

Innovation at Risk? Regulatory Interventions and the Fragility of Digital Platform Ecosystem Performance

Tobias Manuel Lehmann and Stephan Aier

University of St.Gallen, 9000 St. Gallen, Switzerland

tobias.lehmann@student.unisg.ch, stephan.aier@unisg.ch

Abstract. Digital platform dominance is reshaping competition policy. We use an agent-based simulation to examine how three families of regulatory levers affect generativity, a proxy for innovation: (1) switching costs for customers and complementors, (2) customer and complementor inertia, and (3) caps on customer share, complementor share, and platform revenue share. We evaluate outcomes with four metrics: dominant-platform revenue share, average service complexity, requirement-fulfilment rate, and market concentration (Herfindahl-Hirschman Index). Switching costs and complementor inertia move these metrics little, and lowering customer inertia can backfire. By contrast, calibrated share caps deliver the most consistent gains. Two settings perform well across all four metrics: limiting a platform to 80% customer share or 70% revenue share, with no cap on complementor share; overly tight limits dampen innovation and competition. Regulators whose goals align with these outcomes should prioritize market- or revenue-share ceilings and deprioritize interventions in switching costs or inertia.

Keywords: digital platforms, platform competition, agent-based simulation.

1 Introduction

Regulators have been increasing their focus on digital platforms as an emerging socio-technical construct, and on their effects on competition and welfare. Major legislative packages like the EU’s Digital Markets Act or the USA’s American Innovation and Choice Act aim to rein in gatekeepers who dominate their respective markets [1, 2]. In 2024, half of the ten largest companies by market capitalization [3] have been platform businesses. While digital platform ecosystems often outperform more traditional market settings [4, 5], growing economic importance shows the urgent need for competition policy regulators to adapt existing legislation to the changing market landscape. We therefore aim to investigate the effects of platform regulation, both on competition and welfare on the one hand as well as on their power of innovation (generativity) and profitability [4] on the other hand.

To this end, we employ an agent-based simulation model to understand key factors for regulation. The model is built upon existing competition policy as well as platform

literature. The model’s quantitative results are then analyzed, and their implications are discussed. Given the exploratory nature of this research, we abstain from formulating hypotheses but experiment with the regulatory propositions made within the academic discourse on platform regulation [6].

In section two we define digital platforms and platform ecosystems in the context of this research and then elaborate on their performance advantages. Furthermore, section two discusses the main challenges that are inherent to platform ecosystems, which is followed by a discussion of what may be regulated to address those challenges. The third section introduces the agent-based model employed, including the design of the model, its validation, and the design of the simulation experiments. Section four presents the results of the simulation experiments, and section 5 discusses their implications and limitations.

2 Conceptual foundations

2.1 Digital platform ecosystems

In this research we examine digital platforms from a sociotechnical viewpoint [7], which centers around a technological foundation that is usually supplied by a platform owner (*orchestrator*) and which can be expanded by loosely interconnected and self-organized third-party participants (*complementors*), with the goal of jointly creating value through innovation. The digital platform acts as the foundational infrastructure for a platform ecosystem consisting of complementary platform partners, which collectively combine their resources to co-create innovative solutions aimed at addressing customer problems [4, 8-10].

By integrating with the platform, complementors are able to generate innovation that complements the platform and also gain direct or indirect access to the platform’s customer base. Platform ecosystems are perceived as *semi-regulated marketplaces* that stimulate entrepreneurial activity under the guidance and control of the platform owner or as *multisided markets* rather efficiently facilitating transactions between different groups of users, i.e., customers and complementors [11].

Platforms generate network effects by aggregating multiple user groups [12]. Network effects suggest that the value of a platform is positively correlated with the number of users who adopt and use it. Rising levels of adoption can initiate reinforcing feedback loops that amplify the utility of the platform for all groups of participants, i.e., platform owner, complementors, and customers [7].

On digital platforms, autonomously acting agents play a crucial role in enhancing the platform’s value proposition [13]. Recent advances in large-language-model-empowered agents broaden this role further by enabling more autonomous, socially interactive, and heterogeneous software actors with planning, memory, and reflection capabilities, potentially amplifying both ecosystem generativity and coordination complexity [14]. This principle underscores the necessity for digital platforms to facilitate and synchronize an ecosystem of agents while being susceptible to interdependencies. One key attribute of an ecosystem is its generativity, which refers to the ability to generate

unanticipated changes spurred by diverse, extensive, and uncoordinated groups of actors. Exploiting the digital affordances provided by the platform owner, actors within the ecosystem contribute to generativity through their individual innovation capabilities. More concretely, the complementors can exchange information and expertise, leading to novel ideas of creating valuable complements, thus amplifying the generativity of the ecosystem [13-15].

Platform ecosystems offer a multitude of advantages. Through centralization of information and resources, they yield increased efficiency and reduced transaction costs [13, 16, 17]. Their network effects lead to larger and more engaged user bases [13, 16, 18], which in combination with the increased efficiency may lead to an improved access to a wider range of products and services. The presence of multiple players in the ecosystem may lead to increased competition and innovation [11, 13, 16, 19]. Although there is competition among ecosystem members for the generated profits, there is also better alignment of incentives between platform owners, complementors, and customers, because all members benefit from the success of the collective enterprise [11, 13]. Enhanced data collection and analysis may lead to improved decision making and targeting [12, 19, 20], and as a result to more personalized and relevant experiences for users.

Besides specific market conditions that may moderate or even suspend certain advantages of platforms [4], there are also distinct disadvantages inherent in the construct of a platform and its ecosystem. The following section will look more closely at four such challenges.

2.2 Drivers of platform ecosystem regulation

Next to the performance benefits of platform ecosystems are the challenges they provide for long-term competition, innovation, and efficiency: the concentration of market power, a potential lack of interoperability and resulting lock-in effect, negative consequences of network effects, and the development of suitable governance.

One main challenge of platform ecosystems is due to the structural nature of platforms, where one orchestrator coordinates the platform. The power over the specific platform is therefore strongly concentrated, leading to potential monopolistic practices [19, 21]. This is further reinforced by multiple ancillary circumstances. First, there is a reduced bargaining power for platform participants [20]. Second, there is a risk of unequal treatment or exploitation of specific complementors [22, 23] and customers [24]. Third, it is difficult to enforce contracts and protect intellectual property rights [24]. Fourth, complementors depend on platform owners for revenue, leading to increased uncertainty and volatility [24]. Fifth, complementors also depend on platform owners for access to customers, data, and other resources [19, 20, 24]. Sixth, there is a potential for reduced competition and decreased innovation, as dominant platforms may stifle new entrants and existing players [20, 24].

Another main challenge is a lack of interoperability between different competing platforms which can result in a lock-in effect of complementors or customers, reducing their ability to switch to other platforms and further cementing the influence of the current platform over its constituents [12, 19, 20, 24]. It must be noted that

interoperability is no surefire way to avoid systems settling into sub-optimal polarized states due to path dependence, though [25].

Furthermore, as platform ecosystems rely on network effects, where the perceived value of the platform increases as more complementors and costumers adopt it, those may naturally switch to the biggest platform. This leads to a *winner-takes-all* dynamic, accentuating disparities [12, 20, 21, 26]. Digital platforms may become monopolies, dominating markets and stifling competition. The concentration of market power in the hands of a few large digital platforms could therefore create barriers to entry for new businesses, reduce competition, lead to increased prices for consumers, and restrict innovation in the market.

Last but not least, it may be difficult for regulators to draw up legislation or sound discretion-limiting governance rules for platform ecosystems when they lack the necessary resources or information needed to do so [27]. Developing appropriate regulations and governance structures to ensure that digital platforms operate in a way that serves the public interest might be further complicated if short- and long-term interests of users are contrary [6].

2.3 Levers of platform ecosystem regulation

The literature discusses several classes of platform ecosystem regulations. In the following we will elaborate on those relevant to the paper at hand: *strengthening inter-ecosystem competition*, *restricting orchestrator power over complementors and strengthening intra-ecosystem competition*, *regulating firm size or business model*, *regulating prices*, and *inducing self-regulation*. Beyond those regulation classes, literature also discusses specific subclasses such as *restricting growth in power of an ecosystem through expansion* [19, 21] and *restricting changes done to acquired firms* [20], which we did not include here.

First, Biggar and Heimler [24] propose to ensure and *strengthen inter-ecosystem competition*, as do Jacobides and Lianos [20]. This could be achieved through multi-homing of customers and complementors [12, 28, 29] by requiring sunk investments to be generic [24]. More specifically, regulators could control or limit the degree of customization of specific interfaces and protocols within an ecosystem [20, 24] and ensure that users can easily transfer their data from one provider to another [12, 19] which would facilitate switching ecosystems. Finally, regulators may aim to minimize inertia of users, given the significant distortive influence it can have on market dynamics [19].

Second, a *restriction of the platform owner's power over its complementors* and therefore ensuring a sufficient degree of intra-ecosystem competition [20] complements the focus on inter-ecosystem competition. This may be achieved by regulating the interactions with upstream complementors and downstream customers [24], or by formulating policies that seek to restrict or limit the potential for holdup [24]. Holdup is “the threat that the counterparty will change the terms and conditions of trade in a manner adverse to the trading partner ex post” [24], or simply “the risk of exploitation” [24]. To tangibly restrict holdup, regulators may require contractual agreements for specific sunk investments. Furthermore, firms could be required to apply the same contractual conditions to their complementors along the firm’s growth, preventing adverse changes

in the business terms for complementors once a platform has established a strong market position [24]. Finally, the principle of equality could be applied not only over time, but also over products, prohibiting the self-preferencing of own products by the platform owner [23, 27].

Third, *interventions in the firm size or business model of a platform owner* are regulating firm structure. Due to the potential “corrupting influence of large firm size on the political process”, said firm size could be directly regulated [30]. This can be done either by breaking up entrenched dominant firms and anticompetitive consummated mergers [26]. Another approach may be through specific regulation for companies with significant market power [20], or certain business models and ecosystem architectures [20, 31], as fragmenting a dominant platform in the context of social networks may inadvertently channel extreme content into smaller enclaves, while inclusive dominance can coexist with marginalized extremes—suggesting careful, context-specific trade-offs [25].

Fourth, interventions may *regulate prices* directly [20], prohibit price discrimination [24], or regulate rents. Petit and Teece [32] propose that only monopoly rents should be regulated, considering Ricardian and Schumpeterian rents as justified.

Finally, regulators may induce *self-regulation among industry actors* [20, 27], or specifically foster coordination among industry actors for that purpose [27].

While there are a multitude of approaches and tools at hand, in this paper we will focus on the roles of customers and complementor switching costs, inertia, as well as limitations to platforms’ market and revenue share. After having elaborated on remedies for the challenges of platforms and ecosystems in this chapter, the following chapter will look at how such regulations could be implemented.

3 Research design

3.1 Agent-based modelling

This paper employs agent-based modeling to analyze the effects of the above-mentioned levers on digital platform ecosystems. Due to the involvement of a diverse range of actors in platform ecosystems, the complex nature of these systems needs to be considered [33]. Agent-based modeling (ABM) is an approach to studying complex adaptive systems that involves examining the behavior of individual agents as they adapt to their environment based on a set of rules [34]. More specifically, it is a useful approach to investigate the interaction among various stakeholders on a platform under different market conditions and regulatory measures. This approach emphasizes the bottom-up nature of the modeling process, focusing on the behavior of individual agents and how they interact with one another to produce emergent patterns and outcomes at the system level – defining micro-behavior to analyze macro-behavior [35, 36].

The agent-based model in this paper examines the generativity of and competition among platform ecosystems under changing market conditions and regulatory measures. To do so, it simulates an environment in which (1) customers aim to maximize their utility by switching to the most appealing platform that best fulfills their

requirements and consume the local services, (2) complementors aim to maximize their expected revenue by switching to the most appealing platform that has the highest expected revenue and create services to match local customers' requirements, and (3) platform owners aim to maximize their revenue by dynamically altering their revenue share. The model analyzes the influence of independent variables on dependent variables. The independent variables reflect the levers of regulation, i.e. customer switching costs, complementor switching costs, customer inertia as the time to switching platforms, complementor inertia as the minimum frequency at which complementors are allowed to switch platforms, as well as limitations to platforms' share of customers, complementors, and revenues from their complementors. The dependent variables are the revenue share of the dominant platform, the average service complexity, the share of fulfilled customer requirements, and market concentration using the Herfindahl-Hirschman index (HHI).

The model is comprised of agents and their interactions. Finally, there is the environment in which the agents interact, influenced by parameters, which affect the environment. The model therefore consists of agents, interactions, and an environment, and can thus be considered a model of a complex adaptive system (CAS) [37, 38].

Agents. Agents are fundamental units of action in a CAS, representing individual actors such as humans, organizations, objects, or concepts. Each agent is defined by a set of attributes and behavioral rules that guide its decision-making and interactions within the system [34].

The model has three types of active agents: *customers*, *complementors*, and *platform owners*. Throughout a simulation run, customers aim at maximizing their utility. They regularly have new *requirements*, for which they will search for matching *services* to fulfill them. *Complementors* are randomly equipped with *skills* at the start of each simulation run and aim at maximizing their revenue by using their skills to create *services* with the highest expected *payoff*. Platform owners consider the past development of their share of revenue generated in their ecosystem and increase or decrease their revenue share to maximize their own absolute revenue. These three types of *utility agents* are complemented by *reflex agents* with a passive role: *features*, *requirements*, and *services*. In each simulation run there is a predefined number of features, which represent the *complexity* of the environment [4]. Both requirements and services are defined by their links to features. The specific features as well as the number of features they are connected to, vary among the different requirements and services. For a service to fulfil a requirement, the service needs to be connected to all the requirement's features.

Behavior. Interactions in a CAS refer to the *behaviors* of agents that adapt to one another. In agent-based simulation models, interactions between agents are typically defined by a set of rules that determine how agents respond to one another [37, 38].

In our model, interactions are driven by customers looking to maximize their utility, and complementors and platform owners to maximize their revenue. Customers look for services that meet their unfulfilled requirements by looking at all the complementors on their current platform and comparing their services with customers' requirements.

They will spend all their income in equal parts on the chosen matching services. This behavior is based on simplified microeconomic theory, saying that balanced consumption brings greatest utility due to decreasing marginal utility [39]. Furthermore, customers regularly check which platform in the environment best fulfils their current requirements, considering potential costs of switching platforms. Meanwhile, complementors try to maximize their revenue by creating new services to fulfil as many potential customer requirements as possible. By looking at the environment's feature complexity, they consider the expected share of possible requirements that a potential new service will be able to fulfil as a measure of expected revenue. Limited to their current platform, they seek out other complementors' skills if they lack necessary resources on their own, to create together a more complex service that can fulfil more customer requirements and therefore has a higher expected payoff. Potential gains and costs of cooperating with other complementors are considered by looking at the other complementors' skills. Additionally, any potential reduction in revenue is accounted for by considering their current platform's revenue share. Just like the customers, complementors also regularly check which platform in the environment offers the highest expected revenue, considering each platform's number of customers, revenue share, and costs of switching to another platform. Overall, the customers' requirements are always the starting point for both customers and complementors. Platform owners interact with the environment by basing their actions on the development of the revenue generated in their ecosystem.

Environment. The environment refers to the context in which the agents operate and interact with each other. The environment shapes the behavior of agents, and in turn, the behavior of agents can affect the environment [37, 38].

In our model, the environment is influenced by the number of features, representing the potential complexity. Mobile apps may be an illustrative example: the features may represent different functions of the app, e.g., photo capturing, photo editing, cloud storage, etc. Customer requirements describe the needed functions of a service. Complementors have different expertise due to their randomly allocated skills. Complementors with more skills may represent large organizations that cover a broad range of expertise, while complementors with less skills may represent individual developers that are specialized in one application function. The more features a service has, the more requirements it can fulfil, since customers considering a potential service for their requirements do not mind additional incorporated features, but rather a lack of required ones. If customer requirements become more complex, or complementors have less skills, it will require more cooperation among complementors to still craft services that incorporate all required features. The environmental complexity therefore is a combination of the average number of features that customers require, the average number of features that complementors possess as skills, and the total number of different features in the model.

3.2 Model validation

The issue of model accuracy is tackled through model validation, which is an integral part of the model development process [34, 40]. In line with Sargent [40], the model was validated using degeneracy tests and extreme condition tests, face validity, internal validity, operational graphics, and structured walkthrough.

3.3 Simulation experiments

Three scenarios were designed to analyze how (1) different levels of *customer and complementor switching costs* ranging from 0.0 to 1.0 in six increments for a total of 3600 simulation runs, (2) *customer and complementor inertia* ranging from 1 to 20 in six increments for a total of 3600 simulation runs, and (3) limitations to *platforms' customer and complementor share* ranging from 0.4 to 1 in seven increments, and *revenue share* ranging from 0 to 1 in seven increments for a total of 34'300 simulation runs. The limitations to customer and complementor share start at 0.4 because of the three platforms that are in each simulation run. During the other two runs, customer and complementor switching costs, customer and complementor inertia, and the limit for platforms' customer, complementor, and revenue share were fixed. In the case of the switching costs and customer inertia, the specific values were based on degeneracy tests, while the parameters' existence was backed by literature [19, 24]. In the case of complementor inertia, and the limit for platforms' customer, complementor, and revenue share, the values—all set to 1—were based on the idea of an unregulated market without restrictions on actors' behavior.

The focus on actor switching costs [19, 20, 24], actor inertia [19], actor share [20, 30], and revenue share [20, 24] all build on propositions stated in the analyzed literature. The following section will discuss simulation results.

4 Results

In analyzing its effects and utility as a regulatory measure, we look at each of the three scenarios separately. For each scenario, we look at *revenue share* as the main driver for *service complexity*, at the *average service complexity* as the main influence on the *share of fulfilled requirements*, and finally at *market concentration* to get an understanding of what the market looks like. We focus on certain noteworthy outcomes due to the multitude of analyzed scenarios and the limited space in the paper at hand.

4.1 Changes in customer and complementor switching costs

Customer and complementor switching costs only have minor to no influence on long-term outcomes (revenue share, average service complexity, share of fulfilled requirements, and market concentration). We conclude that while complementor switching costs of 0.9 in combination with customer switching costs of 0.9 or 0.7 slightly lower market concentration, and complementor and customer switching costs of 0.5 each

seem to slightly increase average service complexity and share of fulfilled requirements, the effects are too minor to give evidence for the effectiveness of these measures. With the extreme value of switching costs of 1—which essentially stops actors from switching platforms—we see model degradation. Exemplarily Fig. 1 illustrates these limited effects and model degradation.

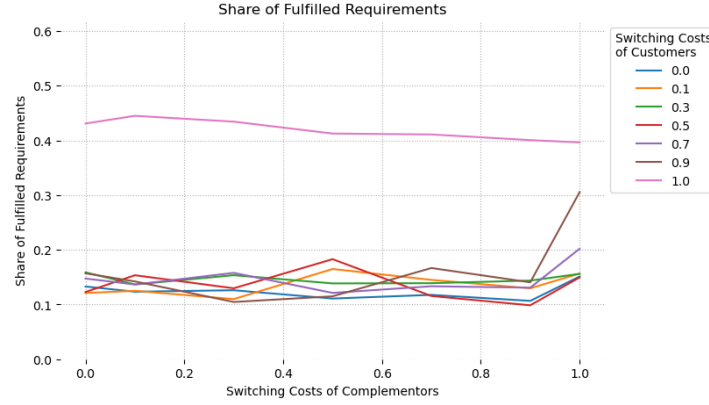


Fig. 1. Customer/Complementor Switching Costs Effect on Share of Fulfilled Requirements

4.2 Changes in customer and complementor inertia

We find that low and very high customer inertia lead to decreased revenue share, and increased share of fulfilled requirements (Fig. 2), while the effect on average service complexity and market concentration is less clear for lower customer inertia but leads to increased average service complexity and decreased market concentration at higher values. The influence of complementor inertia—the minimum switch interval for complementors before they are allowed to switch platforms again—is less clear. Its only distinct impact is in combination with very high customer inertia of 20 time steps, where higher complementor inertia leads to slightly lower revenue share and lower market concentration, while increasing average service complexity and share of fulfilled requirements. We conclude that a case can be made for erasing customer inertia, although its benefits are meager at best, and depend on the current customer inertia level so as not to be counterproductive. It would not be irrational to argue in favor of an increase in customer inertia, too.

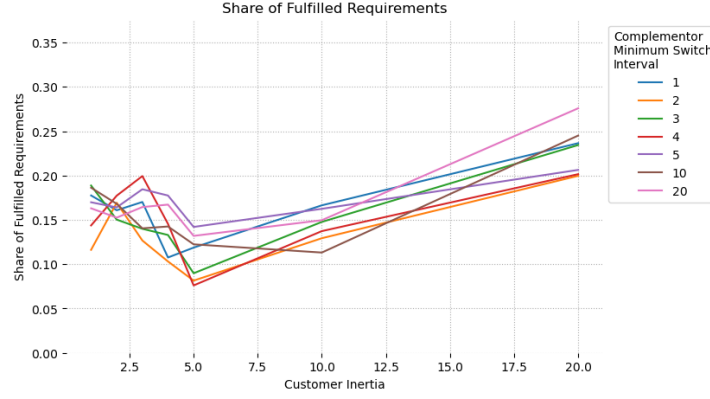


Fig. 2. Customer and Complementor Inertia Effect on Share of Fulfilled Requirements

4.3 Limitations to market or revenue share

We find that, counterintuitively, revenue share of the dominant platform can be lower when revenue share is unregulated: 0.48 (revenue share limit = 1.0) compared to 0.70 (revenue share limit = 0.7) for complementor share limit of 1 and customer share limit of 0.8, or 0.60 (revenue share limit = 1.0) compared to 0.68 (revenue share limit = 0.7) for complementor and customer share limit of 0.9 each. A cutoff for customer share at 0.8 has a substantial impact on revenue share, without regulating complementors or revenue share itself.

While a revenue share limitation of 0.0 (no platform profit) results in average service complexity of 6.80, and a revenue share limitation of 0.1 leads to average service complexity of 6.53, completely abandoning a revenue and complementor share restriction, but slightly capping the customer share limit at 0.8 still gives us average service complexity of 6.10. Alternatively, only limiting complementor share at 0.9 or 0.8 leads to average service complexity of 4.34 or 5.55 respectively, which are still some of the best results possible, given such little interference. Setting a limit to revenue share does result in a higher average (4.63 compared to 5.53 for revenue share limit of 1 (Fig. 3) and 0.7 respectively) but looking at single values and considering the principle to minimize regulatory intervention, the absence of a revenue share limit seems to clearly give better results.

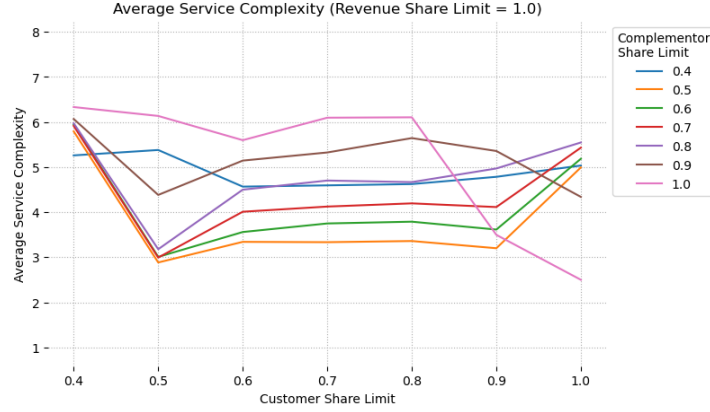


Fig. 3. Customer and Complementor Share Limitation Effect on Average Service Complexity

Considering the share of fulfilled requirements, the result is less clear. Solely limiting revenue share to 0.7 leads to a perfect result of 1.00, with deteriorating results when combined with customer share regulation.

Leaving revenue share unregulated at 1.0, other minor limitations can still help to drastically increase the share of fulfilled requirements: to a value of 0.77 with only a customer share limit of 0.8, or to 0.79 with a complementor and customer share limit of 0.9. Completely unregulated, however, the share of fulfilled requirements will decrease to 0.16.

Exclusively limiting revenue share to 0.7 while letting customers and complementors roam freely results in an HHI of 5951, which according to the theory behind the HHI still makes for a highly concentrated market but is nevertheless clearly preferable over the (near) monopolies resulting from revenue share limits of 1.0 or 0.9. Meanwhile, further limiting the revenue share brings minor changes, with the customer share limit being the main driver, partly due to the calculation of the variable's value, which measures each platform's customer market share.

We conclude that for three out of the four dependent variables we looked at (all apart from market concentration), we found cases where we achieve preferable results with comparatively less regulation. Depending on a regulator's goals, different limitations of the three analyzed independent variables might prove most useful. If trying to minimize regulatory intervention, it seems that a sole limit on customer share of 0.8 already bears substantial gains.

The following section will put the insights gained into the context of research and competition policy, and will discuss its shortcomings.

5 Discussion

Competition policy literature has proposed to curb the negative effects of platforms and ecosystems as an emergent organizational form through a multitude of regulatory

measures. Some of the propositions were focused on switching costs [19, 20, 24], actor inertia [19], customer and complementor share [20, 30], and revenue share [20, 24].

5.1 Contribution and implications

This paper built upon these propositions from literature, implemented them in an agent-based model of a multi-platform market, and measured their effectiveness based on four previously identified dependent variables. The model's results suggest that switching costs have a minor influence on market outcomes in the long run, stressing the significance of network effects and their influence on platform markets. Customer inertia influences market outcomes more clearly, albeit still in a minor way. Finally, restrictions on market and revenue share have shown to be the most effective measure in our model, with the insight that slight limitations often outperform more restrictive approaches.

Our findings may help regulators aiming to regulate platforms, if their goals overlap with one of our four tested dependent variables. With the results suggesting that changes in customer and complementor switching costs as well as complementor inertia have minor effects, and the possibility of changes in customer inertia to be counterproductive, they may focus their efforts on limiting market or revenue shares. While our findings suggest that overshooting the target is also possible within this third tested scenario, a customer share limit of 0.8 or a revenue share limit of 0.7, both while leaving complementor share unregulated, have shown benefits along all four tested dependent variables.

With our model's insights, the effectiveness of the EU's regulatory effort to make Apple switch the iPhone's cable connection from Lightning to USB-C must be questioned regarding its competition benefits, given that it influences switching costs of customers. As a measure to reduce electronic waste, it might nevertheless be beneficial. Measures to artificially increase customer inertia could be implemented through government incentives to customers that switch to small, alternative platforms, committing them to stay on that smaller platform for a specified amount of time. On a state level, this could be seen as a form of development assistance for upcoming competing platforms, ideally leading to a more competitive market or more local alternative offerings.

Applying this idea to complementors, it connects to existing support funds for startups and entrepreneurial activity more broadly but complements the current conditions to receive funding with a pro-competitive dimension. Finally, with leading app stores having commission rates between 10 and 30%, the insight regarding a revenue share limit of 0.7 currently seems of subordinate relevance. Limitations to customer (and complementor) share, however, could be achieved by judging major mergers, and such with potential future significance, more strictly. A prime example here is the past acquisition of Instagram through Facebook, leading to an unchallenged dominance in social media. An even more decided approach would be the breakup of dominant platforms, as has been threatened through the EU's Digital Markets Act [2].

All these measures come at their own cost. While some of our tested measures bring advantages across all four tested dependent variables, there is no free lunch. All the proposed measures will at the very least consume time and money from regulators turning them into effective legislation. With high likelihood, they will also distort market

behavior along further parameters than what has been tested for in this research, with potential negative consequences leading to opportunities for future research.

5.2 Limitations and opportunities for future research

The model used in this research has a range of limitations due to its scope. In many aspects, it has limited heterogeneity, specifically among its agents, but also in parameters like switching costs. Implementing heterogeneity on a wide scale may make the model more realistic and bring further insights. More broadly, the model made substantial simplifications on multiple occasions, e.g., its entire economy including customer income, switching costs as a simple percentage reduction of expected benefits, and the assumption that complementors will always develop a service and do not incur costs for that development. Implementing a more detailed economic system could be another approach to make the model more realistic, and the authors acknowledge that introducing greater agent heterogeneity and validating the model against real-world data would enhance its external validity.

Another simplification was that the three analyzed simulation scenarios were only conducted separately due to computational limitations. A combination of the analyzed measures might yield different results also allowing to explore the interaction effects among measures. This may therefore provide further insights for regulators, as history bears examples that a combination of actions makes for more effective regulation than solitary measures, albeit this paper's specific results for scenario three in parts suggested otherwise.

While literature has proposed multi-homing of customers and complementors as a remedy to strengthen inter-ecosystem competition [24], this model did not implement it, in parts based on the real-world examples that served as inspiration. While other research [41] has already investigated this, it seems like a promising path for further insights that are also close to practical implementation. Future models could therefore focus on multi-homing behavior, besides the other previously discussed limitations of simplified economic assumptions and the separate testing of policy scenarios. Finally, restrictions on market and revenue share have proven to be the most effective measures used in our model, which suggests focusing further research on this area too.

While the limitations may put boundaries on the model's external validity, they also have advantages. The main advantage is to more easily analyze and understand the underlying mechanisms that create the measures' effects and thus to establish cause-effect relationships, which can be translated into means-ends relations for real-world interventions [42, 43]. Based on those findings and acknowledging the cumulative nature of our research, our model provides a sound foundation for future research extending the model presented here [35, 44].

In conclusion, the challenges posed by platforms and their ecosystems are significant and require a nuanced and multidisciplinary approach to regulation. Competition policy must find a balance between promoting consumer welfare, innovation, and competition, albeit this often seems to go hand in hand. At the same time, it is important to recognize the specific challenges posed by platforms and their ecosystems, to ensure that regulation is effective in promoting its goals in improving market landscapes. Platforms and

their ecosystems are key components of the emerging digital economy, and their importance is only set to grow in the coming years.

References

1. Nylen, L., <https://www.bloomberg.com/graphics/2022-tech-antitrust-bill>
2. Paul, K., <https://www.theguardian.com/technology/2022/mar/25/european-union-big-tech-googld-facebook-meta>
3. Ventura, L., <https://www.gfmag.com/global-data/economic-data/largest-companies>
4. Haki, K., Tanriverdi, H., Safaei, D., Schmid, M., Aier, S., Winter, R.: Generativity and Profitability on B2B Innovation Platforms: A Simulation-based Theory Development. *MIS Quarterly* 48, 583-612 (2024)
5. Schmid, M., Haki, K., Aier, S., Winter, R.: Developing Design Principles for Digital Platforms: An Agent-Based Modeling Approach: Research-in-Progress. In: *Lecture Notes in Computer Science*, pp. 195-201. Springer International Publishing, Cham (2020)
6. Jacobides, M.G., Lianos, I.: Regulating platforms and ecosystems: an introduction. *Industrial and corporate change* 30, 1131-1142 (2021)
7. de Reuver, M., Sørensen, C., Basole, R.C.: The Digital Platform: A Research Agenda. *Journal of information technology* 33, 124-135 (2018)
8. Blaschke, M., Haki, K., Aier, S., Winter, R.: Capabilities for Digital Platform Survival: Insights from a Business-to-Business Digital Platform. (2018)
9. Schmid, M., Haki, K., Tanriverdi, H., Aier, S., Winter, R.: Platform Over Market: When Is Joining a Platform Beneficial? *European Conference on Information Systems, Marrakesh* (2021)
10. Haki, K., Blaschke, M., Aier, S., Winter, R., Tilson, D.: Dynamic Capabilities for Transitioning from Product Platform Ecosystem to Innovation Platform Ecosystem. *European Journal of Information Systems* 33, 181–199 (2024)
11. Jacobides, M.G., Cennamo, C., Gawer, A.: Towards a theory of ecosystems. *Strategic management journal* 39, 2255-2276 (2018)
12. Basaure, A., Töyli, J., Mähönen, P.: Regulating data platforms from a value of data approach. *Digital Policy, Regulation and Governance* 27, 369–385 (2025)
13. Hein, A., Schreieck, M., Riasanow, T., Setzke, D.S., Wiesche, M., Böhm, M., Krcmar, H.: Digital platform ecosystems. *Electronic markets* 30, 87-98 (2020)
14. Gao, C., Lan, X., Li, N., Yuan, Y., Ding, J., Zhou, Z., Xu, F., Li, Y.: Large language models empowered agent-based modeling and simulation: a survey and perspectives. *Humanities & social sciences communications* 11, 1-24 (2024)
15. Staub, N., Haki, K., Aier, S., Winter, R.: Governance Mechanisms in Digital Platform Ecosystems: Addressing the Generativity-Control Tension. *Communications of the Association for Information Systems* 51, 906-939 (2022)
16. Asadullah, A., Faik, I., Kankanhalli, A.: Digital Platforms: A Review and Future Directions. *PACIS* 248 (2018)
17. Thomas, L.D.W., Autio, E., Gann, D.M.: Architectural Leverage: Putting Platforms in Context. *Acad Manage Perspect* 28, 198-219 (2014)
18. Kapoor, R.: Ecosystems: broadening the locus of value creation. *Journal of organization design (Aarhus)* 7, (2018)
19. Jenny, F.: Competition law and digital ecosystems: Learning to walk before we run. *Industrial and corporate change* 30, 1143-1167 (2021)

20. Jacobides, M.G., Lianos, I.: Ecosystems and competition law in theory and practice. *Industrial and corporate change* 30, 1199-1229 (2021)
21. Parker, G., Petropoulos, G., Van Alstyne, M.: Platform mergers and antitrust. *Industrial and corporate change* 30, 1307-1336 (2021)
22. Staub, N., Haki, K., Aier, S., Winter, R., Magan, A.: Acquisition of Complementors as a Strategy for Evolving Digital Platform Ecosystems. *MIS Quarterly Executive* 20, 237-258 (2021)
23. Staub, N., Haki, K., Aier, S.: Opportunity or Threat: A Complementors' Perspective on Platform Owner's Acquisitions. 30th European Conference on Information Systems (ECIS 2022), Timisoara, Romania (2022)
24. Biggar, D., Heimler, A.: Digital platforms and the transactions cost approach to competition law. *Industrial and corporate change* 30, 1230-1258 (2021)
25. Banisch, S., Jacob, D., Willaert, T., Olbrich, E.: A dynamical model of platform choice and online segregation. *arXiv* (2024)
26. Kwoka, J., Valletti, T.: Unscrambling the eggs: breaking up consummated mergers and dominant firms. *Industrial and corporate change* 30, 1286-1306 (2021)
27. Cusumano, M.A., Gawer, A., Yoffie, D.B.: Can self-regulation save digital platforms? *Industrial and corporate change* 30, 1259-1285 (2021)
28. Cennamo, C., Ozalp, H., Kretschmer, T.: Platform Architecture and Quality Trade-offs of Multihoming Complements. *Inform Syst Res* 29, 461-478 (2018)
29. Chen, L., Yi, J., Li, S., Tong, T.W.: Platform governance design in platform ecosystems: Implications for complementors' multihoming decision. *Journal of Management* 0149206320988337 (2020)
30. Kirkwood, J.B.: Tech Giant Exclusion. *Florida law review* 74, 63 (2022)
31. Blaschke, M., Haki, K., Aier, S., Winter, R.: Taxonomy of Digital Platforms: A Platform Architecture Perspective. 14th International Conference on Wirtschaftsinformatik (WI2019), Association for Information Systems, Siegen, Germany (2019)
32. Petit, N., Teece, D.J.: Innovating Big Tech firms and competition policy: favoring dynamic over static competition. *Industrial and corporate change* 30, 1168-1198 (2021)
33. Axelrod, R., Cohen, M.D.: *Harnessing Complexity: Organizational Implications of a Scientific Frontier*. Free Press, New York, USA (1999)
34. Wilensky, U., Rand, W.: *An Introduction to Agent-Based Modeling: Modeling Natural, Social, and Engineered Complex Systems with NetLogo*. The MIT Press (2015)
35. Beese, J., Haki, M.K., Aier, S., Winter, R.: Simulation-Based Research in Information Systems: Epistemic Implications and a Review of the Status Quo. *Business & Information Systems Engineering* 61, 503-521 (2019)
36. Beese, J., Haki, K., Aier, S.: On the Conceptualization of Information Systems as Socio-Technical Phenomena in Simulation-Based Research. In: 2015 International Conference on Information Systems (ICIS 2015), Association for Information Systems, Fort Worth, TX (2015)
37. Nan, N.: Capturing Bottom-Up Information Technology Use Processes: A Complex Adaptive Systems Model. *MIS quarterly* 35, 505-532 (2011)
38. Haki, K., Beese, J., Aier, S., Winter, R.: The Evolution of Information Systems Architecture: An Agent-Based Simulation Model. *MIS Quarterly* 44, 155-184 (2020)
39. Kolmar, M.: *Principles of Microeconomics : An Integrative Approach*. Springer International Publishing, Cham (2017)
40. Sargent, R.G.: Verification and validation of simulation models. *Journal of simulation : JOS* 7, 12-24 (2013)

41. Basaure, A., Vesselkov, A., Töyli, J.: Internet of things (IoT) platform competition: Consumer switching versus provider multihoming. *Technovation* 90-91, 102101 (2020)
42. Winter, R., Aier, S.: Design Science Research in Business Innovation. In: Hoffmann, C., Lennerts, S., Schmitz, C., Stölzle, W., Uebernickel, F. (eds.) *Business Innovation: Das St. Galler Modell*. pp. 475-498. Springer Gabler, Wiesbaden (2016)
43. Winter, R., Aier, S.: The Architecture of Project Design Knowledge in Design Science Research. In: Winter, R. (ed.) *Designing the Information Systems Artefact - Typology, Architecture, Abstraction, Collaborative Evolution and Design Patterns*. Springer, Cham (2025)
44. Davis, J.P., Eisenhardt, K.M., Bingham, C.B.: Developing Theory Through Simulation Methods. *Academy of Management Review* 32, 480-499 (2007)