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ARTICLE

Prospects and Limits of Merger Simulations as a Computational Antitrust Tool

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Abstract. Computational antitrust is gaining high attention from competition authorities worldwide. In this paper, we examine the promises and downsides of merger simulations as a tool of computational antitrust. In doing this, we first provide an overview of the working mechanisms of the merger simulation tool and then evaluate its implementation in competition policy, including the question of whether more sophisticated technologies would change analysis. We consider perspectives from industrial economics, institutional economics, and political economics. The results of the analysis show that institutions matter to reap considerable prospects of merger simulations as a computational antitrust tool.

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I. Introduction

With the advancement of technologies and the availability of larger sets of data in the digital era, questions on the adaptation of the toolbox and better integration of the promises of the new technologies into the work of competition authorities are gaining popularity.[1] From the three main areas of competition policy and antitrust law, namely (i) combating cartels, (ii) countering abuses of dominant position, (iii) merger control, in this paper we address the case of merger control. Specifically, we discuss the application of merger simulation models during a merger review. In this article, we aim to shed light on the potential promises and downsides of merger simulation as a tool of computational antitrust – particularly with respect to more advanced and more sophisticated computational methods (for instance, artificial intelligence (AI) or self-learning systems).

To do so, we first provide a non-technical introduction to the mechanisms of merger simulation as a computational antitrust policy tool and an overview of its past applications (Section II). Then, we discuss four topics that we think play essential roles regarding the use of merger simulations in merger control cases: (i) the hypothetical effectiveness of predictive merger simulations (industrial economics reasoning), (ii) their actual effectiveness (institutional economics reasoning tackling the law and economics interface), (iii) the costs and benefits for competition authorities (economic policy reasoning), as well as (iv) the prospects of an ex-post use (controlling economics reasoning) (Section III). In all four discussions, we place a special emphasis on an outlook on what and how advancements in computational methods and powers are likely to alter the respective assessments in the (near) future (also Section III). Eventually, we conclude that the promises of merger simulations as a computational tool of competition policy are significant. However, institutions matter when it comes to reaping these potentials for actual merger control cases – and this presented and still presents the main issue of their use. Furthermore, more systematic use of merger simulations for ex-post analyses would be fruitful (Section IV).

II. Merger Simulations as a Tool of Computational Antitrust

Merger simulation is a tool of computational antitrust which applies advanced economics and econometric methods in order to quantitatively predict post-merger effects based on assumptions of pre-merger situations (shape of demand and form of competition). This tool is applied in ex ante competition policy (merger control), but it is also connected with ex-post econometric analysis since merger simulation models (MSM) are calibrated based on past data in order to estimate the accuracy of the assumptions of the competition model and the demand function. More precisely, merger simulations usually aim to predict effects on market prices and quantities as well as on consumers' and producers' rents,[2] but can also include predictions of product variety and other relevant factors of competition.

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[1] For potential tasks of computational antitrust, *see* Daryl Lim, *Can Computational Antitrust Succeed?*, STANF. COMPUTATIONAL ANTITRUST 38–51, 40 (2021).

[2] Luke M. Froeb & Gregory J. Werden, *An introduction to the symposium on the use of simulation in applied industrial organization*, 7 INT. J. ECON. BUS. 133–137, 134 (2000); Oliver Budzinski & Isabel Ruhmer, *Merger simulation in competition policy: A survey*, 6 J. COMPETITION L. ECON. 277–319 (2010).

At the beginning of 2010, MSM were still a new and developing instrument.[3] One could expect that in the last decade, the promises of this tool were more widely recognized and that the tool was further developed. The main underlying reasons for increased attention to MSM mostly still hold true today or are even reinforced by recent developments:

1) progress in industrial economics with its detailed analysis of the impact of mergers on welfare;[4]
2) progress in calculation methods and computation techniques that has led to the possibility of more complex simulations which process more real-world data;[5]
3) technological progress that has further increased the availability of market data, which is required for identification and calibration of model parameters, like for instance, the data from scanner cash points (based on bar codes, QR codes, or radio frequency identification labels (RFID-labels) which contain even more product characteristics),[6] different sensors in the data-based industry ("smart production"),[7] data-based digital ecosystems collecting and (algorithm-based) processing whole new dimensions of user data,[8] etc., thereby helping a deeper assessment of patterns in consumer choice;
4) focus on innovative economic tools for competition policy. It was especially popular in both largest antitrust regimes in the world (the United States and the EU) and in academic world during 1990s and 2000s.[9] Since then not the interest in, but rather the role of economics has changed from offering an analytical framework and ensuring sound policy-making, to providing support for initiatives leading to reforming the system.[10]

However, whether tools such as MSM gained even more popularity in recent years cannot be evaluated without additional research and a review of both literature and antitrust cases. First, we start with presenting an updated overview of models used for simulations; then we check their application in literature and in cases of merger review.

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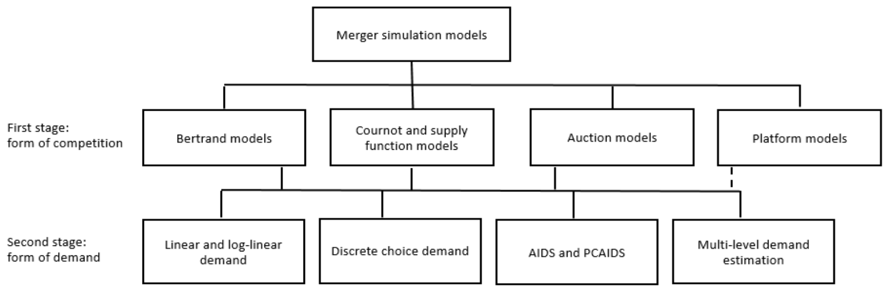
[3] Budzinski & Ruhmer, *supra* note 2.
[4] *See* for instance the excellent overview by PAUL BELLEFLAMME & MARTIN PEITZ, INDUSTRIAL ORGANIZATION: MARKETS AND STRATEGIES (2015).
[5] Budzinski & Ruhmer, *supra* note 2.
[6] *See*, *inter alia*, Jerry A. Hausman & Gregory K. Leonard, *Economic analysis of differentiated products mergers using real world data*, 5 GEO. MASON L. REV. 321 (1997); Roy J. Epstein & Daniel L. Rubinfeld, *Merger Simulation: A Simplified Approach with New Applications*, 69. ANTITRUST L. J. 883 (2001).
[7] *See*, *inter alia*, Claudio Feijóo, José-Luis Gómez-Barroso & Shivom Aggarwal, *Economics of big data*, *in* HANDBOOK ON THE ECONOMICS OF THE INTERNET 510 (2016); Dusit Niyato et al., *Economics of Internet of Things: An information market approach*, 23 IEEE WIRELESS COMMUNICATIONS 136 (2016).
[8] *See*, *inter alia*, Oliver Budzinski, Sophia Gaenssle & Nadine Lindstädt-Dreusicke, *Data (R)Evolution – The Economics of Algorithmic Search & Recommender Services*, *in* Handbook of Digital Business Ecosystems 349 (S. Baumann ed., 2022); Oliver Budzinski & Björn A. Kuchinke, *Industrial Organization of Media Markets and Competition Policy*, *in* 21 MANAGEMENT AND ECONOMICS OF COMMUNICATION 21 (M. B. von Rimscha ed., 2020)
[9] *See*, *inter alia*, Jonathan B. Baker, *Policy watch: Developments in antitrust economics*, 13 J.ECON. PERSPECT. 181 (1999); Damien J. Neven, *Competition economics and antitrust in Europe*, 21 ECON. POL'Y 742–791 (2006); Lars-Hendrik Röller, *Economic analysis and competition policy enforcement in Europe*, *in* MODELLING EUR. MERGERS. THEORY, COMPETITION POL'Y AND CASE STUDIES 11 (2005); Arndt Christiansen, *The "more economic approach" in EU merger control*, 7 *in* CESIFO FORUM 34 (2006); Joseph F. Brodley, *Post-Chicago Economics and Workable Legal Policy*, 63 ANTITRUST L. J. 683 (1995).
[10] *See*, *inter alia*, Pablo Ibáñez Colomo, *Whatever Happened to the 'More Economics-Based Approach'?*,11 J. Eur. Compet. L. Prac. 473 (2020).

For a brief overview of existing MSM, we modify and adapt the framework offered in previous literature,[11] introducing the delineation of the relevant input parameters for any MSM, namely form of competition and form of demand (see Figure 1). In theory, following forms of competition are applied for analysis: Bertrand models (price competition in heterogeneous markets), Cournot and supply function models (quantity competition in homogeneous markets), auction models,[12] and platform models.[13] Among forms of demand, frequently applied models are linear and log-linear,[14] discrete choice demand,[15] almost ideal demand system (AIDS) and proportionality-calibrated AIDS (PCAIDS),[16] or multiple-step demand (in the case of platform markets for each platform side)[17].

Figure 1. Classification Scheme for MSM.



Source: modified from Oliver Budzinski & Isabel Ruhmer, *Merger simulation in competition policy: A survey*, 6 J. COMPETITION L. ECON. 277, 283 (2010).

Our modifications highlight that for the application of MSM, various demand models could be combined with different competition models. Furthermore, (competition on) platform markets have become part of the simulation portfolio.[18] Regardless of the variety of types, most MSM have common underlying assumptions and could be described with a four-stage procedure. Firstly, a form of competition in the simulated market is described (one type of oligopoly model is selected, the most common one being Bertrand competition). For instance, in one of the first MSM cases, Interstate Bakeries/Continental Baking Co. (DOJ 1995),[19] the "relevant markets were the localized (in particular metropolitan areas) and brand-wisely differentiated markets for white pan bread."[20] Thus, the Bertrand

[11] Budzinski & Ruhmer, *supra* note 2 at 283.
[12] *Id.*
[13] David S. Evans & Michael D. Noel, *The analysis of mergers that involve multisided platform businesses*, 4 J. Competition L. Econ. 663–695 (2008); Lapo Filistrucchi, Tobias J. Klein & Thomas O. Michielsen, *Assessing unilateral merger effects in a two-sided market: an application to the Dutch daily newspaper market*, 8 J. J. Competition L. Econ. 297–329 (2012).
[14] Gregory J. Werden, *Simulating the effects of differentiated products mergers: a practitioners' guide*, PROC. NE-165 CONF. 95–110 (1997)
[15] Steven T. Berry, *Estimating Discrete-Choice Models of Product Differentiation*, 25 RAND J. ECON. 242–262 (1994); Aviv Nevo, *A Practitioner's Guide to Estimation of Random-Coefficients Logit Models of Demand*, 9 J. ECON. MGMT. STRATEGY 513–548 (2000); Aviv Nevo, *Mergers with Differentiated Products: The Case of the Ready-to-Eat Cereal Industry*, 31 RAND J. ECON. 395–421 (2000);
[16] Angus Deaton & John Muellbauer, *An Almost Ideal Demand System*, 70 AM. ECON. REV. 312–326 (1980)
[17] Jerry Hausman, Gregory Leonard & J. Douglas Zona, *Competitive Analysis with Differentiated Products*, ANNALES D'ECONOMIE ET DE STATISTIQUE 159–180 (1994); Hausman & Leonard, *supra* note 6, at 321.
[18] See Evans & Noel, *supra* note 13, at 663–695; Filistrucchi, Klein & Michielsen, *supra* note 13, at 297–329.
[19] See details in Gregory J. Werden, *Expert Report in United States v. Interstate Bakeries Corp. and Continental Baking Co.*,7 INT'L J. ECON. BUS. 139 (2000); Budzinski & Ruhmer, *supra* note 2, at 296-298.
[20] Budzinski & Ruhmer, *supra* note 2, at 297.

competition model for differentiated products was applied. Secondly, the most appropriate form of demand is selected. In the case of Interstate Bakeries/Continental Baking Co., the supermarket scanner data was used to derive consumer demand, logit demand form was selected for predictions.[21] Thirdly, demand systems are calibrated based on pre-merger data. Lastly, the final full simulation takes place with respect to previous steps: based on calibrated models, the new post-merger situation is predicted. For the Interstate Bakeries/Continental Baking Co. merger a substantial increase of prices was predicted (5 to 10 percent for two firms involved, with the overall price increase between 3.1 percent in Chicago and 5.9 percent in Los Angeles).[22]

The decision on the adequate model type for a given real-world merger case is rather complicated, and research on models and model selection is ongoing.[23] Challenges associated with these steps are addressed in Section III.

For an overview of the current state of the development of MSM as a tool, we pre-selected publications where full MSM are performed (for both hypothetical and real mergers), and we structure them in the Table 1 (without claiming to be exhaustive). Each cell of Table 1 represents sources where the combination of the respective forms of competition and demand was used. Some papers compare outcomes of different methods and, therefore, are duplicated in the table. The outcomes are in line with theoretical considerations: Bertrand models and discrete choice demand models are leaders in the application. Generally, Bertrand models are used for heterogeneous goods, whereas Cournot models better suit rather homogeneous markets. Auction models and platform models are used in special settings displaying these features.

Table 1. Models Applied in Literature[24]

Stage 1 Stage 2	Bertrand models	Cournot and supply function models	Auction models	Platform models
Linear and log-linear demand (Werden 1997)	Carlton&Keating 2015; Weinberg&Hosken 2013	Greenfield et al 2015	-	Correia-da-Silva et al 2019 (with Cournot for both sides)
Discrete choice demand (Berry 1994; Nevo 2000a and b)	Björnerstedt&Verboven 2016; Bokhari et al 2018; Grigolon&Verboven 2014; Knittel&Metaxoglou 2011; MacKay&Remer 2021;	-	Miller 2014	Filistrucchi et al 2012 (with application of Bertrand model for both sides as in Evans&Noel 2008)

[21] Werden, *supra* note 19, at 139.
[22] *Id.*; Budzinski & Ruhmer, *supra* note 2, at 296-298.
[23] For an extended description of methods, see previous surveys: Budzinski & Ruhmer, *supra* note 2, at 278-296; Nathan H. Miller & Gloria Sheu, *Quantitative Methods for Evaluating the Unilateral Effects of Mergers*, 58 REV. INDUS. ORG. 143–177 (2021); Tommaso Valletti & Hans Zenger, *Mergers with Differentiated Products: Where Do We Stand?*, 58 REV. INDUS. ORG. 179–212 (2021).
[24] Papers that include analysis of real mergers are in bold; "-" means that models have not been applied in reviewed papers.

	Miller 2014; Miller&Weinberg 2017; Miller 2021; Nocke 2018; Weinberg&Hosken 2013; Weinberg 2011			
AIDS and PCAIDS (Deaton&Muellbauer 1980)	Bokhari et al 2018; Weinberg&Hosken 2013	-	-	-
Multi-level demand estimation (Hausman et al. 1994 and Hausman&Leonard 1997)	-	-	-	-

Sources[25]

Let us compare theoretical considerations with practice by different competition authorities, reported in Table 2. Please note that the list of cases and information on the specifications of models is hardly complete due to the limited availability of exact descriptions of all details of applied models. The Table aims to provide an overview of past cases of MSM applications without attempting to be exhaustive. If possible, information from case documents was complemented with additional sources.

[25] Gregory J. Werden, *Simulating the Effects of Differentiated Products Mergers: A Practitioners' Guide*, *in* STRATEGY AND POLICY IN THE FOOD SYSTEM: EMERGING ISSUES 95–110 (1997); Berry, *supra* note 18, at 242–262; Aviv Nevo, *A Practitioner's Guide to Estimation of Random-Coefficients Logit Models of Demand*, 9 J. ECON. MGMT. STRATEGY 513–548 (2000); Aviv Nevo, *Mergers with Differentiated Products: The Case of the Ready-to-Eat Cereal Industry*, RAND J. ECON. 395–421 (2000); Deaton & Muellbauer *supra* note 19 at 312–326 (1980); Hausman, Leonard & Zona, *supra* note 17, at 159–180; Hausman & Leonard, *supra* note 6; Dennis W. Carlton & Bryan Keating, *Antitrust, Transaction Costs, and Merger Simulation with Nonlinear Pricing*, 58 J. LAW ECON. 269–289 (2015); Matthew C. Weinberg & Daniel Hosken, *Evidence on the Accuracy of Merger Simulations*, 95 REV. ECON. STAT. 1584–1600 (2013); Jonas Björnerstedt & Frank Verboven, *Does Merger Simulation Work? Evidence from the Swedish Analgesics Market*, 8 AM. ECON. J. APPLIED ECON. 125–164 (2016); Farasat A. S. Bokhari & Franco Mariuzzo, *Demand Estimation and Merger Simulations for Drugs: Logits v. AIDS*, 61 INT. J. INDUSTRIAL ORGAN. 653–685 (2018); Laura Grigolon & Frank Verboven, *Nested Logit or Random Coefficients Logit? A Comparison of Alternative Discrete Choice Models of Product Differentiation*, 96 REV. ECON. STAT. 916–935 (2014); Christopher R. Knittel & Konstantinos Metaxoglou, *Challenges in Merger Simulation Analysis*, 101 AM. ECON. REV. 56–59 (2011); Alexander MacKay & Marc Remer, *Consumer Inertia and Market Power* (2021) (unpublished manuscript), http://alexandermackay.org/files/Consumer Inertia and Market Power.pdf; Nathan H. Miller, *Modeling the Effects of Mergers in Procurement*, 37 INT. J. INDUS. ORG. 201–208 (2014); Nathan H. Miller & Matthew C. Weinberg, *Understanding the Price Effects of the MillerCoors Joint Venture*, 85 ECONOMETRICA 1763–1791 (2017); Nathan H. Miller, Gloria Sheu & Matthew C. Weinberg, *Oligopolistic Price Leadership and Mergers: The United States Beer Industry* (2021) (unpublished manuscript), www.nathanhmiller.org/priceleadership.pdf; Volker Nocke & Nicolas Schutz, *An Aggregative Games Approach to Merger Analysis in Multiproduct-Firm Oligopoly* (Nat'l Bureau of Econ. Rsch., Working Paper No, 24578, 2018); Matthew C. Weinberg, *More Evidence on the Performance of Merger Simulations*, 101 AM. ECON. REV. 51–55 (2011); Daniel Greenfield, Nicholas Kreisle & Mark D. Williams, *Simulating a Homogenous Product Merger: A Case Study on Model Fit and Performance* (Fed. Trade Comm. Bureau Econ., Working Paper, 2015); Joao Correia-da-Silva et al., *Horizontal Mergers between Multisided Platforms: Insights from Cournot Competition*, 28 J. ECON. MGMT. STRATEGY 109–124 (2019); Filistrucchi, Klein & Michielsen, *supra* note 13, at 297–329); Evans & Noel, *supra* note 13, at 663–695.

Table 2. MSM in Practice[26]

Year Case	CA	Industry	Who prepared/ Specifications of model	Was MSM mentioned?/ Result of merger (Approved / Cleared under conditions/ Blocked/ Withdrawn)	Additional sources
1995 Interstate Bakeries/Continental Baking Co.	DOJ	Bread, Cake, and Related Products	DOJ (MSM by Werden)/ Bertrand competition and logit demand	No, due to mutual agreement outside the court/ Cleared under conditions	Werden 2000, Budzinski&Ruhmer 2010:296-298
1995 Kimberly-Clark/Scott Paper	DOJ	Paper Mills	Parties (Kimberly-Clark with MSM by Hausman&Leonard)/ Multi-level demand estimation	No, due to mutual agreement outside the court/ Cleared under conditions	Hausman&Leonard 1996, Budzinski&Ruhmer 2010:296-298
1996 Maybelline/Cosmair	DOJ	Cosmetics	DOJ/ Bertrand model	X/ Approved	FTC&DOJ 2006: 30-31, Miller&Sheu 2021
1997 Vail Resorts/ Ralston Resorts	DOJ	Amusement and Recreation, Hotels, Motels, and Tourist Courts Skiing Facilities	DOJ/ Bertrand model	X/ Cleared under conditions	FTC&DOJ 2006: 31
1999 Volvo/Scania	EC	Manufacture and sale of trucks, buses, construction equipment, and marine and industrial engines	EC (MSM by Ivaldi and Verboven)/ Nested logit model	Yes, in decision/ Blocked	Ivaldi&Verboven 2005, Budzinski&Ruhmer 2010:298-299

[26] CA - Competition authority; EC - European Commission; DOJ - U.S. Department of Justice; FTC - Federal Trade commission; DCCA - the Danish Competition and Consumer Authority; NMa - Nederlands Mededingingsautoriteit; CMA - Competition and Markets Authority, before 2014 the UK Competition Commission; MSM - merger simulation model; X - information is not available.

2001 General Mills/Pillsbury	FTC	Food manufactory	Merger simulation based on the elasticities calculated from the scanner data	No actions by FTC	FTC&DOJ 2006: 29
2003 Oracle/PeopleSoft	both the DOJ and the EC	Market of enterprise application software (EAS), database, and application server software	DOJ (MSM by McAfee)/English auction model The EC's expert team/Sealed-bid auction model	Yes, in both decisions, but in USA was rejected by court/ Approved	Budzinski & Ruhmer 2010:302-304
2003 Lagarde`re/Natexis/VUP	EC	Book publishing	EC (MSM by Foncel and Ivaldi)/ Bertrand and nested logit model	Yes, in decision/ Cleared under conditions	Budzinski&Ruhmer 2010: 299-300
2003 Nuon/Reliant	NMa	Energy utility	NMa (2 models-by external consultants from Energy Study Center and Frontier Economics) and party (MSM by Nuon's economic advisors)/ one used Cournot, another one applied set of different supply curves	Yes, in decision, but rejected by court / Cleared under conditions, but decision annulled by court	Maa&Zwart 2005, Budzinski&Ruhmer 2010:300-302
2003 Philip Morris/Papastratos	EC	Tobacco manufactory	Parties/ Nested logit simulation	Yes, in decision/ Approved	Walker 2005: 493-494
2006 Pan Fish/Marine Harvest	CMA	Salmon farming companies	Parties/ Cournot competition	Yes, in Final Report/ Approved	
2010 Unilever/Sara Lee	EC	Household and body care market	EC/ Two-stage nested logit model, series of simulations	Yes, in decision/ Cleared under conditions	Valletti&Zenger 2021: 187

2011 H&R Block/Tax ACT	DOJ	Digital Do-It-Yourself Tax Preparation Products/ Software Publishers	DOJ/ Bertrand merger simulation with linear demand	Yes, in Memorandum Opinion/ Blocked	Miller&Sheu 2021: at 173 Remer&Warren-Boulton 2014
2014 Telefónica Deutschland/ E-Plus	EC	Mobile telephony	EC/ Nested logit models	Yes, in decision/ Cleared under conditions	Buettner et al 2016; Valletti&Zenger 2021: 191
2015 Sysco/US Foods	FTC	Foodservice distribution	FTC (MSM by Israel)/ Auction framework	Yes, in Memorandum Opinion/ Blocked	Miller&Sheu 2021: 161
2015 TeliaSonera/Telenor	EC	Mobile telephony, Telecommunications	EC/ Nested logit models	Withdrawn	Valletti&Zenger 2021: 191
2015 Orange/ Jazztel	EC	Telecommunications	EC/ Bertrand merger simulation with a non-linear demand	Yes, in decision/ Cleared under conditions	Valletti&Zenger 2021: 187
2016 Aetna/Humana	DOJ	Direct Health and Medical Insurance Carriers	DOJ (MSM by Nevo)/ Nested logit demand	Yes, in decision/ Blocked	Bayot et al 2018 Nevo 2016
2016 Anthem/Cigna	DOJ	Direct Health and Medical Insurance Carriers	DOJ/ Auction model	Yes, in Memorandum Opinion/ Blocked	Miller&Sheu 2021: 161
2018 Tryg/Alka	DCCA	Insurance	DCCA/ Range of models used	Yes, in decision/ Cleared under conditions	The Danish Competition and Consumer Authority 2021: 6
2018 Wilhelmsen/Drew Marine	FTC	Marine water treatment chemicals and services used by global fleets	FTC (MSM by Nevo) / Auction model	Yes, in Memorandum Opinion, the judge relied on the expert testimony / Withdrawn	Miller&Sheu 2021: 161 Cornerstone research

Sources[27]

[27] Werden *supra* note 19, at 139; Budzinski & Ruhmer, *supra* note 2, at 277-319; Hausman & Leonard, *supra* note 6, at 321-346; Commentary on the Horizontal Merger Guidelines (2006) , https://www.ftc.gov/sites/default/files/attachments/.

From this brief review of practical applications, some trends can be distinguished:

1) Computational power to employ MSM in real-world cases started to be available to the parties already in the late 1990s. We see an increase in application around 2015, which is connected to a merger wave in telecommunication and insurance markets.
2) MSM are rarely performed by national competition authorities or by smaller competition authorities.[28]
3) There is a certain industry selection trend: MSM seem to be more widely used in industries such as telecommunication, insurance market, food sectors, which may be driven by data availability.
4) Incomplete information on the specifications of models used may be due to the fact that even if simulations were part of argumentation, they were rarely used as the main argument; thus, other essential parts are described in more detail than the settings of models.

Overall, we conclude that despite a promising shift in technological development, we cannot observe an enormous growth in the application of MSM. Thus, the following section will address questions emerging from such observation: what do MSM potentially and actually promise and what restricts their more extensive application.

III. Merger Simulation in Antitrust Practice: Prospects and Limits

In order to understand the role that merger simulations can play to benefit antitrust practice, we must consider and balance the prospects and limits of this instrument in merger control proceedings. Given the advances in computational power and methods,[29] we address the particular question of how more advanced and more sophisticated computational methods, compared to those available about a decade ago (especially AI, self-learning systems) can influence and change the relevance of merger simulations. In this section, we address four areas of reflection that should be considered when pondering the role of merger simulations in

merger-review/commentaryonthehorizontalmergerguidelinesmarch2006.pdf; Miller & Sheu, *supra* note 25; Marc Ivaldi & Frank Verboven, *Quantifying the Effects from Horizontal Mergers in European Competition Policy*, 23 INT. J. INDUS. ORG. 669–691 (2005); Jan de Maa & Gijsbert Zwart, *Modelling the Electricity Market: Nuon-Reliant*, *in* MODELLING EUROPEAN MERGERS 150–171 (Peter A. G. van Bergeijk & Erik Kloosterhuis eds., 2005); Mike Walker, *The Potential for Significant Inaccuracies in Merger Simulation Models*, 1 J. COMPETITION L. ECON. 473–496 (2005); Valletti & Zenger, *supra* note 23, at 179–212; Marc Remer & Frederick R. Warren-Boulton, *United States v. H&R Block: Market Definition in Court since the 2010 Merger Guidelines*, 59 ANTITRUST BULL. 599–618 (2014); Thomas Buettner, Giulio Federico & Szabolcs Lorincz, *The Use of Quantitative Economic Techniques in EU Merger Control*, 31 ANTITRUST 68 (2016); Denrick Bayot et al., *The Aetna-Humana Proposed Merger (2017)*, *in* THE ANTITRUST REVOLUTION: ECONOMICS, COMPETITION AND POLICY 24–44 (John E. Kwoka & Lawrence J. White eds., 2018), http://media.clemson.edu/economics/web/425/Aetna%20-%20Humana%20Proposed%20Merger%202017.pdf; Aviv Nevo, *Demonstrative Used in the Testimony of Aviv Nevo* (2016), https://www.justice.gov/atr/page/file/918706/download; The Danish Competition and Consumer Authority, *Economic analysis in Danish Merger Investigations* (2021), https://www.en.kfst.dk/media/wa4glcvr/20210706-economic-analysis-in-danish-merger-investigations.pdf; CORNERSTONE RESEARCH, *FTC v. Wilhelmsen et al.*, https://www.cornerstone.com/insights/cases/ftc-v-wilhelmsen-et-al/.

[28] Next to the United States and the EU, for instance, competition authorities in the UK, Denmark, and the Netherlands have performed MSM. See Table 1 for an overview.

[29] See, e.g. the discussion on improvement of computational merger review process in Anthony J. Casey & Anthony Niblett, *Micro-Directives and Computational Merger Review*, 1 STANF. COMPUTATIONAL ANTITRUST 132–152 (2021), on current topical research directions in Thibault Schrepel, *Computational Antitrust: An Introduction and Research Agenda*, 1 STANF. COMPUTATIONAL ANTITRUST 1–15 (2021), as well as the database with different legal technologies at https://techindex.law.stanford.edu/

antitrust practice: (A) the ability of merger simulations to yield better predictions of merger effects, (B) the fit of merger simulation results as economic evidence with the prevailing institutional settings of antitrust policy, (C) the costs and benefits for antitrust authorities, and (D) the special case of using merger simulations as a controlling mechanism for previous merger control decisions.

A. Better Assessment of Mergers

The fundamental promise of merger simulations is the improvement of the prediction of post-merger effects on competition and welfare. Since these post-merger effects are decisive for allowing, blocking, or modifying any notified merger project in virtually all merger control jurisdictions of the global economy,[30] this promise – if it can be satisfied – is extremely relevant for merger control. In the absence of merger simulations, merger control must rely on the expertise of two groups. Firstly, industry witnesses who are well informed about the mechanisms and competition structures of the markets in question but who are interest-driven and prone to distorted testimonies. Secondly, experts, possibly external to the industry (e.g., antitrust authority staff, academics), assess the merger based on figures like market shares or (perhaps) elasticities, all kinds of documents, and observations of the markets and the industries in question. While this evidence is highly valuable and indispensable for understanding the market as a precondition for creating predictions about the impact of the merger proposal on this market, it contains elements that are influenced by subjective views and interpretations – and depending on the cognitive framing (or specific vested interests), one may arrive at completely different predictions about the merger's effects. Quite regularly, the decision-making body (be it a court like in the United States or an administrative body like in the EU) will be confronted with different experts arriving at and advocating for contrasting and opposing merger assessments (see Table 2 for past examples).

The fascination of a more computational approach is at least partly based on the anticipation that a data-based, quantitative approach offers a neutral and more objective prediction about the merger's effects. Thus, it can reduce the ambiguity of merger control controversies and decisions by providing better assessments, leading to better decisions for competition and welfare. Hence, the first question arises: is the use of merger simulations hypothetically effective? Can merger simulations based on modern industrial economic theory and on precise data yield more accurate predictions about post-merger effects than other evidence? If this was not the case, it would be difficult to see the beneficial role of merger simulations in antitrust policy.

Obviously, more data processing power implies that more elaborated simulation models can be calibrated with real-world market data so that the simulation can provide a more fitting re-capture of the past market process of the

[30] On the international interplay of merger control regimes see e.g., OLIVER BUDZINSKI, THE GOVERNANCE OF GLOBAL COMPETITION: COMPETENCE ALLOCATION IN INTERNATIONAL COMPETITION POLICY (2008); Oliver Budzinski, *International antitrust institutions*, 1 OXFORD HANDBOOK INT. ANTITRUST ECON. 119-146 (2015); Oliver Budzinski, *The economics of international competition policy: New challenges in the light of digitization?*, 26 ILMENAU ECON. DISCUSSION PAPER 1–18 (2020).

market in question, i.e., the model performs well in accurately predicting any past developments of the market at any point within the past process. This calibration, which sensitively depends both on modeling and data-processing/-analyzing capacities and competencies, satisfies the promise of using more computational methods as it reduces the scope to introduce opinions, interests, and beliefs (which would reduce the fit in mirroring the real past developments). Note, however, that data availability may remain a problem, even with more computational power available. While fundamentally more elaborated simulation models yield valuable insights helping to understand the impact of the merger and will definitely contribute to improving predictions about post-merger effects, some limits to the applicability to different types of merger cases, as well as to the precision of results restricted the use of merger simulation in the 2000s:

- By the 2010s, the use of merger simulation models was mostly limited to horizontal mergers, which could be adequately described by not-too-complex extensions of game-theory models of standard oligopoly competition. Complex non-horizontal mergers like those within digital ecosystems or between multi-product companies involving relevant vertical or conglomerate effects were predominantly outside the scope of feasible simulations. During the last decade, advances in computational powers and methods have eased this restriction, for instance, in the form of the application of simulation-like methods, including bargaining models (see the model on the AT&T/Time Warner case[31] and the comparison of seven theoretical settings for bargaining models for vertical merger simulations).[32] Still, simulation models cannot capture the degree of complexity of real-world markets.
- Another limitation relates to the way predictions about post-merger effects are derived in merger simulations. As mentioned above, data-based merger simulation models are calibrated to mirror the hitherto competition dynamics in the market. Then, the simulation is based on extrapolating these dynamics from the pre- to the post-merger market but with two formerly independent companies now treated as one entity, i.e., the competition between the merging companies being omitted. Given the theoretical background of the model, a new post-merger strategy equilibrium (Nash equilibrium) is calculated, and welfare effects are derived. One can expect this to yield an impressively precise prediction as long as the underlying assumption remains true, namely that the fundamental structure of the competition dynamics in the market is not shattered by the merger. This assumption is probably a very good fit for many mergers. However, especially mega-mergers, as well as mergers that significantly influence the competitive landscape of the market, are likely to cause structural breaks and changes in the way "competition is played" in that market. Empirically, the minority of merger cases belongs to this second category. However, these are exactly those cases that are critical for merger control decisions and for protecting the competitive process. The

[31] Carl Shapiro, *Vertical Mergers and Input Foreclosure: Lessons from the AT&T/Time Warner Case*, 59 REV. INDUS. ORG. 303–341 (2021).
[32] Willem H. Boshoff et al., *Bargaining Competition and Vertical Mergers*, (Ctr. Competition L. Econ., Working Paper No. 012021, 2021) http://blogs.sun.ac.za/ccle/files/2021/04/WPS012021.pdf.

precision of merger simulation predictions is significantly decreased if structural breaks occur.

- Due to structural breaks and generally any deviation of the patterns from the past becoming more and more probable in the course of time, merger simulations are much better suited to predict short-run effects than mid- to long-run effects. They share this characteristic with all other types of evidence, so it is not really an instrument-specific limitation. The unpredictable nature of innovation alone implies that mid- to long-run predictions cannot be precise. Furthermore, the probability and effects of external shocks to the market in question, i.e., the evolution of the market environment, come more and more into play.
- The latter leads to a more philosophical but fundamentally relevant issue: the uncertainty of the future. If the world is not deterministic, i.e., if the future is not fully predetermined (by what- or whomever), then there are fundamental limits to precisely predicting the future – simply because the future does not exist now and will only be created (in contrast to just discovered) when it takes place. This general statement can be broken down into the competitive process, which serves as a decentralized coordination mechanism that discovers decentralized coordination knowledge, which is only created by the market participants when their original individual production and consumption plans fail the reality test.[33] A precise prediction of the results of the competitive process is impossible – and the same is true for the prediction derived from merger simulation (and any other evaluation instrument). Thus, even short-run predictions may predict the correct direction or pattern of change, but the precise numbers are unlikely to be fully accurate. This does not erode the usefulness of computational prediction methods, though, since the improvement of predicting more accurate patterns is already a huge step. Similarly, computational tools may be used to document uncertainty levels[34] and although conventional simulation techniques are often also able to do this,[35] the information-richness is likely to increase. The impossibility of numerically precise predictions may be read as being more philosophical reasoning; however, it becomes relevant in certain institutional settings (see Subsection B).

The further development and enhancement of computational methods, including AI and self-learning systems, entails the potential to lessen some of the current limitations to the hypothetical effectiveness of merger simulations as tools of merger control. In particular, computational progress should facilitate the modeling of non-horizontal mergers and more complex market interrelations like

[33] *See* Friedrich August Hayek, *The Use of Knowledge in Society*, 35 AM. ECON. REV. 519–530 (1945); Friedrich A. von Hayek, *Competition as a Discovery Procedure*, *in* NEW STUDIES IN PHILOSOPHY, POLITICS, ECONOMICS AND THE HISTORY OF IDEAS 179–190 (1978); Oliver Budzinski, *An Evolutionary Theory of Competition* (2004), (unpublished manuscript), http://dx.doi.org/10.2139/ssrn.534862.

[34] *See* Nicholas Petit & Thibault Schrepel, Complexity-Minded Antitrust (Mar. 7, 2022). Available at SSRN: https://ssrn.com/abstract=4050536.

[35] A landmark case is the auction model based simulation of the Oracle-PeopleSoft-merger where scenario probabilities were an integral part of the simulation approach. *See* Oliver Budzinski & Arndt Christiansen, *The Oracle/PeopleSoft Case: Unilateral Effects, Simulation Models and Econometrics in Contemporary Merger Control*, 34 Legal Issues Econ. Integration 133 (2007) (including the literature cited therein).

in digital ecosystems. Advances in this direction are already observable, e.g., in the form of modeling platform mergers.[36] Thus, the range of cases that can benefit from employing merger simulations can be expected to increase in the course of time.

Also, the anticipation of structural breaks may become imperfectly possible by virtue of self-learning systems playing out different post-merger strategies and reactions, highlighting the most likely ones. AI/algorithm-based simulation tools may ex ante try out post-merger strategies against each other as if the real-world companies were competing, finding the most profitable ones by (imperfectly) simulating the post-merger competition. Thus, going beyond extrapolation is becoming an option. Especially, if companies and authorities use similar computational tools,[37] the predictive power of the (short-run) post-merger strategy equilibrium may be considerable (although most likely not perfect).

Furthermore, the mid- and long-term predictive power may also be improved, although it must be expected that the number of probable (alternative) scenarios quickly increases with the time elapsed after a merger. The combination of the creative power of companies and the independently ongoing change of the external environment will probably limit the advances that can be achieved here. Eventually, even with AI, self-learning systems, and other sophisticated computational methods, the fundamental uncertainty cannot be resolved. If the world is not deterministic, the future will always remain unpredictable to a relevant extent.

However, the potential benefits that can be drawn from merger simulations in merger control proceedings should significantly increase with the development and advancement of computational methods. Still, the overview in Section II showed that recently the frequency of employing merger simulations has not been increasing. Therefore, the question is whether and under which (institutional) conditions this potential can be reaped.

B. Institutional Barriers to Computational Antitrust

It is not enough if a competition policy tool is more suited to produce better results from an industrial-economic theory point of view. It also needs to fit into the institutional framework of competition policy, i.e., the rules and practices that shape the actual process of merger control. This leads us to the institutional economics related discussion on whether the use of merger simulation is actually effective in the real world. The main issues here relate to how quantitative, computationally-produced evidence is perceived and accepted by authorities and courts and how it intersects with the institutions of the administrative and legal procedure. About a decade ago, we identified institutional misfit as the main barrier to the successful use of merger simulations and computational-quantitative evidence in general, generating an enforcement gap in merger control.[38] Mergers

[36] *See* Evans & Noel, *supra* note 13, at 663–695; Filistrucchi, Klein, & Michielsen, *supra* note 13, at 297–329.
[37] The companies (or their consultants) may use such tools to find optimal strategies to react to the post-merger scenario, the authorities to anticipate the anticompetitive effects.
[38] *See* Budzinski & Ruhmer, *supra* note 2, at 277–319; Oliver Budzinski, *An Institutional Analysis of the Enforcement Problems in Merger Control*, 6 EUR. COMPETITION J. 445 (2010). *See also* Jonathan B. Baker & Carl Shapiro, *Reinvigorating Horizontal Merger Enforcement*, *in* HOW THE CHICAGO SCHOOL OVERSHOT

were allowed or at least not challenged despite knowledge about their potential anticompetitive harms based on economic analysis and computational-quantitative evidence.[39] A decade later, the under-enforcement of merger control is more widely acknowledged and calls for re-invigorating merger control against both horizontal and non-horizontal mergers have become widespread on both sides of the Atlantic.[40] With respect to the market power of digital ecosystem dominators, this has fueled a debate even about breakups of companies and the reversed transaction of mergers (like Facebook-Instagram-WhatsApp).[41]

The institutional misfit or incongruence that causes many of the failures and issues of computational-economic evidence in proceedings and in front of the courts manifests in procedural rules and practices that are not designed to deal with the

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THE MARK 235 (Robert Pitafsky ed., 2008); *and* Jonathan S. Baker & Carl Shapiro, *Detecting and Reversing the Decline in Horizontal Merger Enforcement*, 22 ANTITRUST 29 (2008).

[39] *See, e.g.*, Oliver Budzinski & Arndt Christiansen, *The Oracle/PeopleSoft Case: Unilateral Effects, Simulation Models and Econometrics in Contemporary Merger Control*, 34 LEGAL ISSUES ECON. INTEGRATION 133 (2007); Gisela Aigner, Oliver Budzinski, & Arndt Christiansen, *The Analysis of Coordinated Effects in EU Merger Control: Where Do We Stand After* Sony/BMG *and* Impala?, 2 EUR. COMPETITION J. 311 (2006). For Disney/Fox and AT&T/Time Warner, *see* Shapiro, *supra* note 31; Steven C. Salop, *The AT&T/Time Warner Merger: How Judge Leon Garbled Professor Nash*, 6 J. ANTITRUST ENF'T 459 (2018); *and* Annika Stöhr et al., *Happily Ever After? Vertical and Horizontal Mergers in the U.S. Media Industry*, 43 WORLD COMPETITION 135 (2020). For E.ON/Innogy, *see* Annika Stöhr, Oliver Budzinski, & Jörg Jasper, *Die Neue E.ON auf dem deutschen Strommarkt–Wettbewerbliche Auswirkungen der innogy-Übernahme [The New E.ON on the German Electricity Market-Competitive Impact of the Innogy Acquisition]*, 45 LIST FORUM FÜR WIRTSCHAFTS-UND FINANZPOLITIK 295 (2020). For more examples, *see* Budzinski & Ruhmer, *supra* note 2, at 296-304 (2010).

[40] *See, e.g.*, Steven C. Salop, *Invigorating Vertical Merger Enforcement*, 127 YALE L.J. 1962 (2018); Carl Shapiro, *Protecting Competition in the American Economy: Merger Control, Tech Titans, Labor Markets*, 33 J. ECON. PERSP. 69 (2019); *and* Tommaso Valletti, *How to Tame the Tech Giants: Reverse the Burden of Proof in Merger Reviews*, PROMARKET (June 28, 2021), https://promarket.org/2021/06/28/tech-block-merger-review-enforcement-regulators/; Elena Argentesi et al., *Merger Policy in Digital Markets: An Ex Post Assessment*, 17 J. COMPETITION L. ECON. 95 (2021); Massimo Motta & Martin Peitz, *Big Tech Mergers*, 54 INFO. ECON. POL'Y 100868 (2021); Michael L. Katz, *Big Tech Mergers: Innovation, Competition for the Market, and the Acquisition of Emerging Competitors*, 54 INFO. ECON. POL'Y 100883 (2021); Axel Gautier & Joe Lamesch, *Mergers in the Digital Economy*, 54 INFO. ECON. POL'Y 100890 (2021); Jonathan B. Baker & Joseph Farrell, *Oligopoly Coordination, Economic Analysis, and the Prophylactic Role of Horizontal Merger Enforcement*, 168 UNIV. PA. L. REV. 1985 (2020); Marc Bourreau & Alexandre de Streel, *Big Tech Acquisitions, Competition & Innovation Effects and EU Merger Control*, 26 THE ECONOMIST 10 (2018); Marissa Beck & Fiona Scott Morton, *Evaluating the Evidence on Vertical Mergers*, 59 REV. INDUS. ORG. 273 (2021); Jonathan B. Baker et al., *Five Principles for Vertical Merger Enforcement Policy*, 33 ANTITRUST 12 (2019); *and* Oliver Budzinski, Sophia Gaenssle, & Annika Stöhr, *Outstanding Relevance Across Markets: A New Concept of Market Power?*, 17 CONCURRENCES 38 (2020). Several studies have identified that market power across many industries has significantly increased. *See, e.g.*, David Autor et al., *Concentrating on the Fall of the Labor Share*, 107 AM. ECON. REV. 180 (2017); Jan de Loecker, Jan Eeckhout, & Gabriel Unger, *The Rise of Market Power and the Macroeconomic Implications*, 135 Q.J. ECON. 561 (2020); Pauline Affeldt et al., *Market Concentration in Europe: Evidence from Antitrust Markets* (CESIFO WORKING PAPER NO. 8866, 2021), https://www.cesifo.org/DocDL/cesifo1_wp8866.pdf; Jan de Loecker & Jan Eeckhout, *Global Market Power* (Nat'l Bureau Econ. Rsch. Working Paper No. 24768, 2018), https://www.nber.org/system/files/working_papers/w24768/w24768.pdf; Gustavo Grullon, Yelena Larkin, & Roni Michaely, *Are US Industries Becoming More Concentrated?*, 23 REV. FIN. 697 (2019); *and* Germán Gutiérrez & Thomas Philippon, *Ownership, Concentration, and Investment*, 108 AEA PAPERS AND PROCEEDINGS 432 (2018). Also, retrospective and ex-post studies of past merger control decisions have more often than not identified underenforcement. See the literature referenced in the meta studies by Annika Stöhr, *Price Effects of Horizontal Mergers: A Retrospective on Retrospectives*, (27 ILMENAU ECON. DISCUSSION PAPER NO. 151, 2021), https://www.econstor.eu/bitstream/10419/245947/1/1764123956.pdf.

[41] *See, e.g.*, John Kwoka & Tommaso Valletti, *Unscrambling the Eggs: Breaking up Consummated Mergers and Dominant Firms*, 30 INDUS. & CORP. CHANGE 1286 (2021); Lina M. Khan, *The Separation of Platforms and Commerce*, 119 COLUM. L. REV. 973 (2019); Richard J. Gilbert, *Separation: A Cure for Abuse of Platform Dominance?*, 54 INFO. ECON. POL'Y 100876 (2021); STAFF OF H.R. COMM. ON THE JUDICIARY, 116th Cong., *Investigation of Competition in Digital Markets* (Comm. Print 2020), https://judiciary.house.gov/uploadedfiles/competition_in_digital_markets.pdf; Martin Watzinger et al., *How Antitrust Enforcement Can Spur Innovation: Bell Labs and the 1956 Consent Decree*, 12 AM. ECON. J. ECON. POL'Y 328 (2020); *and* Alessandro Bonatti et al., *More Competitive Search Through Regulation*, (Yale Tobin Ctr. for Econ. Pol'cy, DISCUSSION PAPER NO. 2, 2021), https://tobin.yale.edu/sites/default/files/pdfs/digital regulation papers/Digital Regulation Project - Search - Discussion Paper No 2 (1).pdf.

peculiar characteristics of evidence produced by merger simulations (and other sophisticated quantitative tools). Two interrelated factors lead to unintended raise of intervention thresholds, generating a decisive role of the burden of proof for the outcome of proceedings.[42]

As a first issue, the complexity of computational instruments problematically interacts with the typical knowledge and incentives of judges and courts. Judges are highly-specialized experts in law – but usually neither in computer science nor in quantitative economics. Furthermore, since merger control cases are heard in front of general courts on both sides of the Atlantic, the Judges are often expected to deal with cases from very different areas of law and of life. Combined with a high caseload, implying that each case competes for the scarce attention time of the judges, judges in merger control proceedings may struggle to fully understand how a complex merger simulation model works and how accurate its results may be. Thus, in such situations, judges cannot derive the necessary conclusions from the evidence themselves but instead are forced to rely on experts and their testimonies. However, high-profile proceedings will more often than not see both parties (competition authorities and merging companies; maybe additionally also big competitors) nominating experts for providing merger simulation evidence. This puts judges in the difficult situation to decide the occurring battle of experts without being able to fully assess the relative quality of the presented sophisticated models themselves.[43] One consequence could be that judges dismiss computational evidence altogether, but this is more the exception than the rule. However, the role and the importance of the allocation of the burden of proof indirectly and unintentionally change. If judges cannot identify the more accurate among competing merger simulation models presented by the parties, they experience incentives to rule against the side that carries the burden of proof: this side did not provide sufficient evidence.[44] This puts the judge on the safe side as she or he follows an established institution and avoids procedural mistakes, and at the same time shifts responsibility for wrong decisions (wrong in the sense of the protection of competition) to the party with the burden of proof.

If identifying which evidence prevails among contrasting pieces of evidence is systematically more difficult for judges when facing sophisticated merger simulation models, then the de facto standard of proof for competition authorities carrying the burden of proof to block a merger unintentionally rises compared to non-quantitative, more standard, and more common evidence (like, for instance, interpreting documents and testimonies of industry insiders). It is worth noting that this rise of the de facto standard of proof is not an intentional choice by society or policymakers. Instead, it is an unintended side-effect of the nature of computational predictive evidence like merger simulations. This effect is straightforward for a court-system like the U.S. antitrust system, where any challenge of a merger must be brought to a court. However, it is less obvious for an administration system like the EU competition policy system, where the

[42] *See* Oliver Budzinski, *An Institutional Analysis of the Enforcement Problems in Merger Control*, 6 EUR. COMPETITION J. 445, 458–466 (2010).
[43] For the fundamental difficulties in identifying the "correct" predictive model, see Oliver Budzinski, *Competing Merger Simulation Models in Antitrust Cases: Can the Best Be Identified?*, 6 J. MERGERS & ACQUISITIONS 24 (2009).
[44] *See* Oliver Budzinski, *An Institutional Analysis of the Enforcement Problems in Merger Control*, 6 EUR. COMPETITION J. (2010).

competition authority itself directly rules on a merger proposal. Still, the possibility of a court review of the decision has an effect since losing an appeal by the parties in the courtroom may be viewed to be significantly reputation-damaging. Thus, if the probability of getting challenged is high enough – as it is in high profile merger cases – the danger of failing on appeal in the court review may already be enough to abstain from resting a decision on the results of a merger simulation.[45]

A second issue relates to the predictive nature of merger control assessments: In contrast to other areas of competition policy, merger control is about predicting what would happen in the affected markets in the (near) future if a merger proposal was cleared. Again, the nature of merger simulation evidence and the institutions and practices in legal proceedings mismatch. The first element is the so-called false sense of precision:[46] The predictive results of computational simulations display ostensibly exact numerical results, often with several digits after the decimal point. However, they cannot be that precise in predicting the future (see Subsection II.A). Yet, since the (false) impression of precision may emerge and persist, doubts about minimal deviations may suffice to shatter the trustworthiness of the predictive simulation in the eyes of judges or decision-makers. It may be sufficient for the opposite party to discredit a merger simulation outcome if it is able to show that the post-merger price increase could also be three per-cent instead of the predicted four-point-something per-cent – even though a smaller price increase still signals an anticompetitive merger.

The false sense of precision is complemented by a second element: the false sense of certainty. The legal system has some experience with natural-sciences quantitative evidence in other fields, such as genetic fingerprints in criminal law proceedings. However, the degree of certainty of such evidence and social science predictive evidence fundamentally differs.[47] While the genetic fingerprint is accurate in 99.9 per-cent of all cases, no predictions of post-merger prices, quantities, product diversity, or welfare measures will ever reach numbers in that region. However, suppose the framing and the experience of judges and courts relate to scientific-quantitative evidence being something like the genetic fingerprint. In that case, the opposing party may find it easy to shatter the economic evidence: just showing that the simulated predictions are not "certain" to such degrees may be sufficient. Again, the combination of the false sense of precision and the false sense of certainty unintendedly raises the burden of proof and increases its asymmetry: The de facto standard for shattering a merger simulation outcome is significantly lower than the standard for it to survive the proceeding.[48]

Now, what about the advances in computational methods like self-learning systems and other systems? In contrast to the hypothetical effectiveness of merger simulations (see Subsection II.A), the actual effectiveness of merger simulations is unlikely to improve through advanced and more sophisticated computational

[45] *See, e.g.*, Aigner, Budzinski, & Christiansen, *supra* note 39.
[46] *See* Lars Peter Hansen & James J. Heckman, *The Empirical Foundations of Calibration*, 10 J. ECON. PERSP. 87 (1996).
[47] See FRIEDRICH AUGUST VON HAYEK, *The Meaning of Competition*, *in*: INDIVIDUALISM AND ECONOMIC ORDER 92 (1948).; FRIEDRICH AUGUST VON HAYEK, *Competition as a Discovery Procedure*, *in* NEW STUDIES IN PHILOSOPHY, POLITICS, ECONOMICS AND THE HISTORY OF IDEAS 179 (1978).
[48] *See* – also on the preceding paragraph – Budzinski, *supra* note 42.

methods. Quite the other way: the institutional misfit will be increased, and the issues raised in this Subsection will gain more weight than less. The very recent case of the AT&T-Time Warner merger provides anecdotal evidence for this (although not even involving a full-blown merger simulation model). The (computational) economic evidence of post-merger anticompetitive effects was dismissed by the judge in favor of industry insider testimonies insisting that they do not think such anticompetitive practices will occur post-merger.[49] The real-world development post-merger quickly supported the economic predictions.[50]

C. Costs and Benefits for Competition Authorities: Is the Use of Merger Simulation Efficient?

Merger simulations represent data and knowledge-intensive tools that have the potential to yield excellent results but also generate significant costs. A full-blown merger simulation involves high-end economic expertise (regarding both theoretical economics and empirical methods/econometrics), time-intensive data collection and generation, and must be done on a case-by-case basis. Consequently, it requires extensive agency resources to either engage in producing this type of evidence or commission respective studies. Only a few competition agencies in the world will probably have the resources to employ advanced merger simulations. Furthermore, there may be an imbalance between the financial powers of the competition authority and the merging parties: who can invest more money and who can afford the more qualified (or just more prominent) specialists? In order to represent an efficient tool, the increase in quality of employing merger simulation must at least match the costs of producing/conducting them. Eventually, data availability may be a limiting factor in some cases.

The recent, current, and future advances of computational methods are likely to have an ambivalent effect on the cost-benefit relations. On the one hand, the requirement of special qualifications further rises, and specialists may be even more scarce when it comes to combining advanced industrial economics with sophisticated computational competencies. On the other hand, computational power and capacity costs are decreasing and becoming easier to access with the development of user-friendly interfaces and ready-to-use modules. Additionally, machine learning is said to have the potential to significantly improve the administration of merger law and reduce its costs.[51] Generally, research on the area of cost-benefit analysis of antitrust or regulation tools is comparatively underdeveloped – in contrast to other economic policy areas.

D. A Special Case: Merger Simulations for Ex-Post Evaluation of Merger Control Decisions

Generally, this paper is about the use of merger simulation in merger control proceedings, i.e., as a tool to assess a proposed merger, providing advice and evidence for the competent competition authority on how to decide upon this given merger project. However, there is another potentially extremely useful application

[49] *See* Salop, *supra* note 40; Shapiro, *supra* note 31; Stöhr et al., *supra* note 38.
[50] *See* Tim Wu, *Opinion: How AT&T Fooled the Federal Judiciary*, N.Y. Times, Nov. 7, 2018, https://www.nytimes.com/2018/11/07/opinion/att-hbo-antitrust.html.
[51] *See* Casey & Niblett, *supra* note 29, at 152.

for merger simulation methods: the ex-post analysis of past merger decisions. Like some kind of controlling mechanism, past merger control decisions of competition authorities can be addressed by ex-post impact evaluations, identifying whether in hindsight the decision to block or clear the merger was correct from a competition policy point of view or not.[52] The goal here is not so much to evaluate the quality of the work of the competition authority (which with the benefit of hindsight may be somewhat unfair) but to learn for future cases.

When applying merger simulations for ex-post evaluations, the predictive element gets replaced by simulating a counterfactual: what may have happened if the authority had decided differently. Depending on the specific case in question, this may not be necessary because it suffices to show econometrically that the actual decision, for instance, an approval, led to significant damage to the competitive process. Or, alternative econometric methods like standard time-series and panel regression analysis, difference-in-difference methods or event studies may be more suited to address the counterfactual. The choice of the "right" evaluation technique depends, inter alia, on data availability, the existence of markets that are comparable to the one in question except of the treatment (i.e., the merger control decision), and the stability of the competitive interrelations vs. the occurrence of structural breaks. However, some ex-post evaluation cases will benefit from employing merger simulation. Then, the advantages are explored in Subsection II.A can be more easily reaped than in cases of predictive simulations because the issues of institutional misfit do not interfere. An ex-post analysis with the aim to create better knowledge about merger effects and the impact of merger control decisions and to use this knowledge for better merger control rules and decisions in the future does not run into the institutional traps of administrative procedures and courtroom practices (as explored in Subsection II.B.). Still, ambitious competencies and data availability (see Subsection III.C.) may remain limiting factors.[53]

The advances of computational methods have strong potential to improve the use of merger simulation for ex-post analyses. The increasing options for modeling complex interaction processes with self-learning systems and using AI should excel in this discipline since they are not limited by institutional frictions and factors. Notwithstanding, resources remain an issue (although see the ambivalent character of advances in computational methods in this regard explored in Subsection III.C). In contrast, more sophisticated computational methods may well become able to better overcome limits in data availability. With the view to improve merger control rules, practices, and decisions in the future, the value of investing and engaging more in ex-post studies should not be underrated.[54]

[52] *See,* e.g., William E. Kovacic, *Using Ex Post Evaluations to Improve the Performance of Competition Policy Authorities*, 31 J. CORP. L. 503 (2006); Oliver Budzinski, *Impact Evaluation of Merger Control Decisions*, 9 EUR. COMPETITION. J. J. 199 (2013); Stephen Davies & Peter Ormosi, *Assessing Competition Policy: Methodologies, Gaps and Agenda for Future Research* (CTR FOR COMPETITION POL'CY WORKING PAPER NO. 10-19, 2010); and Oliver Budzinski & Annika Stöhr, *Towards a Systematic Controlling of Antitrust Decisions?*, 1 CPI ANTITRUST CHRON. 45 (2018).
[53] *See* Budzinski, *supra* note 42.
[54] *See also* Oliver Budzinski & Annika Stöhr, *supra* note 52; and Argentesi et al., *supra* note 40.

IV. Conclusion

In this paper, we explored the prospects and benefits of merger simulations as a computational competition policy tool. After updating an earlier overview on the properties of merger simulation models and their actual record in merger control proceedings, we address four areas that can be used to explain the following observation: the use of merger simulations in merger control cases increased up to the mid-2010s, but since then has been stagnating or even falling (see Subsection II).

1) The perspective of industrial economics would rather imply that the opposite development should happen. Advances in both computational methods and capacities continuously improve the hypothetical prospects of employing merger simulations. Due to these advancements, the quality of predictions from merger simulations about post-merger welfare effects increases, and hitherto limitations like case complexity and structural breaks (see Subsection III.A) are likely to be mitigated.
2) However, an institutional economics perspective helps one explain and understand why any euphoria about using merger simulations in real-world proceedings has been chilled. Frictions in the law and economics interface imply that the hypothetical might of merger simulations could often not actually be reaped in merger control proceedings (see Subsection III.B). Unfortunately, the institutional issues are unlikely to disappear and continue to limit the hypothetical usefulness of computational evidence.
3) The economic policy or political economics perspective of costs and benefits for as well as incentives and behavioral barriers within competition authorities as organizations is rather underdeveloped when it comes to comparatively assessing alternative policy tools and instruments (instead of tackling more fundamental and more abstract questions). The effects of computational advances seem to be rather ambivalent (see Subsection III.C).
4) An often-underestimated perspective for useful employment of merger simulations in competition policy is its use to improve ex-post analyses of merger cases for the purpose of policy-learning (see Subsection III.D). Here, the advantages of advanced and sophisticated simulation techniques are easier to reap than in the case of predictive simulations.

In summary, our main conclusion is: institutions matter! The institutional design of competition policy proceedings – be them administrative or court-based – is more decisive for the success of a computational instrument than (further) advances of the methods themselves.

V. Further Research

In relation to our main conclusion summarized at the end of the preceding section, it would be important to address the following questions:

A. What is the adequate standard and allocation of proof for computational evidence?

Too ambitious standards of proof and an inadequate allocation of proof can easily lead to the unintended side-effect of eroding the scope for merger simulation methods (see Subsection III.B). Possible solutions could be, inter alia, (a) twists to the standard of proof like giving a higher weight to caution for harm to the competitive process in cases of uncertainty or considering two-sided standards of proof, i.e., requiring that counter-evidence by the parties must match the quality of the simulations it tries to shatter (instead of merely raising doubts),[55] (b) implementing rebuttable presumptions of competitive harm with a reversed burden of proof if the presumptions shall be rebutted in a given case,[56] or (c) generally reverse the allocation of the burden of proof, so that it falls on the merging parties.[57]

B. How can the competencies and incentives for judges be adapted to the nature of computational evidence?

Topics that warrant discussion include (1) the knowledge-preconditions of judges (generalized vs. specialized judges), (2) the possible roles of independent experts vis-à-vis party experts (including the topic of the battle of experts), (3) the extent and procedures of the rights of defendants, (4) the accountability of decision-makers regarding substantive matters vs. procedural issues, (5) the (de facto) incentive schemes for judges and administrations, and many more.

C. How can the organizational structure of competition policy agencies and their interaction be better shaped?

Alongside questions about the equipment and competencies of competition authorities, i.e., teams of economists and computer/information scientists complementing legal teams, the interplay between competition authorities also plays a role. Most big merger cases are international or even intercontinental in effect. Does it promote using computational tools with its requirements of resources, competencies, and data if each competent competition authority addresses the case on its own, or would inter-jurisdictional agency cooperation and (even) lead jurisdiction models represent better institutional designs?[58] Also, which design of competition policy regimes better fit computational methods: a United

[55] For more details, *see* Budzinski, *supra* note 42, at 471-473.
[56] *Id.* at 466-471.
[57] *See* Valletti & Zenger, *supra* note 23.
[58] *See* OLIVER BUDZINSKI, THE GOVERNANCE OF GLOBAL COMPETITION: COMPETENCE ALLOCATION IN INTERNATIONAL COMPETITION POLICY (2008); Oliver Budzinski, *International Antitrust Institutions*, *in* 1 OXFORD HANDBOOK INT'L ANTITRUST ECON. 119 (Roger D. Blair & Daniel D. Sokol eds., 2015); Oliver Budzinski, *The Economics of International Competition Policy: New Challenges in the Light of Digitization?* (ILMENAU ECON. DISCUSSION PAPER NO. 135, 2020).

States-style court system, an European administration system, or other designs? Here, issues of lobbyism also need to be considered.

D. How can a systematic controlling system for merger control decisions be designed, financed, and implemented?

Systematic ex-post reviews for policy-learning objectives would be extremely beneficial. The knowledge that is generated can then be used to fine-tune rules, procedures, and practices of merger control and lead to better decisions in the future.

The brief and incomplete outline of areas for further research points at the necessity for scientific cooperation between law, economics, and technology[59] or legal, economics, and information science scholars. Siloed analyses of technological options, economic promises, or legal institutions miss an essential part of relevant topics to tackle existing barriers against computational antitrust tools.

[59] *See* Simonetta Vezzoso, *Digital Platforms and Antitrust: Towards a More Techno-Economic Approach*, *in* RECHT UND ÖKONOMIE 119 (2020).