elhauge found that but-for prices for both competing vaccines Menactra and Menveo would have been substantially lower than actual prices. For example, Menactra actual price in 2013 was $99.36 while its but-for price derived from Elhauge's empirical model would have been $61.25. The 38% difference between the actual and the but-for price was the overcharge that could be imputed to the alleged anticompetitive bundling (Exhibit 51B, p. 204).

The computation of the but-for prices using an empirical model is not the end of the model application activity because the economic expert also needs to provide evidence $E'_1, \ldots, E'_m$ that the empirical model M, based on the theoretical model M', describes accurately the particular market to some degree. In other words, the expert should put forward what I called a strong applicability claim. As a matter of fact, Elhauge's expert report is replete with sections dedicated to this purpose.

In Section 4 I partitioned evidence $E'_1, \ldots, E'_m$ used in a strong applicability claim in three groups: direct evidence, indirect evidence, and sensitivity analysis. Since no direct evidence was available here, Elhauge exploited both indirect evidence and sensitivity analysis. For example, a section called 'Other evidence confirms plausibility of these but-for prices' argues that but-for prices and the relative profit margin were both within normal range for the vaccine industry (Exhibit 51B, pp. 205-206). In addition to indirect evidence, Elhauge performed sensitivity analysis concerning marginal costs – that is, he studied how different numerical values for marginal costs would affect the values of but-for prices. His conclusion was that alternative choices

would give rise to lower but-for prices (and thus even higher overcharges), thus reinforcing the idea that his but-for prices were a conservative result (p. 185).

5.2 The Daubert challenge

Section 4 argued that many *Daubert* challenges aim to cast doubt on the evidence E_1, …, E_n and E'_1, …, E'_m that the expert uses to put forward the two model applicability claims. The *Castro* case is no exception. Sanofi's attorneys raised a motion to exclude Elhauge's testimony under the *Daubert* standard:

> The question presented by Sanofi's *Daubert* motion is whether the methodology that led Elhauge to this opinion passes muster. As Sanofi explained, each of its components departs from generally accepted practices, is riddled with error, and lacks the scientific validity required by a court of law. (Reply Brief, p. 2)[15]

The first part of the challenge revolves around the fact that the plaintiff's expert 'did not ensure that the assumptions that generated the models' results were satisfied here' (Reply Brief, p. 4). This part corresponds to what I called a weak applicability sub-challenge stating that evidence E_1, …, E_n is insufficient to justify the weak applicability claim proffered by the expert. We saw that Elhauge relied on certain evidence to show that some critical assumptions of the DB model were shared by the target. The defendant's attorneys, however, pointed out that other assumptions of the DB model were highly suspicious given the intended target:

> It is the one-shot game assumption that is unrealistic. In a one-shot game, each firm has "one shot" to earn the business at stake. […] Bertrand *assumes away* the most likely business strategy and the one Novartis employed in the actual world: enter at approximate parity and wait and see what happens. (Reply Brief, p. 12)

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[15] *Castro*, Reply Brief. Retrieved from: https://advance.lexis.com/api/document?collection=briefs-pleadings-motions&id=urn:contentItem:5YX8-9GF1-FBV7-B32M-00000-00&context=1516831.

In other words, the defendant was trying to show that additional evidence existed that some critical assumptions of the DB model were not shared by the target and that, therefore, this model was not weakly applicable to it. Defendant's attorneys seemed to suggest that alternative theoretical models where firms repeatedly interact in the product market would have been better to describe this specific vaccine industry.

The *Daubert* challenge also contains a strong applicability sub-challenge that evidence $E'_1, \ldots, E'_m$ is insufficient to justify the strong applicability claim proffered by the expert. In *Castro* this sub-challenge takes the following form:

> A simulation is not reliable "without validation," or the process of ensuring it "accurately predicts" real-world behavior. "Calibrating" the model is so important that an "inadequately calibrated" model must be "excluded under *Daubert*" because the "reliability of an economic theory is tested by comparing it to reality." (Reply Brief, p. 14)

Among the deficiencies spotted by the defendant, an important one was the fact that the plaintiff's expert allegedly used the wrong cost data to identify numerical values for marginal costs. Without this error, the defendant argued, the empirical model built by the plaintiff's expert would give rise to different but-for prices and, therefore, different overcharge (Reply Brief, pp. 18-19). For this reason, the evidence proposed by plaintiff's expert Elhauge did not suffice to make a strong applicability claim and, therefore, his testimony had to be excluded under the *Daubert* standard (Reply Brief, p. 20).

As already mentioned above, the district court denied the *Daubert* motion to exclude Elhauge's expert witness testimony. The court argued that even though other approaches could have been employed, including alternative theoretical models, 'the use of the differentiated Bertrand model here, however, is not error' since the plaintiff's expert 'notes that Sanofi and Novartis documents indicate there are no production

limits. And Menactra and Menveo are differentiated products' (*Castro*, p. 838). Therefore, the court was satisfied by the evidence put forward for the weak applicability of the DB model to the but-for market for MCV4 vaccines:

> Professor Elhauge *has provided defensible reasons for not using the various models Defendant proposes* and all alternate models need not be ruled out. Defendant's disagreement with the model selected is not a basis for inadmissibility here. (*Castro,* p. 839, emphasis added)

The court also argued that Elhauge had built a reliable empirical model using real-world data on market demand and cost data, thereby concluding that 'defendant's motion to exclude Professor Elhauge's expert reports is denied' (*Castro*, pp. 840-842).[16]

This case is just an example of how my framework can be applied to examine antitrust cases. Further research will tell whether the framework is generalizable to analogous cases where the use of economic models by expert witnesses has been questioned under *Daubert* standard.[17]

6 Concluding remarks

In this paper I investigated the use of models by economic expert witnesses in courtroom by providing a framework of model applicability in the context of antitrust litigation and, specifically, of *Daubert* challenges raised against a model's 'scientificity'. Based on this framework, I showed that the fit requirement can be suitably explicated as

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[16] It might be worth reminding that a *Daubert* motion does not require the judge to enter into the merits of the dispute but only to validate the expert's testimony as 'scientific'. Therefore, even if the *Daubert* challenge is dismissed the challenger can still present alternative models during the trial.

[17] To mention but a few cases: *Concord Boat Corp. v. Brunswick Corp.*, 207 F.3d 1039 (8th Cir. 2000), *Heary Bros. Lightning Prot. Co., Inc. v. Lightning Prot. Inst*., 287 F. Supp. 2d 1038 (D. Ariz. 2003), and *Williamson Oil Co. v. Philip Morris USA*, 346 F.3d 1287 (11th Cir. 2003).

the claim that economic expert witnesses should provide both weak and strong applicability claims. Furthermore, I employed my framework to carry out a review of *Castro* (2015), a US antitrust case concerning the bundling of pediatric vaccines where the economic expert's testimony had to face a *Daubert* challenge. The possible extension of this framework to other areas where economic models are employed is left for future research.

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