

The Transfer of Economic Models into the Courtroom: A Failed Promise?

Edoardo Peruzzi*¹

¹Institute of Philosophy, Leibniz University Hannover

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Abstract

The contemporary justification for the transfer of scientific models from the realm of scientific research into various social and institutional contexts is usually based on two premises: first, that certain scientific models exert a discernible influence in those external contexts; second, that making use of scientific models outside of science is beneficial for the respective context. The purpose of this article is to discuss these two premises by focusing on the often-neglected case of the transfer of scientific models into the legal system, particularly the use of economic models in competition cases. Drawing on United States case law, I argue that (i) economic models often fail to exert a significant influence on judicial decision-making and that (ii) model-based evidence is frequently neutralized in the adversarial process, where it tends to serve primarily as a shield for weaker and less reliable evidence. As a result, rather than improving decision-making, the use of economic models in litigation can sometimes lead to worse outcomes, as decisions become grounded in weaker or less reliable evidentiary base.

Keywords: model transfer, scientific models, evidence, economic models

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*edoardo.peruzzi@philos.uni-hannover.de

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1 Introduction

Scientific models are routinely transferred from academic and research-based settings into various social and institutional contexts, often accompanied by high expectations of enhancing reasoning and strengthening the evidential basis for decision-making in these contexts. Notable examples explored by philosophers of science include the use of economic models in central banks and auction design, model ensembles in climate science, and natural hazard models in probabilistic risk assessment (e.g., Gluck 2023; Jhun 2023; Parker 2010, 2011; Roussos, Bradley, and Frigg 2021; van Basshuysen 2023; Winsberg and Harvard 2024; Zanetti 2024).

A common lesson emerging from these studies is that using scientific models outside academic and research-based settings introduces a range of epistemic and practical challenges. One major challenge is how to aggregate input from multiple scientific models when making policy decisions amidst model uncertainty (Jhun 2023; Roussos, Bradley, and Frigg 2021; Zanetti 2024). Another challenge arises from the urgency of decision-making in what is often referred to as the “fast science” context. In such situations, scientists are forced to bypass standard scientific practices to develop rapid interventions against catastrophic threats (Friedman and Šešelja 2023; Stegenga, forthcoming). This can result in models with poorly estimated parameters, insufficiently validated assumptions, or reliance on incomplete data. Accordingly, philosophers of science have debated the extent to which we can trust model predictions in policy decisions based on fast science (Northcott 2022; Stegenga, forthcoming; Van Basshuysen and White 2021; Winsberg, Brennan, and Surprenant 2020).

Incidentally, most philosophical analyses to date have focused on the use of models within the scientific community, such as in cases of peer disagreement over the assessment of evidential strength in support of a hypothesis, or in policy contexts where scientific models help generate evidence for guiding policy decisions. However, a third domain exists where scientific models play a crucial role: the courtroom. The goal of this article is to expand the literature by examining how expert witnesses use scientific models to influence judicial decision-making in legal proceedings.

I will focus on the two implicit justificatory premises that seem to underlie the transfer of models from science into policy or legal contexts, where expert knowledge is frequently sought: first, that scientific models developed in academic and research-based settings exert a discernible influence on decision-making outside of science; and second, that transferring these models positively impacts the domain into which they are applied. Consider, for example, a politician who hires a scientific expert to use or construct models to guide a policy decision. If these models did not influence the decision-making process, the transfer would seem to be a costly yet futile endeavor. Thus, model transfer seems unjustified if there is no discernible impact in the recipient domain. At the same time, a justified transfer is one in which the use of a scientific model “improves” the decision-making process, helping the decision-maker to arrive at better outcomes. If decisions in these contexts are worse as a result of using scientific

models than they would have been without them, the transfer itself appears unjustified. As we will see in Section 2, these two premises lie at the heart of an ongoing debate among legal scholars, economists, and judicial authorities regarding the justification for transferring and using economic models in legal proceedings

Drawing on a case study of the use of economic models in US competition cases, I will challenge these two implicit premises underlying the transfer of models outside the academic context.¹ First, I demonstrate that, despite their widespread use, economic models often fail to influence judicial decision-making, thereby undermining the justification for their transfer into courts of law. To illustrate this, in Section 3 I will clarify the concepts of *judicial influence* and *irrelevance of economic models* using Bayesian epistemology and survey US case law to demonstrate that instances of economic irrelevance are not negligible. Second, in Section 4, I will argue that evidence produced by economic models is often neutralized in the adversarial system, where it tends to be overshadowed by weaker and less reliable evidence. As a result, rather than improving decision-making, the use of economic models in litigation can sometimes even lead to worse outcomes, as decisions made by fact-finders become grounded in a weaker or less reliable evidentiary base – a phenomenon I refer to as the “paradox of neutralized model-based evidence.”² Thus, the second premise for justifying the transfer of models in legal proceedings is violated, at least in some cases. Eventually, Section 5 defends the view that economic models often struggle to improve judicial decision-making both because they lack the necessary resources to provide the type of evidence courts require, and because courts demand more than economic models can reasonably offer.

The article aims to advance the discussion on the use of scientific models outside the academic environment in two ways. First, there is often insufficient reflection on the justifications for transferring and applying scientific models beyond academic settings. This may be because, in some of the case studies discussed recently, it seems almost self-evident that policymakers should use scientific models to inform their decisions. However, as we will see later, in the legal domain, we cannot take for granted that scientific models should always be used to improve decision-making. Therefore, in contrast to existing literature, I explicitly focus on the often implicit premises that justify the transfer of models outside academia. Second, while many examples focus on policy contexts where scientists or expert panels advise policymakers, I draw attention here to the legal context, which is often neglected in the philosophy of science literature. Given the importance that modern legal systems place on expert knowledge, along with the adversarial nature of court proceedings – which differs from the advisor-advisee relationship typical in policy-making – examining whether and how the use of scientific models enhances judicial decision-making becomes crucial.

Before proceeding with the main content of this article, three disclaimers are in order. First,

1. Competition cases are legal disputes concerning alleged violations of antitrust laws, such as monopolistic practices, anti-competitive agreements, abuse of market dominance, or unfair trade practices.

2. “Fact-finder” refers to the individual or entity responsible for assessing the facts of a case – the judge in a bench trial or the jury in a jury trial, depending on the type of case.

my focus in this article is not on the systemic influence of economic thought on the legal system, but rather on specific ways in which economic models impacts court verdicts in competition cases. Second, I will set aside the long-standing debate on the goals of competition policy and proceed on the assumption that courts enforcing antitrust laws aim to protect competition and consumers – whatever that may entail in specific circumstances (see, e.g., Esposito 2022; Giocoli 2024; Martin 2007). Finally, given my focus on US legal system, the terms “antitrust”, “competition law”, and “competition policy” will be used interchangeably.³ Also, I follow the common practice in US legal scholarship and use “courts” and “judges” as synonyms.

2 Case study: economic models in competition cases

Our case study concerns the use of economic models in competition cases. In these cases, economists are often hired as expert witnesses to construct models of counterfactual scenarios, that is, of what would have occurred in the absence of the anticompetitive conduct.⁴ Antitrust practitioners usually refer to this counterfactual scenario as the “but-for” world to indicate 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.

An important example of but-for modeling is merger simulation, a modeling technique that involves using game-theoretic models of oligopolistic markets to simulate how prices in the relevant market would be affected if a merger were allowed. Another example is the counterfactual analysis of the competitive landscape in the absence of certain behaviors by one or more firms, such as an allegedly exclusionary agreement.⁵ The results of these models are used as evidence to influence judicial decision-making. For example, if the model indicates that, in the absence of a particular agreement, prices would have been lower, this could serve as evidence that the behavior was anticompetitive and that the firms violated antitrust laws (Peruzzi 2023).

Such practices rest upon the premises that, first, using economic models can have an effect on decision making and that, second, they can help courts to make better-informed decisions. Berkeley economist Carl Shapiro, for example, has recently made a compelling case for the beneficial impact that economics has had on antitrust enforcement:

Economics provides an indispensable way to sift through a mountain of evidence to better understand the likely economic effects of various business practices in

3. Antitrust law was introduced in North America at the end of the nineteenth century to prevent anti-competitive behavior and promote market competition. In Europe and other jurisdictions, antitrust law is referred to as competition law.

4. On the role of economists as expert witnesses, see the classic articles by Mandel (1999) and Posner (1999) and the recent contributions by Maas and Svorenčík (2017), Chassonnery-Zaigouche (2020), Giocoli (2020), Peruzzi (2023, 2024), and Peruzzi and Cevolani (2024).

5. An exclusionary agreement occurs when one party agrees not to purchase from anyone other than the specified party. These are generally prohibited by antitrust laws and include practices such as exclusive dealing, tie-in arrangements, and long-term contracts (Jing and Winter 2013; Shepard Wiley Jr 1998).

comparison with some suitable counterfactual. Economics is not “pro-defense” or “pro-plaintiff.” Properly used, economics instructs us *what to look for* in a given case to assess effects. (Shapiro 2021a, 39)

“Economics,” he continues, “is a neutral tool that helps us understand the economic effects of various business practices.” (*ivi.*) The idea is that, when effectively applied by experts, economics provides tools to assist decision-makers in understanding the impacts of firms’ conduct across various markets. Shapiro acknowledges that many factors beyond economic reasoning, such as how courts allocate burdens of proof and establish legal standards, routinely influence judicial decision-making. Nevertheless, in his optimistic view, economic models – and, by extension, the economist *qua* economic expert – has the potential to assist the court in making correct decisions: convicting guilty firms while acquitting innocent ones. In Shapiro’s view, both premises justifying the transfer of scientific models are upheld: economic models not only influence court decision-making but also have the potential to enhance the quality of those decisions, thereby validating the benefits of integrating economic models into the legal system (see also Schinkel 2008 for similar statements).

A few economists and antitrust practitioners, however, have adopted a more pessimistic view on the relationship between economic models and judicial decision-making. Both premises underlying the justification for transferring scientific models from academia to the legal system are contested. First, it is argued that the extent to which economic models influence actual judicial decisions remains limited. This lack of influence is often attributed to a problem of expertise – or, more precisely, a lack thereof (Haw Allensworth 2012; Lopatka 2016; Posner 1999). Both the generalist judge and, even more so, the jurors lack a formal education in economics: why should we expect that courts are capable of adequately assessing economic models in the first place?⁶ Second, even if economic models exert some influence, its overall effects may not be as beneficial as intended. This is because expert witnesses, it is often said, have shifted from being scientists to becoming partisan advocates.⁷ Given the high stakes involved and the adversarial nature of the trial, especially in common law countries, there are concerns that expert witnesses, unlike scientific inquirers, primarily act as advocates for the party that has hired them.⁸

To find a clear expression of skepticism regarding the use of economic models in the courts, one does not have to look far. Notably, Jonathan Kanter, the current Assistant Attorney General at the Department of Justice Antitrust Division, has recently voiced these criticisms. He stated:

6. A consistent body of evidence exists showing that both judges and jurors have difficulty understanding scientific evidence (e.g., Hans and Saks 2018, and Koehler 2018).

7. The accusation that expert witnesses are simply “hired guns” is a common refrain in the media. For example, consider the following article from *ProPublica*: <https://www.propublica.org/article/these-professors-make-more-than-thousand-bucks-hour-peddling-mega-mergers>.

8. For an extensive analysis of the distinction between scientific inquirers and advocates in the context of expert testimony, see Haack (2014) and Walton (2008). I will revisit the relationship between the adversarial system and the use of economic models in Section 5.

We spend millions arguing about models of the economy and how conduct will hypothetically shift outcomes to the fourth decimal point up or down. Plaintiffs and defendants offer experts to present quantitative models. More often than not, courts reject both competing models and do not believe either side.⁹

Speaking about “a crisis of expertise in our antitrust and competition community”, he recently added that there has been “a pervasive breakdown in the distinction between expertise and advocacy in competition policy.”¹⁰ These words loom large over the current influence of economic models in judicial cases and raise questions about whether that influence is beneficial.

Beyond the ongoing debate among economists and antitrust practitioners, it is insightful to examine in more detail what courts “say” about economic models employed in competition cases. A casual observation of judicial opinions in antitrust cases litigated in the US over the last twenty years reveals a range of relevant reactions to the use of economic models in the courtroom by expert witnesses.

One notable example is the contemptuous skepticism expressed by Judge Richard Leon. In his opinion on the *AT&T/Warner* vertical merger case, he ridiculed the bargaining model presented by the Justice Department’s economic expert, Carl Shapiro, describing it as a Rube Goldberg machine devoid of any factual content:¹¹

After hearing Professor Shapiro’s bargaining model described in open Court, I wondered on the record whether its complexity made it seem like a Rube Goldberg contraption. [...] The evidence at trial showed that Professor Shapiro’s model lacks both “reliability and factual credibility,” and thus fails to generate probative predictions of future harm. (*AT&T/Warner*, 149)

The parallel between Shapiro’s economic model and a Rube Goldberg machine – a contraption intentionally designed to perform a simple task in an indirect and overly complicated way – sounds almost insulting for a science that takes constructing and using models for knowledge production as its main theoretical tool. As a result, a number of leading economists seized on the *AT&T/Warner* case to reopen the discussion on the perks and perils of using economic models in competition cases (e.g., Carlton and Israel 2021; Katz 2021; Salop 2021; Shapiro 2021a, 2021b).

In contrast, some courts acknowledge that the use of economic models has strengthened the litigator’s case, contributing to a favorable outcome. A pertinent example is the attempted

9. Keynote at the University of Chicago Stigler Center, Chicago, IL, Thursday, April 21, 2022 “Antitrust Enforcement: The Road to Recovery.” Transcript of the speech available here: <https://www.justice.gov/opa/speech/assistant-attorney-general-jonathan-kanter-delivers-keynote-university-chicago-stigler>.

10. Remarks for the Fordham Competition Law Institute’s 51st Annual Conference on International Antitrust Law and Policy, Thursday, September 12, 2024. Transcript available here: <https://www.justice.gov/opa/speech/assistant-attorney-general-jonathan-kanter-delivers-remarks-fordham-competition-law-0>.

11. *United States vs. AT&T Inc.*, 310 F. Supp. 3d 161 (DC District Court, June 2018) (“AT&T/Warner”).

merger between book publisher Penguin Random House and rival Simon & Schuster.¹² In this case, the court enjoined the merger, relying on empirical models provided by the plaintiff’s economic expert that predict potential harm to book authors. The court acknowledged that while “models are imprecise and do not perfectly reflect the way books are acquired in the publishing industry,” they “generally *corroborate* the other evidence in the record that author advances would decrease in the wake of the merger.” (*Penguin Random House*, 77, emphasis added)

Finally, there are instances where the court finds that the economic arguments presented by expert witnesses hold limited or no relevance to its decision. To see that, let us consider the recent *Peabody* case in which the Federal Trade Commission (FTC) sought to block a proposed joint venture between two coal mining companies, Peabody Energy and Arch Resources, arguing it would severely harm competition in a region supplying 40% of America’s coal.¹³ In this instance, confronted with conflicting expert testimonies regarding modeling choices, the court washed its hands of the matter and remarked that the “Court need not decisively sift through various models and theories.” (*Peabody*, 907)¹⁴

Overall, the ongoing debate over the role of economic models in court decisions raises the question of whether their transfer and use into legal proceedings is justified. In the next section, I use Bayesian confirmation theory to characterize these three judicial attitudes and show that, in certain cases, economic models seem to have no discernible impact on court verdicts.

3 A Bayesian definition of judicial influence and the irrelevance of economic models

Scientific models are employed in the legal context to produce evidence that influences judges’ beliefs about a state of affairs. In the case study discussed here, this includes determining whether a firm’s behavior or conduct violates competition laws. As a working definition, I refer to *model-based evidence* as any item or information derived from scientific models that can affect what one is justified in believing about a given state of affairs.¹⁵ For example, if a merger simulation model predicts that a proposed merger will increase prices by 5%, prices, this prediction becomes part of the model-based evidence presented in the case. Similarly, probabilistic models used in DNA analysis estimate the likelihood that DNA found at a crime scene matches the suspect’s, often providing crucial evidence in criminal trials.

It is important to distinguish model-based evidence from other types of evidence that can

12. *United States v. Bertelsmann SE & Co. KGAA, et al.* WL 16949715 (D.D.C. Oct. 31, 2022). (“Penguin Random House”)

13. *FTC v. Peabody Energy Corp.*, 492 F. Supp. 3D 865 (E.d. Mo. 2020). (“Peabody”).

14. We will return to the *Peabody* case later in the paper, especially in Section 4.

15. There is significant debate within the philosophy of science about what constitutes evidence (for an overview, see Kelly 2016 and Ho 2021). That said, my definition of model-based evidence follows the standard conception of evidence as something that can make a difference to what one is justified in believing (see Kelly 2016).

also play a significant role in legal proceedings. Legal texts often categorize evidence based on the role it plays in supporting or challenging arguments. *Factual evidence* refers to direct observations or testimonies that can be verified, such as witness statements about a company’s practices or sales records showing pricing strategies. *Documentary evidence* includes written or recorded materials supporting a claim, such as contracts, emails, or reports detailing communications regarding pricing agreements or market strategies.

Let us now consider, at an abstract level, the decision-making process of a court in a competition case. The court must evaluate a hypothesis H (for example, “Firm f ’s behavior in market G violates antitrust law” or “Firm’s f behavior violates the Clayton Antitrust Act”) against the available evidence, which may include factual, documentary, and model-based evidence.¹⁶

Given the decision-making problem faced by judges, how can we determine whether economic models influence their rulings? A recent trend in the philosophy of science builds on Bayesian models to elucidate traditional concepts, such as confirmation, causal strength, and explanatory power (e.g., Bovens and Hartmann 2003; Dahlman and Wahlberg 2015; Hahn, Oaksford, and Harris 2013; Hedden and Colyvan 2019; Crupi 2021; Lin 2024; Sprenger and Hartmann 2019; Zenker 2013). Here I follow this trend by studying the influence of economic models on court verdicts through the lens of Bayesian epistemology.

To do so, I consider the applications of economic models as a source of evidence and investigate whether such evidence “makes a difference” in the court’s assessment of the case. In its simplest form, Bayesian confirmation theory posits that evidence e confirms hypothesis H for a person at a given time if and only if, at that time, her credence in H would increase upon conditioning on e . By analogy, I contend that an economic model influences judicial decisions if and only if it produces evidence e that changes the court’s subjective probability concerning H – either enhancing or diminishing it.

Let us consider the hypothesis H and the available evidence e , which I assume consists of factual, documentary, and model-based evidence. Now, imagine removing the model-based evidence from e ; for example, imagine a scenario where both parties in litigation choose not to hire economic experts to conduct an analysis to support their case. I will denote this modified set of evidence as e' , which includes only the factual and documentary evidence. Thus, $p(H|e)$ represents the probability that H is correct given the complete set of available evidence e , while $p(H|e')$ reflects the probability of the same hypothesis being correct based solely on the evidence in e' .

One can now define *judicial influence* as follows:

Definition 3.1 (Judicial influence). *Economic models exert a judicial influence if and only if $p(H|e) \neq p(H|e')$.*

Definition 3.1 states that economic models have an influence on judicial decision-making

16. The Clayton Act is a US antitrust law enacted in 1914 to prevent anticompetitive practices. It addresses issues such as price discrimination, exclusive dealings, and mergers or acquisitions that may substantially lessen competition or create monopolies.

when the probability of H changes depending on whether model-based evidence is included. Specifically, if the inclusion of model-based evidence e alters the probability that the judge assigns to H compared to a situation where only factual and documentary evidence e' is available, we can say that economic models influence the court's decision-making process.

From the plaintiff's standpoint, it is crucial that reliance on economic models results in a positive variation in the probability of H ; specifically, using model-based evidence should enhance the judge's confidence in H . In this context, we define the following relation:

Definition 3.2. *Economic models strengthen H if and only if $p(H|e) > p(H|e')$.*

Conversely, if the use of model-based evidence diminishes the judge's confidence in H compared to a situation where no model-based evidence is employed, we conclude that economic models *weakens* H :

Definition 3.3. *Economic models weaken H if and only if $p(H|e) < p(H|e')$.*

Definitions 3.2 and 3.3 illustrate that, from the plaintiff's perspective, economic models either strengthen or weaken H based on whether the inclusion of model-based evidence leads to a positive or negative change in the judge's subjective probability compared to a scenario where no model-based evidence is presented. The situation is symmetric from the defendants' perspective. Just as the plaintiff aims to increase the probability that the judge assigns to H , the defendants strive to decrease it. They do so by challenging the relevance or credibility of the model-based evidence presented by the plaintiff. Thus, both parties are engaged in a similar process of influencing the judge's decision, albeit with opposing objectives.

Despite their simplicity, these definitions capture two judicial attitudes toward the use of economic models in the courtroom that we already discussed. Recall the *Penguin Random House* case, where the court acknowledged that, despite their imprecision, the empirical models presented by the plaintiff's expert generally strengthened the hypothesis H . In this case, economic models effectively strengthen the claim that the merger would violate the Clayton Antitrust Act.

Not all independent or secondary source evidence serves as corroboration; at times, additional evidence may undermine initial findings. This appears to be the case in *AT&T/Warner*, where the application of economic models actually weakened the hypothesis H by lowering the judge's subjective probability in H . Paradoxically, it might have been more beneficial for the plaintiff not to present any model-based evidence at all. What is crucial to note, however, is that in both *Penguin Random House* and *AT&T/Warner*, economic models played a discernible role in influencing judicial decisions, as the model-based evidence presented in these cases led to a shift in the judges' beliefs regarding the hypothesis H being adjudicated. This effect is what is relevant for us at this point.

The Bayesian framework introduced so far represents a simple way to define judicial influence and characterize two widespread judicial attitudes toward the use of economic models

in the courtroom. Now, following again Bayesian confirmation theory, let us define the *irrelevance of economic models* as a situation where the subjective probability of the judge in H is left untouched by conditioning on the model-based evidence, that is,

Definition 3.4 (Irrelevance of economic models). *Economic models are irrelevant if and only if $p(H|e) = p(H|e')$.*

There are reasons to suspect that situations in which evidence from economic models is irrelevant to court verdicts may be more frequent than commonly assumed. In Section 2, we have already seen an example of it in *Peabody*, where the Federal Trade Commission (FTC) sought to block a proposed joint venture between Peabody Energy and Arch Resources. The court had to make a decision on the hypothesis H that the merger would significantly reduce competition, thereby violating the Clayton Act. To reach such a decision, the court also needed to assess, alongside other types of evidence, the model-based evidence provided by the contending parties.

The FTC presented the expert opinion of Dr. Nicholas Hill, who worked for the leading economic consulting group Bates White. The court was initially swayed by the market definition presented by the FTC's economic expert, who effectively argued for a narrow relevant market consisting of coal sourced from the Powder River Basin.¹⁷ With the relevant antitrust market established, the FTC needed to provide evidence that the merger would generate anticompetitive effects. The expert witness employed market-share evidence, highlighting a significant change in the Herfindahl–Hirschman Index (HHI) post-merger.¹⁸ Additionally, the expert estimated a Cournot model to quantify the anticipated competitive effects, including potential price increases resulting from the merger (see *infra* Section 4 for more details).

Defendants contested the evidence arising from the FTC's application of the Cournot model on several grounds, primarily arguing that it neglected dynamic risks, such as coal plant closures and the rise of renewable energy sources. Faced with a battle of experts over the appropriate modeling choices, the court opted not to delve deeply into the matter, stating:

This Court need not decisively sift through various models and theories. [...] The FTC's HHI analysis created a “presumption...that [the merger] will substantially lessen competition” by “showing that the [merger] will result in a significant market share and an undue increase in concentration.” (*Peabody*, 907)

Peabody is not an isolated case; similar expressions regarding the relative irrelevance of the evidence produced by economic models can be found in various cases litigated before US

17. The Powder River Basin is a geologic basin in southeast Montana and northeast Wyoming. Generally, the smaller the market, the easier it is for the plaintiff to demonstrate potential anticompetitive effects, making a narrow market definition a strong starting point in a competition case.

18. The Herfindahl-Hirschman Index (HHI) is a common measure of market concentration that varies from 0 to 10000. It is calculated squaring the market share of each firm competing in the market and then summing the resulting number. In Section 4 *infra*, I further discuss market concentration measures in contrast to model-based evidence.

federal courts. For instance, in *FTC v. Tronox*, after evaluating the empirical models proposed by competing experts, Judge McFadden remarked:

While the Court found them [empirical models] ultimately consistent with the other evidence presented by the plaintiff’s economic expert, his [model-based] analysis was not dispositive on either the relevant market or the likelihood that the merger will increase market concentration.¹⁹

The court’s reluctance in *Tronox* reflects a broader trend in antitrust litigation, where judges often avoid choosing between the economic models presented by the plaintiff and the criticisms raised by the defense. In fact, the courts in both *Peabody* and *Tronox* explicitly continued a legal precedent established in *Sysco*, which determined that courts should not decide which economic model is most appropriate for the case.²⁰

To be sure, a more in-depth empirical study would be needed to fully understand the actual influence of economic models on court verdicts. What I aim to highlight here is that the case law presented, coupled with the ongoing debate over the use of economic models in antitrust litigation, suggests a risk that model-based evidence may be irrelevant in the sense defined here – that is, failing to make any meaningful impact on a judge’s confidence in a target hypothesis. If the evidence produced by economic models fails to significantly influence judicial decision-making, their continued use becomes difficult to justify, especially given the increased financial and cognitive costs borne by judges and jurors. In this way, the foundational premise justifying the transfer of economic models in courts of law is undermined.

4 The paradox of neutralized model-based evidence

The examples presented in the previous section suggest that it is not uncommon that evidence produced by economic models is irrelevant in court rulings when it comes to competition cases. However, many legal proceedings are hindered by an even deeper problem: in the absence of model-based evidence, court verdicts can be significantly flawed the remaining evidence that becomes dispositive for the decision is often weaker and less reliable. In these instances, scientific models, which are supposed to strengthen the evidentiary base of judicial decision-making, are effectively “neutralized”. Instead of contributing to better judicial decision-making, these models end up shielding weaker and less reliable evidence. I refer to this phenomenon as the “paradox of neutralized model-based evidence”, in which the very epistemic tools that

19. *FTC v. Tronox Ltd.*, 332 F.Supp. 3d 187 (D.D.C. 2018).

20. *FTC v. Sysco Corp.*, 113 F. Supp. 3d 1 (D.D.C. 2015) (“Sysco”). For another example of the irrelevance of model-based evidence in court verdicts, see the opinion issued by Judge Victor Marrero in *New York v. Deutsche Telekom AG*, 439 F. Supp. 3d 179 (S.D.N.Y. 2020). There, he argued that the parties’ efforts were reduced to “imprecise and somewhat suspect aids: competing [sic] crystal balls” (188). “The parties’ costly and conflicting [...] economic [...] models,” he wrote, “along with the incompatible visions of the competitive future their experts’ shades-of-gray forecasts portrayed, essentially canceled each other out as helpful evidence the Court could comfortably endorse as decidedly affirming one side rather than the other” (*ibid.*, 187).

are meant to improve judicial decision-making are sidelined, potentially leading to poorer decisions. This paradox challenges the second premise that justifies model transfer outside academia, namely, that transferring these scientific models is beneficial for the affected environment.

4.1 Model-based and index-based evidence

To understand what happens in those legal cases where model-based evidence becomes irrelevant, I propose to distinguish between *model-based evidence* and what I will refer to, for lack of a better term, as *index-based evidence*. I have already defined model-based evidence as any evidence derived from economic models, primarily through the structural estimation of industrial economics models. Index-based evidence differs from model-based evidence along three key dimensions: 1) reliance on scientific models, 2) complexity, and 3) internal reliability. In particular, index-based evidence does not rely on scientific models, is simpler than evidence produced by a model, and is less internally reliable than evidence produced by a scientific model.²¹

First, index-based evidence does not rely on scientific models but, as the name implies, on simple arithmetic indices. A key example is the use of market concentration measures, which are derived from observable data such as market shares. For instance, the n -firm concentration ratio shows the combined market share of the largest n firms.²² Another example, which we have already encountered, is the Herfindahl-Hirschman Index (HHI). These measures are based on the assumption that markets with fewer firms are less competitive. This assumption stems from the idea that competition flourishes when there are many buyers and sellers, making it harder for any single firm to control prices. Thus, markets dominated by a few large firms are often interpreted as exhibiting reduced competition.

Second, index-based evidence is generally simpler than model-based evidence, as it usually relies on basic arithmetic calculations that are easy to compute and understand, even for non-experts. For example, the Herfindahl-Hirschman Index (HHI), one of the most commonly used market concentration measures, is a normalized index that can be calculated once market shares are known. In contrast, model-based evidence requires the use of complex economic models and statistical techniques to generate results that can be used as evidence, making this kind of evidence more sophisticated and less accessible to laymen such as judges and jurors.

Third, model-based evidence is generally regarded as more internally reliable within the relevant scientific community than other kinds of evidence. Economists typically agree that

21. The distinction between model-based and index-based evidence does not exhaust the kinds of evidence that scientific experts might employ in principle. For example, economists routinely accept other types of evidence, such as randomized controlled trials (RCTs), quasi-experimental empirical research, and laboratory experiments, in their academic work. However, I do not explicitly consider these types of evidence here, as they are generally not central in the context of legal proceedings (Einav and Levin 2010).

22. For example, in a market where the three largest firms, A, B, and C, hold market shares of 50%, 30%, and 10% respectively, the 3-firm concentration ratio would be 90% (i.e., 50% + 30% + 10%).

inferences drawn from model-based evidence are more trustworthy than those based on index-based evidence. In particular, although concentration measures are relatively simple to calculate and understand, economists broadly agree that a basic calculation of market concentration based on indices does not yield reliable conclusions about market competitiveness. This is because high concentration can also result from competitive market dynamics, rather than from anticompetitive behavior or reduced competition.

Harold Demsetz (1973, 1982) famously introduced the concept of “concentration through competition,” arguing that concentration is not necessarily a sign of reduced competitiveness but can instead reflect successful entrepreneurial efforts. He noted that “if rivals seek better ways to satisfy buyers or to produce a product, and if one or a few succeed in such endeavors, then the reward for their entrepreneurial effort is likely to be some (short-term) monopoly power, and this may be associated with increased industrial concentration” (1973, 3).

Overall, market concentration is widely recognized by economists as, at best, a rough indicator of an anticompetitive behavior. For this reason, economists agree that index-based evidence should not be relied upon in isolation for court verdicts in competition cases (e.g. Berry, Gaynor, and Morton 2019; Carlton and Israel 2021; Fisher 2008; Syverson 2019).²³

With the distinction between model-based and index-based evidence in mind, let us go back to the paradox of neutralized model-based evidence. To illustrate the paradox, a toy example involving a judge’s decision on whether to approve a merger between two companies (or, equivalently, on the hypothesis H : “The proposed merger is anticompetitive”) should be useful. The plaintiff’s economic expert calculates the market shares before and after the merger, demonstrating that the already concentrated market will become even more concentrated. In doing so, she provides index-based evidence supporting the hypothesis H , indicating a potential presumption that the merger could be anti-competitive, leading to higher prices for consumers.

In addition, the economic expert constructs an empirical model to predict the price increases resulting from the merger, effectively assessing its actual impact on end consumers. The results of this model constitute the model-based evidence in this case. Suppose now that the defendants raise objections to the model and its results, questioning the quality of the data used for parameter estimation and the underlying theoretical assumptions. To counter the plaintiff’s case, the defense’s economic expert proposes an alternative empirical model, perhaps based on a different theoretical framework or utilizing different data. This alternative model yields results used as model-based evidence that contradict the model-based evidence provided by the plaintiff.

Faced with competing model-based evidence from both sides, the judge may opt not to de-

23. It is important to note that the distinction between model-based and index-based evidence simplifies a more complex spectrum. In practice, evidence varies in the degree to which it relies on a theoretical framework, with some types of evidence drawing more heavily on scientific models than others. However, for the purposes of this article, this dichotomy will serve as a useful working framework. What is crucial for my argument is merely that contemporary economics suggests that index-based evidence, when considered in isolation, is unreliable for assessing competition and should not be the sole basis for competition policy decisions.

termine which evidence is more credible, effectively sidelining the model-based evidence altogether. What remains is the index-based evidence (such as an increase in market concentration post-merger), which becomes the sole basis for the court’s verdict. As a result, model-based evidence, derived from the application of economic models, is effectively neutralized in that it does not have any effect on the hypothesis and thus merely serves to “protect” index-based evidence. This is a serious problem for the transfer of models into the courtroom: the evidentiary base of the decision relies solely on evidence that, when considered in isolation, is regarded as less reliable or even misleading, since market shares alone may not accurately reflect the competitive conditions of the market.

This toy example starkly illustrates the paradox of neutralized model-based evidence: despite the introduction of sophisticated economic models intended to clarify and improve the court verdicts in competition cases, ultimately it is the reliance on index-based evidence – recognized as very fragile and unreliable – that often prevails. In such cases, economic models do not provide any evidential support for or against a hypothesis; instead, the evidence they produce become neutralized, serving primarily to protect the weaker, index-based evidence.

4.2 An example: *Federal Trade Commission v. Peabody Energy Corporation* (2020)

To illustrate a real legal dispute where the paradox of neutralized model-based evidence is particularly evident, let us revisit the *Peabody* case, which we have briefly touched upon in Sections 2 and 3. Here, we will examine the expert testimonies in more detail. To recall, *Peabody* was a legal dispute dating back to 2020, concerning whether an attempted merger between two coal mining companies, Peabody Energy and Arch Resources, violated US antitrust laws. In an effort to influence the court’s judgment, the FTC employed both index-based and model-based evidence in a stepwise manner.

First, the FTC’s economic expert defined a relevant market for studying the anticompetitive effect of the merger. Second, the expert calculated the variation in market concentration before and after the merger using the HHI. The variation in market shares within the relevant market constitutes what I have defined as index-based evidence. Finally, economic models were employed to quantify the likely competitive effects of the merger on some key variables, typically prices and output.

This is how the court summarizes Dr. Hill’s expert testimony and the evidence he provided:

In support of its prima facie case, the FTC makes a market share argument based on the HHI, which it then supports with evidence of head-to-head competition between Peabody and Arch [...]; and argument that just such a price increase is likely from the proposed JV [Joint Venture]. (*Peabody*, 902)

Dr. Hill calculated that the two companies had a combined market share of 68% as measured

by production volumes. Moreover, he computed the HHI using 2019 mine production data and found that the merger would increase the HHI by 2258 points to 4965. To recall, the HHI is a normalized index that ranges from 0 to 10,000, and the higher the number, the more concentrated the industry. From the court's perspective, such an increase in the HHI index "creates, by a wide margin, a presumption that the merger will lessen competition." (*ibid.*, 903)

Eventually, to provide further evidence to support its case, the FTC's expert employed a Cournot model, a standard model from industrial economics that describes an oligopoly market where firms produce a homogeneous product at constant marginal costs and compete by choosing the quantity of output they produce. Accordingly, the plaintiff's expert modeled the market as one in which a few coal mining companies (including the two merging companies, Peabody Energy and Arch Resources) compete with each other, offering similar products and having similar cost structures.²⁴ Applying the Cournot model using available data on prices, quantity, and demand substitution patterns, the plaintiff's expert argued that if the merger were allowed, it would cause "significantly higher prices for SPRB [Southern Powder River Basin] coal over the next ten years, causing total harm with a net present value of over \$1 billion." (*ibid.*, 906). The plaintiff argued that the model results constituted solid evidence that "the parties' [...] claimed marginal cost efficiencies" would not prevent the joint venture from "substantially reducing competition, raising prices, and harming consumers." (*ivi*).

The defendants, with the help of their own economic experts, attacked the application of the Cournot model by the plaintiff's expert witness. The first allegation was that Dr. Hill's model did not incorporate dynamic risks. Their argument was that, given the growth of renewables in recent years, the coal industry would likely face a rapid decline in demand as consumers switch to renewable energy. An economic model that does not include such considerations, the defendants argued, is bound to overestimate the harm caused by the merger. Broadly, their critique was that the plaintiff's model did not reflect the actual properties of the coal industry under examination, and therefore could not provide solid evidence that should influence the court's decision.

The court discusses the use of the Cournot model by the plaintiff and the critiques raised by the defendant over several pages, including some variations in the plaintiff's model that produced opposite results. However, in its written verdict, the court decisively states that it does not take a position on the model-based evidence, that is, the evidence that results from applying economic models – in this case, to predict the merger's effect on prices. "This Court," we read, "need not decisively sift through various models and theories." (*ibid.*, 907) Thus, model-based evidence did not play a role in the court's verdict; it was irrelevant as it did not alter the judge's hypothesis about the competitiveness of the merger.

Yet, the court verdicts does not stop there. It goes on to state: "The FTC's HHI analysis created a 'presumption [...] that [the Joint Venture] will substantially lessen competition by 'showing that the JV [Joint Venture] will result in significant market share and an undue in-

24. For a textbook treatment of the Cournot model, see Tirole (1988).

crease in concentration' in the SPRB [Southern Powder River Basin] coal market.” (ivi) The conclusion is clear: setting aside the model-based evidence, what remains is the index-based evidence in the form of market share and the increase in the HHI. This, and this alone, appears to be the decisive factor behind the court’s decision to block the merger.

5 Scientific models in the adversarial system

The irrelevance of the evidence produced by economic models and the paradox of neutralized model-based evidence fundamentally undermine the justification for transferring economic models into the courtroom. According to the standard rationale for applying scientific models outside the academic context, this justification relies on the belief that such models can not only impact, but also meaningfully improve judicial decision-making. However, when models are neutralized, their role paradoxically shifts from enhancing the quality of judicial analysis to protecting weaker and less reliable index-based evidence.

To see the consequences the above analysis and why it matters for philosophy of science, let us return to the question posed in the title of the article: is the transfer of economic models into legal proceedings a failed promise? In light of the previous discussion, at least two interpretations are possible. The first one emphasizes that the neutralization of model-based evidence may reflect a proper feature of the adversarial system’s design in legal disputes. The second one suggests courts misinterpret what economic models can bring to the fore. Let us examine the two interpretations in turn.

In the Anglo-American common law system, which is the focus of my analysis, disputes are resolved through the so-called *adversarial system*, in which parties present their cases in a public forum before independent judges.²⁵ Each party hires its own lawyers and potentially also scientific experts to present a partisan view of both the law and the facts. In principle, the goal of the adversarial system is to reveal the procedural “truth” through the clash of opposing and self-interested views, presented on an equal footing. The paradox of neutralized model-based evidence can be understood as follows: it is *exactly* the mutual neutralization of economic models during the adversarial process that reveals a particular “truth” – namely, that model-based evidence is irrelevant for resolving the specific case at hand. Thus, according to this interpretation, the neutralization of economic models is not a flaw but a deliberate feature of the adversarial system in common law.

Clearly, this interpretation casts a rather grim light on the epistemological status of economic models. In practice, the epistemic tools typically used in academic contexts do not withstand the highly-competitive scrutiny of the courtroom and the counterarguments from the opposing parties. Economic models may be employed and *are* employed in competition cases,

25. The adversarial system may be contrasted with the inquisitorial system used in many European countries, in which the judge has a much more active role in directing the case and often makes inquiries, calls and examines witnesses and generally determines the matters that the court will decide.

but they often lack the strength to provide dispositive evidence for adjudicating legal disputes. What remains are simple, often inadequate, market concentration metrics that nonetheless frequently succeed in persuading judges to lean one way or another in relation to the plaintiff's claims. In some sense, this is not new to philosophers of economics, who have long highlighted the open issues surrounding the use of economic models for explanatory, predictive, or policy-related purposes (e.g., Aydinonat 2018; Hoover 2023; Jhun 2021; Mäki 2018; Rodrik 2015). The key difference here lies in the institutional setting, which exacerbates these challenges: economic models, being fragile objects, are further exposed to these vulnerabilities in the adversarial environment of the courtroom (see also Giocoli 2020, Peruzzi 2023; Peruzzi and Cevolani 2024).

A second, more charitable interpretation is less critical of economics and more critical of judicial behavior. On this interpretation, the irrelevance of economic models and the paradox of neutralized model-based evidence result from courts' misreading of the information or evidence that can be derived from applying economic models. Consider again an economic model used to predict the price effects of a merger between two companies. Upon reflection, this is a problem of enormous complexity with many degrees of freedom, as acknowledged by economists and practitioners (see, e.g., Miller and Sheu 2021; Panhans and Taragin 2023). Even assuming the appropriate theoretical model has been chosen to describe the market in question, there is still the problem of having reliable data to estimate or calibrate its parameters. Assuming the right model and good data are available, the issue then arises regarding functional forms for estimating, say, a demand system. Simpler functional forms impose more structure on consumers' product substitutions, but require fewer data and are easier for judges to understand. More complex functional forms impose fewer unrealistic assumptions about product substitution, but require more data and are harder to interpret.

Even after overcoming these hurdles, a significant challenge remains for economic expert witnesses: model results, which constitute model-based evidence, often fail to account for many factors that could influence a given market after a merger. Recall the *Peabody* case, where the defendant's economic expert argued that the growing renewable energy sector would reduce demand in the coal market. If this is not considered, the predictions from the model could be completely off. All of this suggests that the application of economic models, even when rigorously performed, remains a problem of immense difficulty, at least in the context of competition cases.²⁶

Although this second interpretation is more charitable toward the scientific status of economic models, it raises significant concerns about the quality of legal decisions in competition cases. Courts that base their verdicts solely on index-based evidence fail to reflect the current status of academic economic research: such evidence cannot reliably support inferences about

26. For an extensive analysis of the obstacles to using economic models in competition policy from the perspective of practitioner economists, see Asker and Nocke (2021), Budzinski and Ruhmer (2010), Miller and Sheu (2021), and the classic articles by Fisher (1980, 1986).

the level of competition in a market. As we have seen, this concern has been raised repeatedly by prominent economists and experts in competition economics. For instance, Franklin Fisher points out that “it is a mistake – and sometimes a major error – to concentrate only on market share in an analysis of monopoly or market power. Market share measures, even when properly done, provide only a crude guide. They ought not to be treated as a ‘bright-line test.’” (2008, 139) Echoing Fisher, Dennis Carlton and Mark Israel recently claimed that “the Demsetz critique does mean that using thresholds that are based on the level of HHI to determine the level of competition is questionable at best.” (2021, 218) In light of these considerations, I contend that what should be viewed with suspicion (index-based evidence) is elevated to dispositive evidence, while what could yield more reliable inferences (model-based evidence) is overlooked. Therefore, as it stands, it is difficult to assert that employing economic models in this manner enhances the decision-making process of the courts.

These two interpretations of the paradox of neutralized model-based evidence likely capture part of the truth. I argue that, taken together, they show why economic models often fail to improve judicial decision-making: both because they lack the necessary resources to provide the type of evidence courts require, and because courts demand more than economic models can reasonably offer.

6 Concluding remarks

Philosophers and historians of science are increasingly interested in the epistemic and practical problems involved in transferring and applying scientific models in non-academic contexts. Crucially, the transfer of scientific models in legal proceedings has been severely neglected. As I have argued in this article, the use of economic models in courts of law faces specific challenges that raise doubts about their effectiveness and usefulness in legal proceedings. Given these challenges, it is, at best, uncertain whether transferring scientific models into the courtroom is truly justified.

This article represents only an initial step toward understanding how scientific models are, and possibly should be, employed in court proceedings, but much more work remains for philosophers of science. In conclusion, I will address two important open research problems related to the topic of this article.

First, the analysis here is likely not limited to economic modeling or competition cases. In principle, the paradox of neutralized model-based evidence applies to any situation in which model-based evidence is effectively discarded during the adversarial process, leaving weaker and less reliable evidence to dominate court verdicts. This paradox could arise with other types of scientific models used in the courtroom, such as forensic models (e.g., ballistic or bloodstain pattern analysis), psychological models (e.g., risk assessments or mental state evaluations), or financial models (e.g., estimating damages in patent or fraud cases). Thus, a promising direction for future research is to explore whether scientific fields with a stronger consensus on

reliable methods of obtaining evidence, such as DNA or fingerprint analysis, are less prone to neutralization.

A second avenue for future research is to examine the relationship between the courtroom setting and recent debates in the philosophy of science regarding the use of multiple models for policy guidance (e.g., Aydinonat 2018; Grüne-Yanoff and Marchionni 2018; Morrison 2011; Parker 2010, 2011; Roussos, Bradley, and Frigg 2021; Zanetti 2024). In particular, philosophers could work on identifying remedies to make scientific models more relevant in court verdicts. One such remedy could involve methods like model averaging or robustness analysis to handle conflicting models presented by the parties' experts in the trial. In the model averaging approach, judges could be required to average conflicting model-based evidence instead of simply discarding it altogether.²⁷ Similarly, robustness analysis might suggest that judges focus on model results that are robust across expert testimony.²⁸ In any event, further work is needed to align these perspectives from philosophy of science, which have largely focused on policy guidance, with the adversarial nature of legal proceedings.

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27. More sophisticated methods that model averaging exist, but the core idea of leveraging model ensembles in the face of uncertainty remains the same (Roussos, Bradley, and Frigg 2021; Zanetti 2024).

28. The epistemic value of robustness analysis varies among authors. See, for instance, Liscianra and Korbmayer (2021), Kuorikoski, Lehtinen, and Marchionni (2010), Lloyd (2015), Odenbaugh and Alexandrova (2011), and Woodward (2006).

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