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## Digitalization, copyright and innovation in the creative industries: an agent-based model

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# Digitalization, copyright and innovation in the creative industries: an agent-based model

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**Abstract**

The ambiguity of the empirical results on the relationship between copyright and creativity calls for a better theoretical understanding of the issue, possibly enlarging the analysis to other factors such as technology and copyright enforcement. This paper addresses these complex policy issues by developing an agent-based model (ABM) to study how the interplay between digitization and copyright enforcement affects the production and access to cultural goods. The model includes creators who compete in different submarkets and invest in activities that might lead to the generation of creative outputs in existing submarkets, new (to the creators) submarkets, or in newly "invented" submarkets. Finally, the model features a copyright system that provides creators with the exclusive right to reproduce their original copies and a pirate market responsible for creating and distributing pirated copies.

**Keywords:** Innovation, Intellectual property rights, Creative industries, Copyright, Agent-based models

**JEL classification:** L10 · L82 · O30 · O34 · C63

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# 1 Introduction

A tenet of economic theory is the need for IPR to incentivize innovation and creativity. In fact, without proper appropriation means, of which patent and copyright are major examples, inventors and creators can not recoup the investment determining underprovision of innovations and creative works. The empirical testing of such a statement is not straightforward. For the case of patents, Budish et al. (2016) discuss the empirical challenge of identifying a causal relation between patents and innovative activities. Their review of the empirical literature indicates inconclusive results, as they are highly dependent on the context and level of analysis (Sakakibara and Branstetter, 2001; Qian, 2007).

In the case of copyright, Giorcelli and Moser (2020) examine the effect of copyright protection on the development of new operas in Italy during the Napoleonic age. Their results indicate that copyright adoption leads to a significant increase in the number of newly created operas and their quality (measured as numbers of performance and longevity). However, the strengthening of copyright protection (i.e. the extension of the protection beyond the creator's life) does not have any further effect. While this paper presents a strong identification strategy, it is doubtful that we can extend the results to other cultural goods and to modern times.

A challenge to the positive relation between IPR, innovation and creativity is also posed by the increasing literature documenting how creativity might thrive in industries characterized by low or no copyright enforcement.[1] Examples of these cases are "haute cuisine" (Fauchart and von Hippel, 2008), adult entertainment industry (Darling, 2014), fashion (Raustiala and Sprigman, 2006), and stand-up comedians (Oliar and Sprigman, 2008).[2]

Concerning the consumption of cultural goods such as movies, music, and games, economists have studied whether illegal access channels such as photocopying and file-sharing might harm copyright owners with inconclusive results. As summarized in Liebowitz (2005), file-sharing harms copyright owners through different channels such as substitution effect (i.e. consumers decide to access a cultural good through illegal channels rather than legal channels) or a delay effect (i.e. consumers postpone the legal consumption). Using different data sources, some studies indeed identify a negative relation between piracy and legal consumption (Michel, 2006). However, a positive effect is also plausible because illegal consumption might introduce consumers to music, films and games and, therefore, might promote demand. Furthermore, illegal consumption might drive demand for complementary goods such as concerts for music. Indeed, Aguiar (2017)

[1]For a definition and a taxonomy of Negative IP space see Rosenblatt (2011).

[2]See Raustiala and Sprigman (2012) and Darling and Perzanowski (2011) for a collection of case studies.

finds a positive relation between free streaming and consumption. Moreover, evidence from French universities shows that piracy increased video rentals and purchases (Bounie et al., 2006). It is worth to highlight that these studies focus on impacts on copyright owners. However, the increased accessibility of culture also through illegal channels has an overall positive welfare effect (van Eijk et al., 2010).

The ambiguity of the empirical results calls for a better theoretical understanding of the issue, possibly enlarging the analysis to other factors such as technology and copyright enforcement.[3] Digitalization has brought about the Golden Age of entertainment. Product variety and availability to consumers have indeed exploded thanks to digitization. Even from a producer point of view, threats to revenues have gone hand in hand with cost reductions (Waldfogel, 2017). Also, copyright enforcement could discourage illegal consumption. However, Rayna (2004) discusses that, even if piracy might be an innovation-killer, it might facilitate innovation and a high level of IPR protection creates additional market distortions, and, consequently, a loss of welfare.

This paper addresses these complex policy issues by developing an agent-based model (ABM) to study how the interplay between digitization and copyright enforcement affects the production and access to cultural goods. ABMs provide a way to explore scenarios and understand interactions through simulations. These models study from the bottom-up the behaviour of consumers without the need for theoretically-restrictive consistency assumptions (e.g. full rationality). Furthermore, ABMs can account for both institutional and technological characteristics of different industries and markets. Thus, to our purpose, they may provide a strong tool to analyze how creators and, more generally, industry dynamics behave under different scenarios related to copyright enforcement and to the intensity of digitalization. Our model is a re-adaptation of the industry agent-based model developed by Dosi et al. (2021). While the latter model focuses on the role of patent protection in the pharmaceutical sector, its flexibility allows us to include some key mechanisms that represent the working of the creative industries.

The model includes creators competing in different submarkets, which might correspond to different genres (of music, movies, etc.). Although the model could represent the functioning of different cultural industries, for illustrative purposes, we will focus on the movie industry. Creators invest in three types of activities which might lead to the generation of creative outputs in existing submarkets, or in new (to the creators) submarkets, or in newly "invented" submarkets. The model features a copyright system that provides movie creators with the exclusive right to reproduce their original movies. At the same time, the model embeds a pirate market which is responsible for the creation and distribution of pirated copies of original movies. Depending on the strength of copyright enforcement

[3] For an overview of the theoretical literature see Belleflamme and Peitz (2010).

and on the level of digitalization, consumers will be more or less likely to obtain pirated copies of movies.

Preliminary results indicate that the model is able to replicate stylized facts of a representative creative industry such as the movie industry (Hadida, 2009; Hennig-Thurau et al., 2019; Vogel, 2020; Hennig-Thurau et al., 2021). Furthermore, policy experiments introducing some shock to the parameters associated to the strength of copyright enforcement and to the effects of digitalization highlight their overall impact. More specifically, stronger copyright enforcement supports creators' profits, hampering the emergence of the pirate market. Yet it also leads to higher prices, less demand and ultimately lower consumer welfare. Digitalization, on the other hand, exhibits positive effects on profitability while also driving price reductions and higher market demand.

The paper is structured as follow: Section 2 describes all the steps and features of the model. Section 3 and 4 illustrate, respectively, the methodology and results. Conclusions will follow.

## 2 The model

The model formulation is general enough to represent the dynamics of different cultural goods (e.g. movie, music, and games). However, to ease the reading and understanding of the model we will use the movie industry as an example. The model includes $N$ creators (i.e. creative individuals or firms, indexed by $i$) competing in different submarkets (i.e. movie genres, indexed by $j$). New genres emerge over time as a result of creative processes. Competition in each genre takes place via the development and production of new movies. A submarket (genre) is modelled as a bi-dimensional product space with coordinates $x$ and $y$ being two discrete measures of movie quality. Hence, a movie produced by creator $i$ at time $t$, belonging to genre $j$ can be represented by the pair of coordinates: $x^j_{i,t}, y^j_{i,t}$. The overall quality of a movie is assumed to be simply additive: $x^j_{i,t} + y^j_{i,t}$.

The model examines the dynamics of the creative process looking at creators' investment decisions and the different creative outcomes, and at competition both in the legal and illegal markets. Furthermore, the model features a copyright system that provides creators with the exclusive right to reproduce their original movies and a pirate market which is responsible for the creation and distribution of pirated copies of original movies.

All these events take place at different steps according to the following timeline:

1. Creators set their expenditures for movie development and allocate them to three different types of development activities. Namely: (i) develop a higher quality movie in a genre where they are already active; (ii) diversify into an existing genre where

they are not yet active; (iii) discover a new movie genre.

2. An illegal copy of newly developed movies is introduced in the pirate market.

3. Market competition starts in the two different markets. Creators set prices for their original movies, while the price of pirate copies is generally lower. Consumers discount the risks associated with being prosecuted for copyright infringement when acquiring an illegal movie in their buying decisions. At the end of this process, creator-specific sales are computed in each submarket, as well as sales for pirated copies. Creator profits are also determined.

4. Creators stop producing and distributing movies with market shares below a minimum threshold. Similarly, also pirated copies exit the market when market shares are below a certain threshold. A creator exits when market shares for all its movies are below the threshold. New creators enter the markets, replacing exiting creators.

In the next subsections we are going to presents all the details of each phase of the timeline.

## 2.1 Creativity in the movie industry

The creative process and its outcomes are described by two steps. First, creators invest a constant share ($s$) of their past sales in order to face the costs associated to the development of new movies:

$$I_{i,t} = s^I \; sales_{i,t-1}, \tag{1}$$

where $s^I \in (0, 1)$. Movie creators are assumed to split their investment into three different types of development activities possibly leading to different outcomes: (A) they invest to produce new movies in genres where they are already active; (B) they strive to diversify along existing genres; (C) finally, a share of investment is devoted to the discovery of new genres which eventually replace older ones. Accordingly, $I$ is divided between these three activities according to fixed shares (labelled using letters $A$, $B$ and $C$):

$$I^A_{i,t} = s^A I_{i,t}, \tag{2}$$

$$I^B_{i,t} = s^B I_{i,t}, \tag{3}$$

$$I^C_{i,t} = (1 - s^A - s^B) I_{i,t}, \tag{4}$$

where $s^A, s^B \in [0, 1]$ and $(s^A + s^B) \leq 1$.

Movie development is uncertain and it is modelled as a two-step stochastic process. In the first step, a Bernoulli draw determines whether the producer is successful in developing a new movie. The probability of success is positively influenced by the extent of the investment:

$$p^A_{i,t} = pmax^A(1 - e^{-\theta^A I^A_{i,t}}), \tag{5}$$

$$p^B_{i,t} = pmax^B(1 - e^{-\theta^B I^B_{i,t}}), \tag{6}$$

$$p^C_{i,t} = pmax^C(1 - e^{-\theta^C I^C_{i,t}}), \tag{7}$$

with $pmax^A$, $pmax^B$, $pmax^C \in (0, 1)$ and $\theta^A$, $\theta^B$, $\theta^C > 0$. The exponential parameters ($\theta^A$, $\theta^B$, $\theta^C$) account for industry-wide factors that positively affect innovation probabilities.

If a creator is successful in one of the three activities, it will be able to produce a new movie. Notice that creators may eventually be successful in all the three activities at the same time, that is, they may introduce at most three new movies at any time step.

The second step depends on which activities are successful and the development process determining the characteristics of newly created movie, i.e. the submarket (genre) and its location in the product space (quality).

When a creator is successful in activity A, there will be a *quality improvement* as the creator will develop a new movie, with higher quality, in a genre in which it has already experience (i.e. it has produced another film in the past). For simplicity, we assume that each creator is allowed to distribute only one movie per genre, that is, as a new movie is produced, it replaces the older one in the same genre. Hence, if creator $i$ is successful in type A activity, first, he will randomly pick a genre where it already operates (let us label the selected submarket with $j^*$). Then, it will simply add a quality shock to its previous film quality in that genre. Hence, the new movie will have coordinates:

$$x^{j^*}_{i,t} = x^{j^*}_{i,t-1} + u^x_{i,t}, \tag{8}$$

$$y^{j^*}_{i,t} = y^{j^*}_{i,t-1} + u^y_{i,t}, \tag{9}$$

where $x^{j^*}_{i,t-1}$ and $y^{j^*}_{i,t-1}$ account for the two dimensions of quality for the movie previously produced by creator $i$ in genre $j^*$, and $u^x$, $u^y$ are idiosyncratic shocks from a discrete uniform distribution with positive support.

When a creator is successful in activity B, we will observe a *diversification into existing genres*, as the creative process will allow creators to enter in an existing genre and, thus, to diversify their movie portfolio. After being successful in activity B, the creator will simply randomly draw a genre where it is not currently operating (let us label it $j^{NEW}$). Then, it will draw an initial quality level (initial location in the product space) as:

$$x_{i,t}^{j^{NEW}} = \bar{x}_{t-1}^{j^{NEW}} + \epsilon_{i,t}^{x}, \tag{10}$$

$$y_{i,t}^{j^{NEW}} = \bar{y}_{t-1}^{j^{NEW}} + \epsilon_{i,t}^{y}, \tag{11}$$

where $\bar{x}_{t-1}^{j^{NEW}}$ and $\bar{y}_{t-1}^{j^{NEW}}$ are the weighted averages (by market shares) of $x$ and $y$ in genre $j^{NEW}$, and $\epsilon^x$, $\epsilon^y$ are idiosyncratic shocks from a discrete uniform distribution.

Finally, when a creator is successful in activity C, there will be the *discovery of a new genre*. This last type of successful creative process can be understood as a "radical" type of innovation in which a new genre (i.e. a submarket) emerges. Define $J$ as the number of existing genres at $t-1$, then the creator will come up with the new genre $J+1$. The initial movie quality in $J+1$ will be randomly drawn in the ranges $[1, Xinit]$ and $[1, Yinit]$, where $Xinit$ and $Yinit$ account for the initial quality opportunities. The innovative creator will be the first mover and it will add the genre to its portfolio. In subsequent periods, second-movers will be allowed to join the new genre (via diversification, i.e. innovation type B).

## 2.2 The pirate market

Following the creative process that determines the quantity and the quality of the new releases, the illegal market emerges. We assume that there is a single producer and distributor of pirate copies that competes with movie creators. The pirate seller simply reproduces the contents created by creators and offers them to consumers at different (possibly lower) prices, as will be discussed in the next section. Anytime a creator develops a new movie, we assume that a pirate copy is immediately made available to consumers with quality coordinates:

$$\widehat{x}_{i,t}^{j} = (1-\Psi)x_{i,t}^{j}, \tag{12}$$

$$\widehat{y}_{i,t}^{j} = (1-\Psi)y_{i,t}^{j}, \tag{13}$$

with $\Psi \geq 0$. Thus, consumers can always choose whether to buy their products from the original creator or in the private market with a quality discounted by a factor $\Psi$ (when $\Psi = 0$, the pirate seller is able to offer copies of the exact same quality of the original).

## 2.3 Pricing and market dynamics

Both the creators and the pirate sellers set the prices for their products according to markup rules. In each submarket, the price charged by the creator is:

$$p^j_{i,t} = (1 + m^j_{i,t})(\frac{uc}{1+\beta}), \tag{14}$$

where $uc$ is an exogenous unit cost for distribution, $\beta$ is a discount factor, and $m$ is a genre- and creator-specific markup. The parameter $\beta$ can be interpreted as a proxy of the strength of digitalization, which reduces the costs of distribution and allows creators to charge lower prices.

Instead, in each submarket, the price charged by the pirate seller is:

$$\widehat{p}^j_{i,t} = \pi^j_{i,t} p^j_{i,t}, \tag{15}$$

where $\pi$ is a uniform idiosyncratic shock with support $[\pi^{min}, \pi^{max}]$ and $0 < \pi^{min} < \pi^{max} < 1$. Hence, the term $\pi$ accounts for the price reduction when buying the illegal copy. Nevertheless, consumers do not only take into account the effective price paid but also discount the potential costs associated to the risk of being prosecuted for copyright violation. Let us define the perceived price for an illegal copy as:

$$\widehat{\widehat{p}}^j_{i,t} = (\pi^j_{i,t} + CopEnf) p^j_{i,t}, \tag{16}$$

where $CopEnf$ is a proxy for the strength of copyright enforcement (i.e. a proxy of the expected costs related to copyright infringement). The role of this parameter is to reduce (and eventually overturn, if $\pi^j_{i,t} < CopEnf$) the price advantage of pirate copies. Notice that for original movies the perceived price coincides with the effective one.

When a creator enters in a new genre, the initial markup is drawn from a uniform distribution defined over $[m^{min}, \widehat{m}]$, which reflects creators' initial pricing decisions. Markups are updated at any time step according to the dynamics of market power. More specifically, we assume a discontinuous adjustment in the form:

$$m^j_{i,t} = \begin{cases} min\{m^j_{i,t-1} + v^j_{i,t};\ m^{max}\}, & \text{for } g(sales)^j_{i,t-1} \geq \tau \\ m^j_{i,t-1}, & \text{for } \rho < g(sales)^j_{i,t-1} < \tau \\ max\{m^j_{i,t-1} - v^j_{i,t-1};\ m^{min}\}, & \text{for } g(sales)^j_{i,t-1} \leq \rho, \end{cases} \tag{17}$$

where: $\tau > 0$; $\rho < \tau$ and $m^{max} > m^{min} > 0$. The parameters $m^{max}$ and $m^{min}$ impose respectively upper and lower bounds on markups. The term $g(sales)$ stands for the growth rates of sales experienced by the creator in submarket $j$, while $\tau$ and $\rho$ represent thresholds above (or below) which the creator will adjust its markup. Moreover, $v$ is a stochastic shock from a uniform distribution with support $[v^{min}, v^{max}]$. Intuitively, markup adjustments occur as a result of sufficiently large variations in market power (as proxied by past sales growth).

Total demand in each submarket ($D^j$) evolves according to a logistic function of time:

$$D_t^j = \frac{D_j^{final}}{1 + e^{-\gamma_D (t - t_0^j)}}, \tag{18}$$

with $D^{final}$, $\gamma_D > 0$. The term $t_0^j$ stands for the time step when the genre was first discovered, $D^{final}$ is the final level of demand and $\gamma_D$ accounts for the speed of saturation. We assume that $D^{final}$ is heterogeneous across submarkets, accounting for more or less mainstream genres. Specifically, every time a new genre is discovered, $D^{final}$ is drawn from a uniform distribution with support $[D^{min}, D^{max}]$ with: $D^{max} > D^{min} > 0$. At the same time, demand for other genres is scaled down uniformly by a factor $\eta D^{final}$ (with $\eta \in [0, 1]$), thus, accounting for demand substitution across genres. The parameter $\eta$ shall also be interpreted as inversely related to the intensity of digitalization in the industry, since it is plausible to assume that digitalization provides users with easier access to movies and mitigates demand substitution effects. When demand for a genre reaches a quasi-zero threshold ($D^{tr}$), it stays at that level, i.e. outdated genres converge to a minimum demand level.

Total demand for each genre is then allocated to individual creators (and to pirate copies) via a process of market selection. More specifically, we use a quasi-replicator dynamics to determine creators market shares ($f$) according to their competitiveness (or fitness, $fit$), defined as:

$$fit_{i,t}^j = \frac{x_{i,t}^j + y_{i,t}^j}{1 + p_{i,t}^j}. \tag{19}$$

Thus, in each submarket $j$, product fitness is measured as a price-discounted quality. Symmetrically, the fitness of a pirate copy is:

$$\widehat{fit}_{i,t}^j = \frac{\widehat{x}_{i,t}^j + \widehat{y}_{i,t}^j}{1 + \widehat{p}_{i,t}^j}, \tag{20}$$

where the fitness for pirate copies takes into account the perceived price ($\widehat{p}$) which includes the copyright enforcement parameter ($CopEnf$).

Then, market shares are computed as:

$$f_{i,t}^{j} = f_{i,t-1}^{j}(1 + \mu \frac{fit_{i,t}^{j} - \bar{fit}_{t}^{j}}{\bar{fit}_{t}^{j}}). \tag{21}$$

The parallel market share for the copy is:

$$\widehat{f}_{i,t}^{j} = \widehat{f}_{i,t-1}^{j}(1 + \mu \frac{\widehat{fit}_{i,t}^{j} - \bar{fit}_{t}^{j}}{\bar{fit}_{t}^{j}}), \tag{22}$$

with $\mu > 0$. The variable $\bar{fit}$ represents the weighted average fitness in submarket $j$, while the parameter $\mu$ accounts for the strength of competition and market selection.[4] In economic terms, the quasi-replicator equation implies that creators that are more efficient than the average (i.e. those producing high-quality movies and charging low prices) will expand relatively to their competitors in the same submarket. When a creator discovers a new submarket its initial market share is set to one, while, as a creator enters in an existing submarket, it starts with a near-zero market share ($f^{min}$).

Creators' total sales are then computed aggregating sales from each movie:

$$sales_{i,t} = \sum_{j \in P_{i,t}} f_{i,t}^{j} D_{t}^{j}, \tag{23}$$

where $P$ is the set of genres where creator $i$ operates at time $t$. Accordingly, total profits are computed subtracting investment costs ($I$) and unit costs ($Q_{i,t}\frac{uc}{1+\beta}$) from total sales:

$$\Pi_{i,t} = sales_{i,t} - I_{i,t} - Q_{i,t}\frac{uc}{1+\beta}, \tag{24}$$

where $Q_{i,t}$ stands for the number of copies sold by creator $i$ at time $t$.[5]

In a similar way we aggregate total sales for the pirate distributor:

$$sales_{i,t} = \sum_{j \in J_t} \sum_{i \in S_{j,t}} \widehat{f}_{i,t}^{j} D_{t}^{j}, \tag{25}$$

where $J_t$ is the number of existing genres at time $t$ and $S_{j,t}$ is the set of creators competing in genre $j$ at time $t$.

[4]Specifically, the variable $\bar{fit}$ is computed as: $\bar{fit}_{t}^{j} = \sum_{i \in S_{j,t}}(fit_{i,t}^{j} f_{i,t-1}^{j} + \widehat{fit}_{i,t}^{j} \widehat{f}_{i,t-1}^{j})$, where $S_{j,t}$ is the set of creators competing in submarket $j$ at time $t$.

[5]The number of copies is simply computed as: $Q_{i,t} = \sum_{j \in P_{i,t}} \frac{sales_{i,t}^{j}}{p_{i,t}^{j}}$.

### 2.4 Creators entry and exit

Finally, at the end of each round, creators abandon less profitable genres. Specifically, we assume that they leave a submarket when their market share is below a minimum threshold ($f^{min}$). In a similar fashion, copies with market shares below the threshold are removed from the pirate market. When a creator exits from all the submarkets it is considered dead and replaced by an entrant, thus keeping fixed the total number of creators. Entrants first randomly draw a genre and then pick their initial quality by adding a discrete uniform shock (with support: $[\lambda, \omega]$) to the weighted averages of incumbents' $x$ and $y$.[6]

# 3 Methodology

The complexity of an ABM model does not allow for a closed-form analytical solutions. Hence, model properties and results are analyzed by means of Monte Carlo simulations (25 runs). The Monte Carlo approach allows us to remove the potential confounding effects stemming from the different realizations of random shocks (Fagiolo et al., 2019).

Regarding initial conditions, we generate 50 identical creators and assign them to a random location in a single product space. Pirate copies of the 50 movies produced by legitimate movie producers are also generated at the beginning of the simulation and are assigned a zero market share. The standard length of a simulation is 100 time steps.

An important aspect of ABM models is the choice of the initial parameters which are reported in Table A.1. The choice of the parameters follows an indirect calibration approach commonly adopted in agent-based modelling and based on the collection of secondary sources (Hadida, 2009; Hennig-Thurau et al., 2019; Vogel, 2020; Hennig-Thurau et al., 2021). Specifically, we set parameters in order to get an empirically validated baseline scenario in which the model replicates some basic stylized facts of the movie industry (observable parameters, nevertheless, are set within realistic ranges). Indeed, in the next Section we will investigate empirical consistency of the baseline scenario by contrasting the model outcomes with real world features of the movie industry. After validating the model, we will perform policy experiments introducing some shock to the parameters associated to the strength of copyright enforcement and the effects of digitalization to highlight their overall impact.

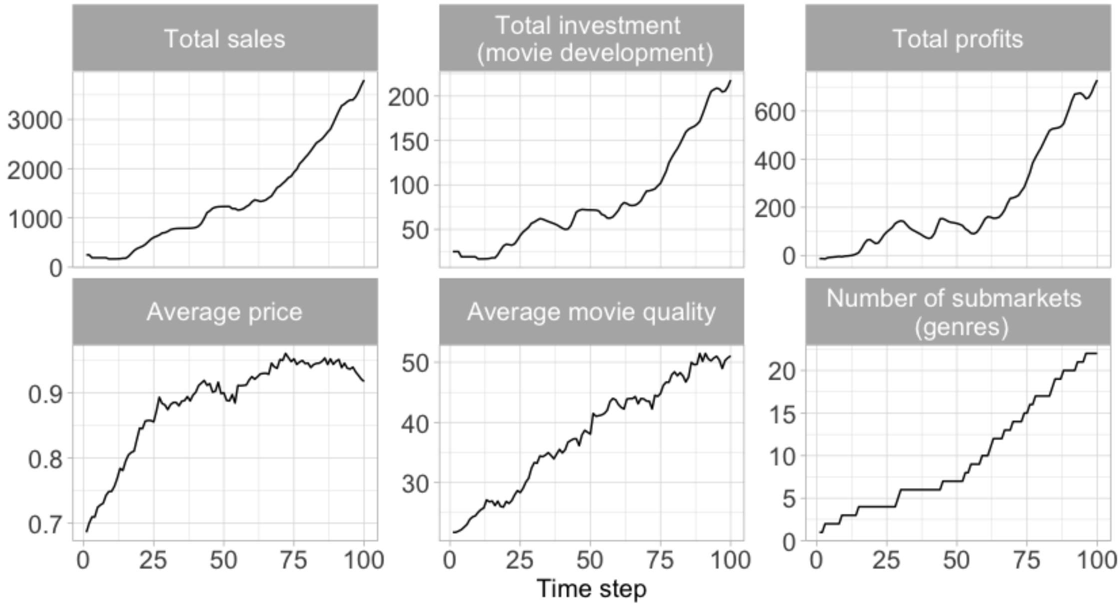
[6]The initial market share of the entrant is $f^{min}$ and the initial markup charged on its product is drawn from a uniform distribution with support $[m^{min}, \widehat{m}]$.

# 4 Results

## 4.1 Baseline run

For a baseline scenario the model generates results that are in line with empirically observed patterns. Figure 1 reports the dynamics of some variables such as total sales, investments, profits, and average prices.

Figure 1: Baseline run: time series of main industry-level variables



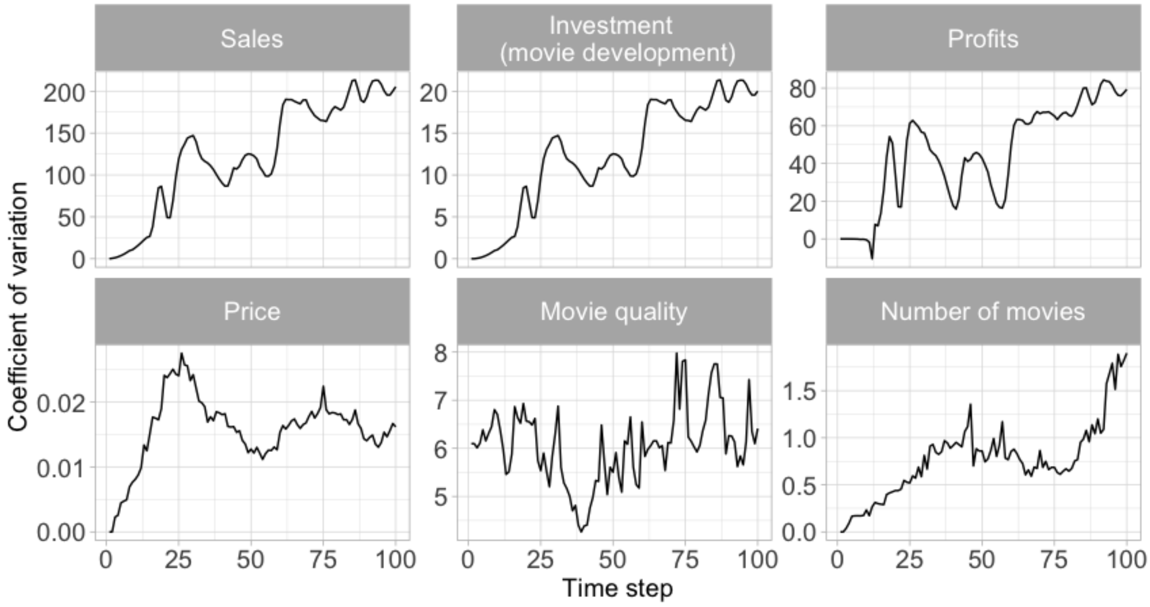

*Notes*: The figure shows the evolution over time of some main industry variables for the baseline run.

Figure 1 highlights that the industry grows over time as a result of the emergence of new genres which foster additional demand opportunities. The growing size of the industry also entails increasing total profits and investments in movie development which ultimately drive movie quality enhancements and the arrival of new genres. Consistently with empirical findings (Hennig-Thurau et al., 2019), the model yields relatively high innovation frequencies as 25 new genres are discovered in 100 time steps and the average movie quality grows at about a 2% rate per period.

A second relevant pattern concerns creator heterogeneity. As shown in Figure 2, starting from identical initial conditions, creators become heterogeneous (as measured by the coefficient of variation) over time along several key dimensions including profits, size, prices, the quality of the movies produced as well as the number of genres where they are operating. As a result of innovation, they differentiate and move in the product space (cf. Figure 6 describing creator position in the product space in a single submarket).

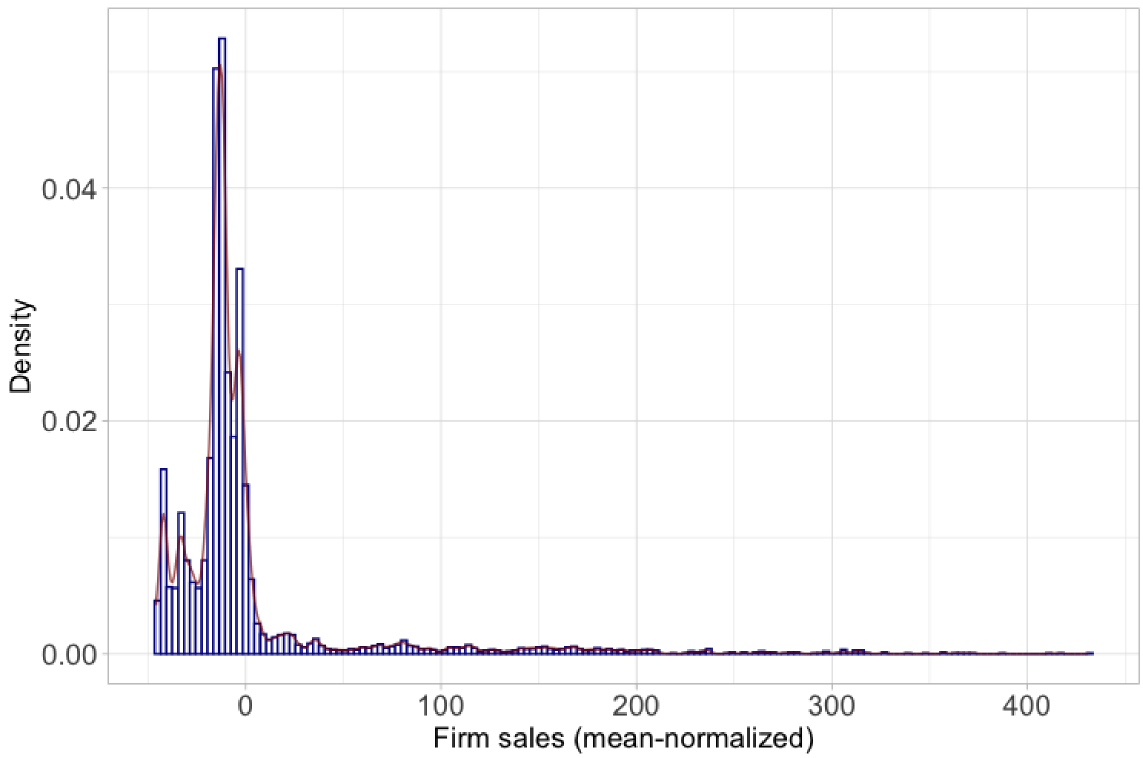
Figure 3 depicts the distribution of creator size which is right-skewed. Such distribution

Figure 2: Baseline run: emerging heterogeneity (coefficient of variation) over time



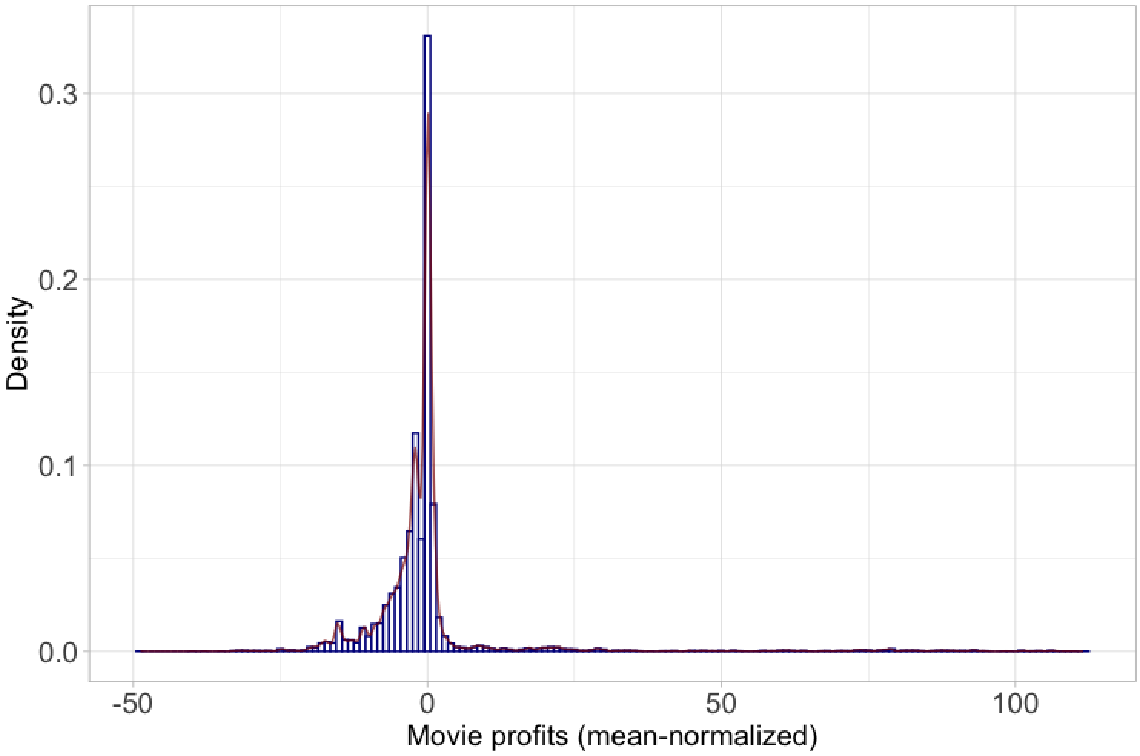

*Notes*: The figure shows the evolution over time of emergent heterogeneity among creators for a baseline run, captured by the coefficient of variation within each time step, for different indicators.

Figure 3: Baseline run: distribution of creator size




*Notes*: The figure shows the pooled (across time steps) distribution of creator sales. Sales are mean-normalized by removing their time-specific mean.

Figure 4: Baseline run: distribution of movie profits




*Notes*: The figure shows the pooled (across time steps) distribution of movie profits. Profits are mean-normalized by removing their time-specific mean.

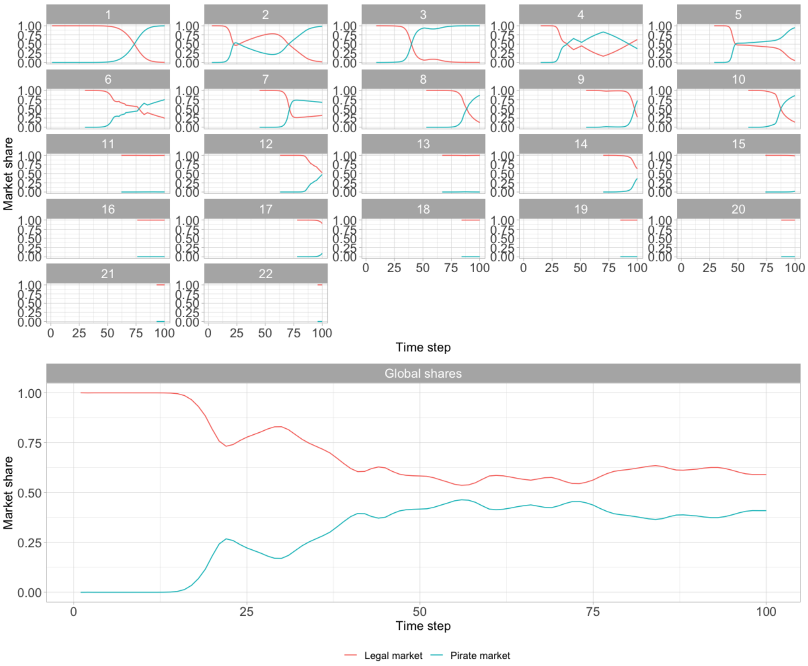
implies a highly concentrated market structure revealing the co-existence of two market clusters, i.e. the independent one, which is characterized by small creators with low market shares, and the commercial one, with few large entertainment producers. This particular industry structure is consistent with some empirical studies (see e.g. Hennig-Thurau et al., 2019).

Figure 4 reports the profit density for single movies. Returns on single movies are largely heterogeneous as well, with many misses and few hits (Vany and Walls, 1996; Hadida, 2009), that account for the majority of the industry's profits.

Our baseline scenario also features the emergence of a pirate market coexisting with a legal one. Figure 5 shows the evolution of market shares in all the genres (i.e. submarkets) and in the global industry. Note that heterogeneity emerges also across submarkets, such that this indicates the presence of niches where either illegal or legal consumption prevails.

Figure 6 shows the positioning of original and pirate copies in the product space for a single submarket, at three different time steps. Illegal copies have slightly lower quality than their legal counterparts, but prices are lower in the pirate market (cf. Fig. 7). As a consequence, pirate copies of original movies gain a large share of total demand. Yet,

Figure 5: Baseline run: dynamics of market shares in each submarket and in the global industry




*Notes*: The figure shows the dynamics of market shares for the legal and the pirate market. Top panels show the dynamics in specific genres while the bottom panel represents the global industry.

a minimum degree of copyright enforcement is enough not to allow pirate movies to completely dominate the market.

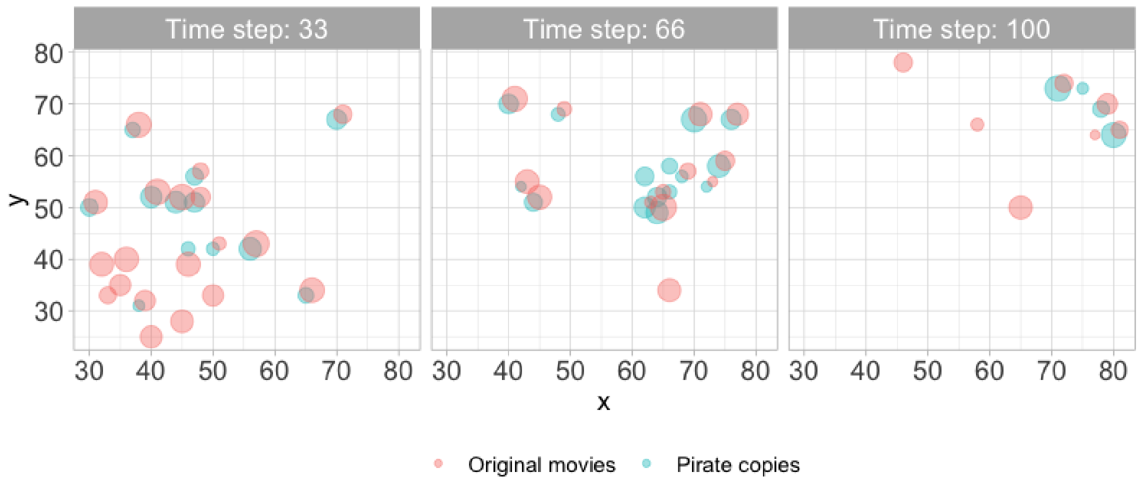
In this baseline setting, we calibrated the copyright enforcement parameter ($CopEnf$) in order to generate a scenario wherein both the pirate and the legal market gain approximately half of industry demand.

Taken together, these results indicate that the model quite successfully generates outcomes matching broadly-established empirical patterns of the motion picture industry. Starting from such empirically validated setting, we introduce in the next section shocks to copyright policy and technology and investigate the effects on industry dynamics and welfare.

### 4.2 Copyright enforcement and strength of digitalization: policy scenarios

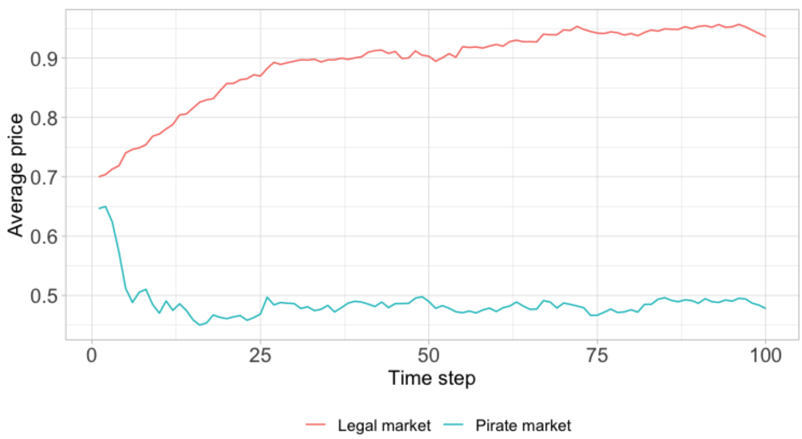
In this section we implement different simulation experiments focusing on the role of copyright enforcement and digitalization in the industry.

Figure 6: Baseline run: creators' position and size in a single submarket




*Notes*: The figure shows creators' position in the product space and size at three different time steps in submarket 1. Bigger dots represent creators characterized by larger size.

Figure 7: Baseline run: the pirate charges lower prices




*Notes*: The figure shows creators' evolution over time of average prices respectively in the legal and pirate market.

### 4.3 Highlighting the role of digitalization and the illegal market

As a first exercise, we investigate a scenario removing simultaneously the effects of digitalization ($\beta = 0$ and higher demand substitution, i.e. $\eta = 0.5$) and of the pirate market. This is intended to mimic the characteristics of the industry prior to the major transformations driven by the arrival of digital technologies.[7] Figure 8 contrasts the outcomes of such "no digitalization" scenario with our baseline run.

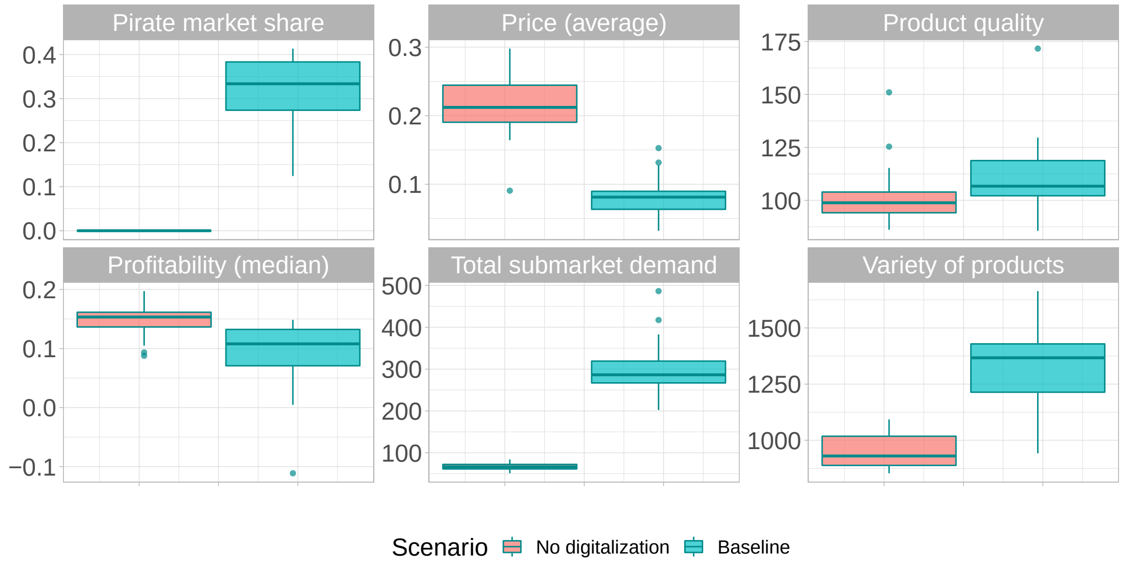
In our model, the advent of digitalization reduces prices via lower unit costs and thanks to the joint rise of the pirate market offering cheaper illegal copies. At the same time, it increases total industry demand via lower demand stealing effects when a new genre is discovered. Moreover, in the "no digitalization" world, consumers face lower movie variety and quality. Thus, results suggest that digitalization has a strong positive impact on consumer welfare. The effects on profitability, instead, are *a priori* uncertain since, on the one hand, the advent of digitalization entails higher demand and profitability while, on the other, it also fosters the emergence of the pirate market which harms firm profits. In the model we find a mildly negative effect on profitability, suggesting that the second effect (i.e. emergence of pirate market) appears to dominate over the positive impact on industry demand. Notice, however, that this crucially depends on the parametrization of demand substitution effects in the baseline run. Indeed, assigning a lower $\eta$ (i.e. digitalization reduces even more demand substitution among genres) would probably reverse the negative effect on profitability.

### 4.4 Highlighting the role of copyright enforcement

The second exercise tackles the central policy question of this work and studies the effects of copyright enforcement on different dimensions of welfare. In Figure 9 we show results for different values of the $CopEnf$ parameter which regulates the risks and costs perceived by consumers when buying an illegal copy of an original movie. As expected, stronger enforcement of copyright implies lower market shares for pirate copies as consumers will be discouraged from buying illegal copies. Yet, consumers will also face higher prices as they switch to buying movies in the legal market and this, in turn, leads to lower industry demand. Stronger copyright seems to spur more product variety as it partially incentivizes innovation of movie producers. Quite surprisingly, similar effects do not emerge on movie quality which instead decreases slightly as copyright enforcement becomes stronger. Concerning creators profitability, as expected, stronger copyright enforcement fosters the profitability of movie producers by hurting the competition of the pirate creator. Hence,

[7] For simplicity, the pirate market is switched off in this simulation setting as, prior to the advent of digitalization, the production and circulation of illegal copies was much more difficult and less widespread.

Figure 8: What is the role of digitalization?



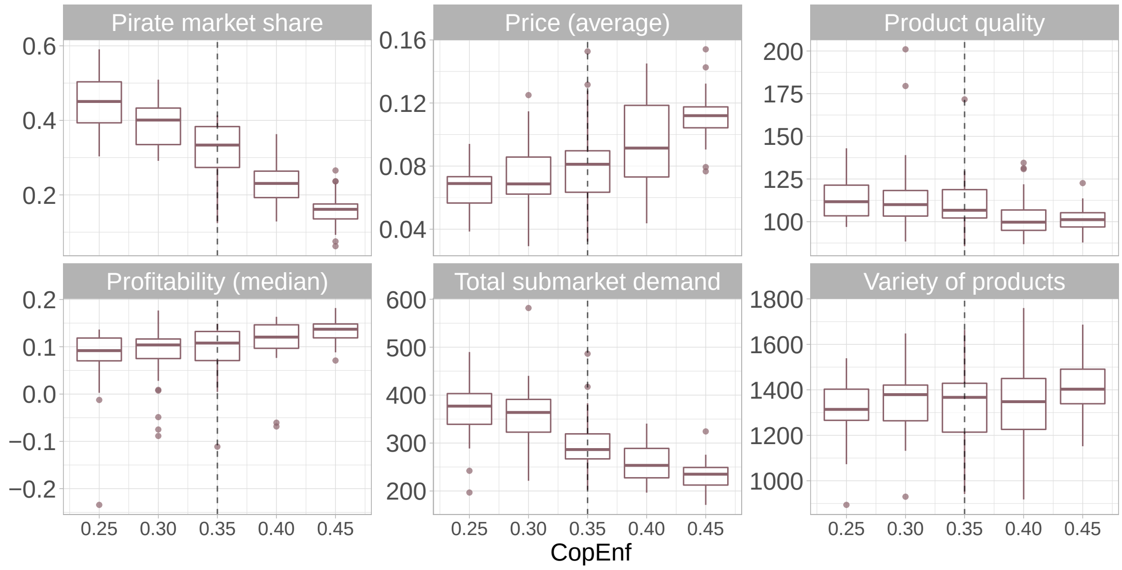

*Notes*: Monte Carlo distributions for scenario with no digitalization and for the baseline with digitalization, across selected variables. The variables considered are respectively: (i) the pirate market's average market share; (ii) average prices, weighted by market shares; (iii) an indicator of product quality at the frontier, measured as: $\frac{1}{J}\sum_{j=1}^{J} X_T^j + Y_T^j$; (iv) median profitability across legal creators; (v) average total demand per submarket; (vi) product variety in terms of total number of products discovered.

the model suggests an important trade-off associated to the enforcement of copyright laws in the movie industry: by implementing stronger enforcement the policy-maker may preserve creator profitability at the cost of imposing higher prices on consumers, reducing market demand and movie quality, albeit with a mild positive effect on product variety.

## 4.5 Highlighting the role of larger diffusion of digitalisation

As a final simulation experiment, we analyze settings increasing the intensity of digitalization. Figure 10 reports the results of the model at different levels of the $\beta$ parameter, which regulates the digitalization impact on unit costs. A first direct effect is on prices since lower unit costs entail lower prices and higher market demand, as already depicted in Figure 8. More interestingly, higher intensity of digitalization holds back the rise of the pirate market, as reflected by a lower market share for pirate copies. Intuitively, insofar as digitalization drives down the price of movies, it also limits the room for achieving price advantages for the pirate firm, thus, hampering their competitiveness. In turn, this has a positive effect on the profitability of movie producers and a slightly positive impact on movie variety, while movie quality seems to remain unaffected. To summarize, our results suggest that fostering digitalization may act as a welfare-enhancing substitute for stronger copyright enforcement since it is effective as well in contrasting the pirate market, while,

Figure 9: Varying the strength of copyright enforcement




*Notes*: Monte Carlo distributions for different values of copyright enforcement, across selected variables. The dashed line represents the baseline scenario. The variables considered are respectively: (i) the pirate market's average market share; (ii) average prices, weighted by market shares; (iii) an indicator of product quality at the frontier, measured as: $\frac{1}{J}\sum_{j=1}^{J} X_T^j + Y_T^j$; (iv) median profitability across legal creators; (v) average total demand per submarket; (vi) product variety in terms of total number of products discovered.

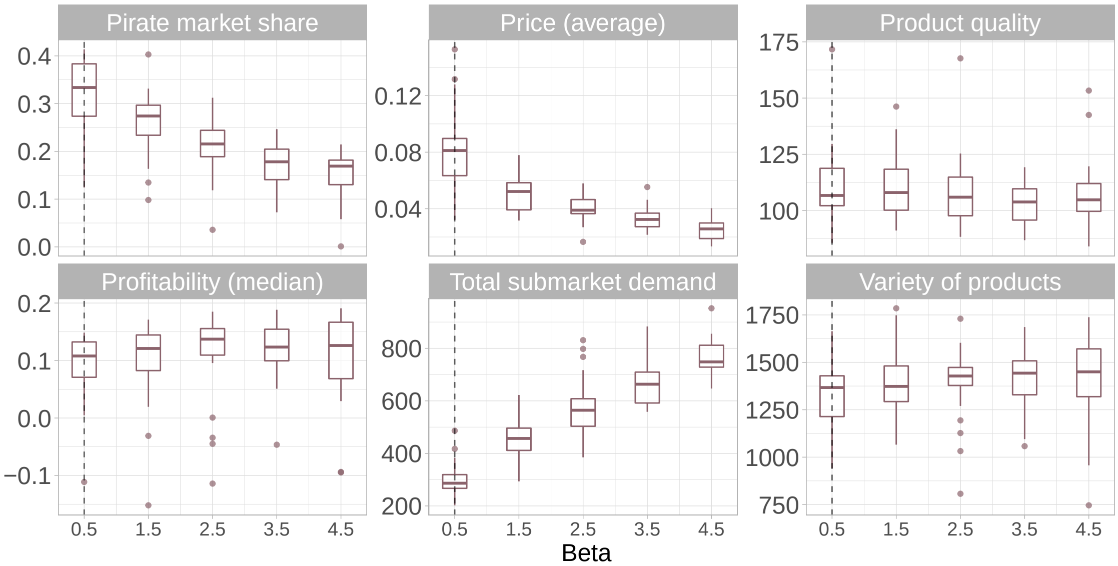
contrarily to enforcing stronger copyright laws, it also entails higher consumer welfare.

# 5 Conclusion

This paper develops an agent-based model (ABM) to study how digitization and copyright enforcement affect cultural goods production and access. The advantage of such approach is the possibility to account for the complex relations between creators' incentives, creative outcomes and market dynamics, while also considering technological and institutional factors.

Building on the modelling framework in Dosi et al. (2021), we developed a new model tailored on the characteristics of creative industries. Our model includes creators competing in different submarkets that might correspond to different genres (of music, movies, etc.). Creators invest in three types of activities that might lead to the generation of creative outputs in existing submarkets, new (to the creators) submarkets, or newly "invented" submarkets. The model features a copyright system that provides movie creators with the exclusive right to reproduce their original movies. At the same time, the model embeds a pirate market responsible for creating and distributing pirated copies of original movies. Depending on the strength of copyright enforcement (and indirectly the intensity of digitalization), consumers will be more or less likely to obtain pirated copies of movies.

Figure 10: Varying the strength of digitalization




*Notes*: Monte Carlo distributions for different degrees of digitalization (values for $\beta$), across selected variables. The dashed line represents the baseline scenario. The variables considered are respectively: (i) the pirate market's average market share; (ii) average prices, weighted by market shares; (iii) an indicator of product quality at the frontier, measured as: $\frac{1}{J}\sum_{j=1}^{J} X_T^j + Y_T^j$; (iv) median profitability across legal creators; (v) average total demand per submarket; (vi) product variety in terms of total number of products discovered.

Preliminary results indicate that our model can replicate some stylized facts such as market heterogeneity and concentration typical of creative markets (e.g. the movie industry).

As a first simulation experiment, we studied the advent of digitalization jointly with the emergence of the pirate market. Results suggest that they positively affect consumers, allowing them to enjoy lower prices due to both cost-reductions and to the higher circulation of illegal copies. The effects on profits, instead, remain uncertain and crucially depend on the balance between higher demand (positive effect) and stronger market stealing from pirate copies (negative effect).

Regarding the role of copyright enforcement, stronger copyright increases consumer prices and lowers industry demand as it makes illegal copies less attractive. Nevertheless, we find some positive effects on product variety as it partially incentivizes creators innovation while similar effects do not emerge, instead, for movie quality. As expected, stronger copyright enforcement fosters the profitability of movie producers by hurting the competition of the pirate creator. Hence, the model suggests an important trade-off between consumer welfare and firm profitability associated to the enforcement of copyright laws in the creative industries. It is also worth noticing that the model does not contemplate the possible adoption from the side of creators of strategies aimed at exploiting the success of a product in the pirate market to generate further revenue streams (i.e., merchandising, promotion of life performances, etc.). The inclusion of such mechanisms may eventually tame the aforementioned trade-off and is left for future extensions of the model.

Finally, we studied the impact of increasing intensity of digitalization in the industry. We find that fostering digitalization drives down the price of movies and generally enhances consumer welfare and profitability. Interestingly, it also limits the room for achieving price advantages for the pirate firm, thus, hampering their competitiveness. In turn, this suggests that promoting digitalization may act as a welfare-enhancing substitute for stronger copyright enforcement.

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# Appendix A Benchmark parametrization

Table A.1: Parameters (baseline scenario)

| Description | Symbol | Value |
|---|---|---|
| Montecarlo replications | MC | 25 |
| Number of time steps | T | 100 |
| Number of creators | N | 50 |
| Movie development investment share | $s^I$ | 0.1 |
| Allocation shares to innovation activities | $(s^A, s^B, s^C)$ | (0.5, 0.3, 0.2) |
| Upper bound probabilities for innovation activities | $(pmax^A, pmax^B, pmax^C)$ | (0.4, 0.4, 0.05) |
| Industry-wide innovation system parameters | $(\theta^A, \theta^B, \theta^C)$ | (0.1, 0.1, 0.3) |
| Quality improvement shocks (support) | $[u^{min}, u^{max}]$ | $[1, 8]$ |
| Initial quality shock in new genres (support) | $[\epsilon^{min}, \epsilon^{max}]$ | $[1, 8]$ |
| Parameter for demand stealing across submarkets | $\eta$ | 0.2 |
| Copyright enforcement | $CopEnf$ | 0.35 |
| Quality reduction in pirate copies | $\Psi$ | 1 |
| Discount factor in pricing | $\beta$ | 0.5 |
| Price reduction shock distribution for the pirate (support) | $[\pi^{min}, \pi^{max}]$ | $[0.3, 0.8]$ |
| Maximum markup | $m^{max}$ | 0.9 |
| Minimum markup | $m^{min}$ | 0.05 |
| Maximum markup when entering an existing submarket (type B) | $\hat{m}$ | 0.6 |
| Upper threshold for markup adjustment rule | $\tau$ | 0.08 |
| Lower threshold for markup adjustment rule | $\rho$ | -0.02 |
| Uniform shock to markup (support) | $[v^{min}, v^{max}]$ | $[0.02, 0.005]$ |
| Final submarket demand shock | $[D^{min}, D^{max}]$ | $[200, 300]$ |
| Minimum submarket demand | $D^{tr}$ | 30 |
| Initial dimension of submarkets | $(Xinit, Yinit)$ | (40, 40) |
| Speed of demand saturation | $\gamma_D$ | 1 |
| Strength of competition and market selection | $\mu$ | 1 |
| Market share threshold for exit | $f^{min}$ | 0.00001 |
| Entry shock (support) | $[\lambda, \omega]$ | $[-5, 2]$ |