Rational Addiction to Audiovisual Narratives: an Analysis of Broadcasting and Consumption of Fiction in France*

Olivier Bomsel, Victor Lavialle‡

Abstract. TV-series have traditionally been watched and monetized through broadcasting on free-to-air and pay television. They are increasingly consumed *via* on-demand platforms and *catch-up* services. The purpose of this paper is to evaluate how the narrative structure of TV-series influences their consumption and causes delinearization.

We use data from *Médiamétrie*, reporting the live and *catch-up* audience for all movies and series aired between 8 p.m and 10 p.m on free and public French TV-channels, from 2011 to 2016. We show that when the story takes several episodes or seasons to develop, consumers are more likely to watch the program on alternative platforms or *catch-up*. We provide evidence that the consumption of such programs follows a model of rational addiction, where current consumption is influenced by its past and future values.

These results allow us to explain recent changes in the industrial organization of the French free-to-air television market. We show how the narrative structure of TV-series can explain broadcasters' competitive strategies. These results can have important policy implications, as broadcasters are one of the main investors in the production of audiovisual content in France.

Key words: TV series demand, rational addiction, competition

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†CERNA, MINES ParisTech, PSL Research University, Chaire d'Économie des Médias et des Marques

‡victor.lavialle@mines-paristech.fr

1 Introduction

For a long time, television was the only way to access domestic audiovisual content. TV programs synchronized society around major events of the *present*, such as the newscast or sports. It created *habits*, and organized the time of the viewer with combination of stories to the present (news, games, sports) and to the past (fiction).

The generalization of broadcasting on the Internet, via *catch-up* services, or dedicated platforms disrupts the classical model of television, which is no longer delegated the organization of the evening. These evolutions in broadcasting technology follow the video cassette recorder and the DVD, and loosens the constraint of the TV schedule, by allowing a non-linear consumption of audiovisual content. This evolution in consumption of programs has an impact on screenwriting and narrative. TV series constitute a strong example of this change in paradigm: non-linear consumption allows screenwriters to develop the story over several episodes without using *tricks* such as a summary of recent events at the beginning of each episode. More intensive watching of the program also makes the spectator more likely to identify inconsistencies in the script, which incentivizes coherent narrative over a whole season. In the end, the new modes of consuming TV series change narrative writing and give rise to new formats of TV series.

We claim that new forms of narrative writing and broadcasting changes the demand and utility functions for TV series. This underlies a transition from a *synchronized* audiovisual consumption (the collective habit created by linear television) towards *on demand* consumption. Such non-linear watching patterns can lead to *addictive* effects, as illustrated by the emergence of *binge-watching*[1] with the rise of online media services.

[1]Binge-watching is the practice of watching television for a long time span, usually a single television

This phenomenon has industrial and policy implications, as the evolution of TV series and their narrative leads to changes in the broadcasting strategies of channels. Free-to-air TV must face the competition of new players, using series as the center of a commercial strategy focused on these new modes of non-linear consumption. The first response of free-to-air broadcasters against this new competition is the creation of catch-up services, such as *MyTF1* or *M6replay* in France, but the traditional model of television has a hard time valuing non-direct audience.

In this paper, we wish to estimate the economic effects of these new modes of consuming TV series, and their impact on the French broadcasting industry. We also aim at proving how the changes in narrative writing led to a shift in the demand function for TV series. To this effect, we use the rational addiction framework[2] to characterize the consumption of series. We show how the narrative structure of fiction programs is key in explaining non-linear demand. The paper is based on Médiamétrie audience data from 2011 to 2016.

The paper is structured as follows: in section 2 we study the existing literature on the consumption of cultural goods, and specifically audiovisual fiction, as well as the economic effects of the narrative structure of these programs. In section 3, we draw an analysis of the market for broadcasting of fiction in France, highlighting the possible effects of narrative on the strategies of agents. Section 4 consists of the study of the causal link between narrative structure and delinearization of consumption. Finally, we estimate a rational addiction model to explain this link. We propose an application of this idea by modeling audience using ARIMA processes.

show.

[2]We say a good is addictive if and only if an increase in past consumption leads to an increase in current consumption holding current prices and the marginal utility of wealth fixed. This definition is from Becker, 1988, [2]

2 Economic effects of narrative: habits and addiction

2.1 TV series viewing in social sciences' litterature

There are two main modes of viewing TV series. The first one consists on relying on the schedule set by broadcasters. This is the principle of television *appointments*: episodes from the series are aired at fixed times by the TV channel, and make up appointments for the spectator.

The second mode of consuming audiovisual content has been made possible by the invention of the VCR, the DVD, and more recently by the new editorial strategies of the VOD and SVOD broadcasters. The viewing of an episode from a series is not linked to a specific time or day, but at the spectator's convenience. Various sociological studies[3] suggest that this second mode of viewing generally leads to consuming more episodes at once, in a short time period. This is often referred to with the term *Binge-Watching* in everyday language. The viewer, rather than making pauses between each episode, may chose to watch for many hours in one session, at the detriment of other activities. He accepts to degrade its future utility to be able to consume an additional episode immediately. Mikos (2016 [14]) defines binge watching as a *metaphor describing a form of intensive consumption of television series*. According to him, complex narrative structures reinforce this phenomenon. He claims that:

> Complex narrative structures reinforce the distinction since viewers can immerse themselves more deeply in the fictional worlds and so experience the "complex pleasures of narrative", in which one is **caught in the contradictory desire to find out what happens next and for the story not to end**

[3]See Combes 2015, Kranz 2015 [11]

This quote highlights that it is the narrative form of the series that induces or reinforces behaviors such as *binge-watching*. As we stated, the evolution of broadcasting technologies allows screenwriters to develop more complex narratives, over a complete season. Such TV series narrative might give rise to addictive effects. In a study based on interviews, Julian Kranz (2015, [11]) shows that the identification with the main characters of a series is one of the most powerful vectors of addiction. This identification, made possible by the evolution of characters is notably absent from other narrative formats (for instance movies), making addiction effects specific to TV series. This dichotomy between different modes of viewing TV series translates into economics as different utility functions associated with different programs.

From the consumer's point of view, the opposition between linear and non-linear watching translates more into *rationed* and *all you can watch* consumption. The constraint of the television schedule imposes a specific pattern of consumption and can hinder addictive effects from developing.

This evolution of viewing and emergence of new modes of consumption has direct applications to the broadcasting industry and TV series marketing. Some broadcasters have been able to identify the binge watching phenomenon and applied it as part of their editorial strategy. The marketing for *La Vengeance aux Yeux Clairs*[4] by TF1 takes advantage of this specificity of consumption by making the entire season available on demand after the broadcast of the first episode.

While non-linear consumption, and its extreme forms with binge watching emancipates the spectator from the TV schedule, it's important to note that some phenomena

[4]French TV series aired from September 8th 2016 on TF1. Produced by J-L Azoulay and JLA Productions

can still lead to a relative synchronization in viewings. For instance, the common term *spoiler* refers to the act of revealing a key element of the plot of an episode to someone who has not seen it yet. The utility of watching a *spoilt* episode is thus considerably lower. This effect can be linked to network externalities, as the probability of the spoiler occurring increases with the number of viewers. It affects the consumer by increasing his rate of preference for the present: the expected utility of watching the episode at some future point in time has to be discounted by the probability of a spoiler occurring.
The importance of such peer effects in the emergence of addiction is well known in the literature of rational addiction, and is explained for instance in Laux (1999, [12]) for the case of tobacco consumption.

Many econometric studies investigate the consumption of cultural goods[5], or apply the theoretical framework of rational addiction to goods such as drugs, cigarettes or alcohol[6]. On the other hand, very few articles focus on the addictive effects of cultural goods. Cameron (1999) studies this phenomenon in the case of cinema demand. His results fail to support the presence of rational addiction. Yet, Castiglione and Infante (2015) demonstrate that some addictive effect exists in the demand for theatre in Italy. We allege that such an analysis can be made for the viewing of TV series, and that it can help us understand non-linear forms of consumption.

To identify the economic effects of the narrative structure in TV series, we use a typology distinguishing series with independent episodes and series where the narrative builds up during several episodes (*serials*)[7]. The series with independent episodes, or

[5]Borgonovi 2004, Ateca et Amestoy 2008, Werck and Heyndels 2007, Zieba 2009
[6]See Chaloupka 1991, Grossman *et al.* 1998, Bask Meklersson 2004
[7]Details on this typology can be found on table 7

recurring characters is a format linked to traditional television. The continuity is ensured by the persistence of the main characters. In that sense, such programs are close to the franchises of cinema (*James Bond*, *Sherlock Holmes*, *etc.*). We say a series has independent episodes[8] if and only if those episodes can be followed in any order without significant loss of utility.

By opposition, *serials* create an attachment, not only to recurring characters, but also to the narrative itself, broken over several episodes or seasons. Episodes are interdependent and narrative develops slowly. We allege that this continuity of narration gives rise to addiction effects that are unique to this format, and, by construction, weak or non-existent for independent series. It is important to note that this typology is simple and corresponds to ideal-type cases. While a continuum exists between series with completely independent episodes and ones where a story is broken over strongly linked episodes, such a rough distinction is necessary to our economic and statistical analysis.

2.2 Preferences and cultural goods: a theoretical framework

Several theories of preference formation for cultural goods account for the importance of experience in explaining demand. First, a theory of *habit formation* was applied by Houthakker and Taylor (1970) in the estimation of the demand for cultural goods in the United States. This form of preference modeling assumes that the utility derived from the consumption of a good depends on past consumption *via* a habit variable:

$$U = u(c_t, h_t) \tag{1}$$

$$h_t = f(c_{t-1}) \tag{2}$$

A second way of modeling consumption of cultural goods is to assume consumers are uncertain about the quality of goods, and update their preferences in response to their

[8]Later referred to as *independent series*

experience. In Lévy-Garboua and Montmarquette (1996, [13]), consumers discover their preferences through this sequential process. The taste for experience goods increases with consumption and stabilizes after some time.

The contribution of the theory of rational addiction, developed by Becker and Murphy (1988, [2]), is the introduction of a fundamental distinction between *habits* and *addictions*, based on two key variables: the utility of adjacent consumption and the discount rate. This also allows to takes into account expectations about the future, as the consumption of an episode from a TV series depends on the anticipation of being able to watch the entire season, or several seasons, which is not modeled in previous theories.

We develop an application of the rational addiction model to television series. We assume viewers are rational agents, and behave in a way that maximizes their inter-temporal utility under budget constraint[9]. They have limited time and resources to establish their current and future levels of consumption.

Let u be the utility of the viewer, so that:

$$u(t) = u[y(t), c(t), S(t)] \tag{3}$$

It is assumed that u is a concave function. The utility depends on the consumption of two goods, c, the TV series, and y a control supposed to be a non-addictive good. S stands for the stock past consumption of c. The presence of this *stock* helps us explain addictive behaviours. Applied to TV series, we'll say that in the case of inter-dependent

[9]As we deal with free-to-air television, the budget constraint should be understood as a limited free-time constraint

episodes, the viewer has to watch previous episodes to gain maximal utility from a given episode. S represents the watcher's understanding the past developments of the story. The stock depreciates as follows:

$$\dot{S}(t) = c(t) - \delta S(t) \tag{4}$$

Where $c(t)$ stands for the consumption of series time t, $\delta \in [0; 1]$ the exogenous depreciation rate of past consumption (that we can understand as the consumer forgetting past developments of the story).

We define an *habitual* good such as an increase in consumption at time t causes a raise of future consumption.

$$\frac{\partial c(t)}{\partial S(t)} > 0 \tag{5}$$

With a level of consumption c such that $c \leq \delta S$, the evolution of the stock S converges (equation 4) and there is an equilibrium.
We define an *addictive* good such that:

$$\frac{\partial c(t)}{\partial S(t)} > \delta \tag{6}$$

In that case, the evolution of the stock of consumption will diverge and lead to an ever-growing consumption.

Following Becker and Murphy, we note the inter-temporal utility of a consumer with length of life T such as:

$$U_0 = \int_0^T e^{-\sigma t} u[y(t), c(t), S(t)] \mathrm{d}t \tag{7}$$

Where sigma stands for the preference for the present, A_0 the initial value of assets, r the interest rate, constant over time and $\omega(t)$ the earnings at time t.
The consumer's maximization program can be written as:

$$\max_{c(t),y(t)} U_0 = \int_0^T e^{-\sigma t} u[y(t), c(t), S(t)]\mathrm{d}t \tag{8}$$

$$\text{s.t.} \int_0^T e^{-rt}[y(t) + p_c(t)c(t)]\mathrm{d}t \leq A_0 + \int_0^T e^{-rt}\omega(t)\mathrm{d}t \tag{9}$$

In the case of strictly addictive goods, Becker and Murphy (1988) show that only two stationary states can exist, one stable (total abstinence), and the other one unstable. In the second one, consumption continues to increase even if the viewer is aware of possible harmful effects on its future utility (*binge watching*). We tend towards a bi-modal consumption: quasi-abstinence or excessive consumption.

This framework identifies two key variables of addiction. First, the *addictiveness*, $\frac{\partial c(t)}{\partial S(t)}$ is linked to the growing utility of the narrative, and can be stronger as the story crosses several intrigues, and uses devices such as cliffhangers[10]. Thus, narrative writing can be aimed at generating addiction.

The particularity of TV-series relatively to other addictive goods is the importance of novelty. The series can only be addictive as long as the story evolves from an episode to the next one and new seasons are produced. The addictive behaviors are limited by the number of available episodes, and total abstinence is imposed at the end of the season or series. It is important to note that the rate of depreciation of the capital $S(t)$ is an incentive for the producer to minimize the time between two seasons of a series,

[10]A cliffhanger is a plot device in fiction which features a main character in a precarious or difficult dilemma, or confronted with a shocking revelation at the end of an episode of serialized fiction. A cliffhanger is hoped to ensure the audience will return to see how the characters resolve the situation.

in order to benefit from addictive effects. On the other hand, he has incentives to wait and observe the success of a first season before choosing to invest in an additional one. The time period between two seasons of a serial is also an opportunity for producers and broadcasters to offer substitutes, in order to keep the audience captive. This explains the growing importance of recommendation algorithms on online platforms.

The discount rate, σ is the other key variable in explaining addiction, as the higher it is, the more likely the consumer is to get addicted. Younger consumers are thought to have a higher discount rate, leading to a short-term preference. The risk of *spoilers*, linked to network effects leads to an increase in σ.

3 Competition for broadcasting of fiction on the free-to-air television market

We claim that the specifics of TV series narrative, and the difference in demand function for linear and non-linear watching can help understand the industrial organization of the French market for fiction broadcasting.

We use audience data from Médiamétrie. The database covers every fictional program aired between 8:30 p.m. and 10 p.m. (*prime time*) on French free-to-air channels from 2011 to 2016. More details about the dataset can be found on table 6 in the appendix. The audience is estimated using surveys on a representative sample of the French population.

3.1 Demand for TV programs: the audience scatters

The market for free-to-air broadcasting during prime-time in France is shared between public channels (France Télévisions), free hertzian private channels (TF1, M6) and TNT channels. Their main source of revenue comes from the sale of advertising space, the price

of which is proportional to the audience. Public channels don't broadcast advertising during the time slots we study.

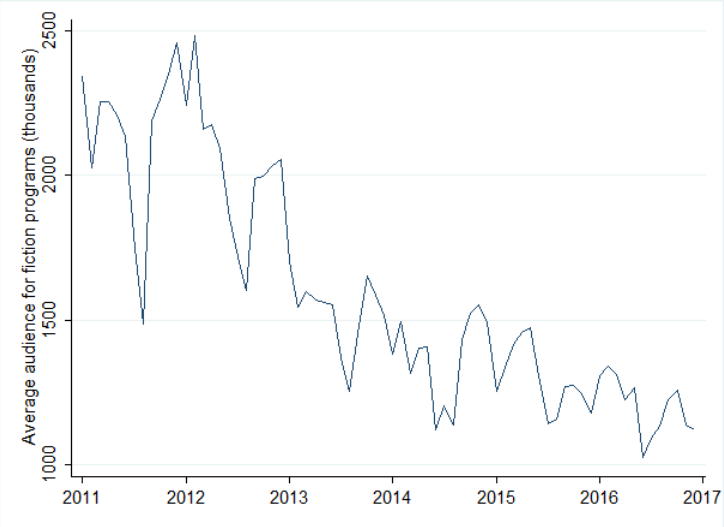

Figure 1: Average audience for fiction programs (thousands)

The average time spent watching television remains stable in France, around 3 hours and 41 minutes[11]. This average rises to 5 hours for those over 50, and is the lowest among young people.

The average audience for a fictional program decreased by almost 40% between 2011 and 2016. This fragmentation of demand is partly due to the entry of new TNT channels, such as HD1, Numéro 23, RMC Découverte, Chérie 25, available in December 2012.

[11]Médiamétrie

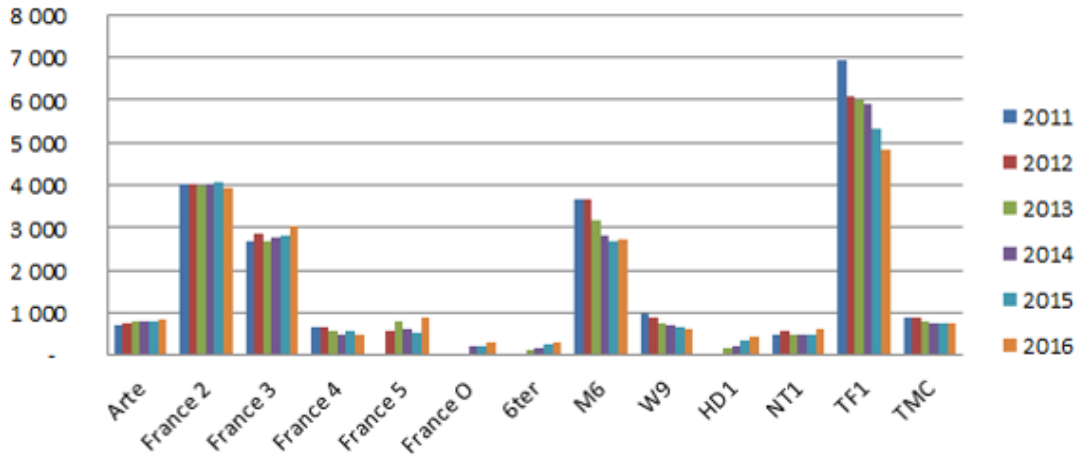

Figure 2: Average audience for fiction programs for each channel (thousands)

This downward trend impacts mostly the private channels M6 and TF1. The average audience of France Télévisions is maintained, and that of the TNT channels is increasing, though still low.

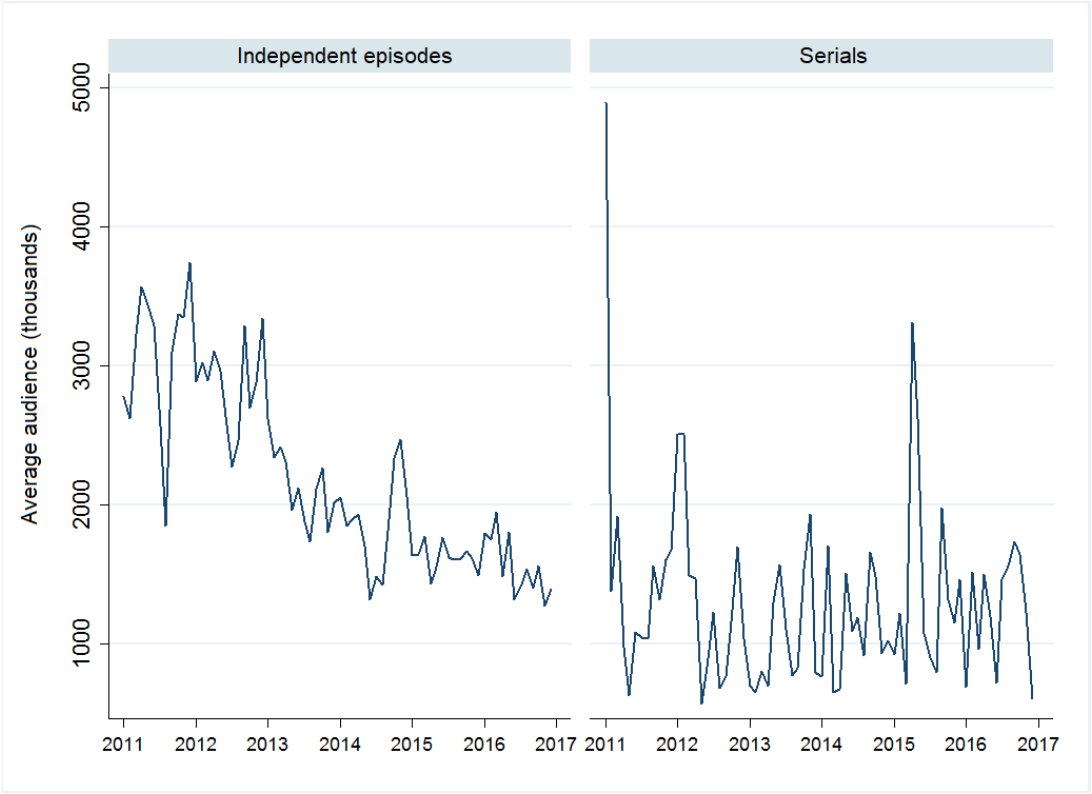

Figure 3: Audience for TV series (mean)

Contrary to the general trend, the demand for serials is holding still (see figure 3). This effect may reflect unobserved characteristics of these programs. Indeed, as the development of such programs has accompanied the evolution of broadcasting technology, notably allowing for non-linear consumption, these series could be on average more recent, and potentially more popular. We do not have the data necessary to control such effects.

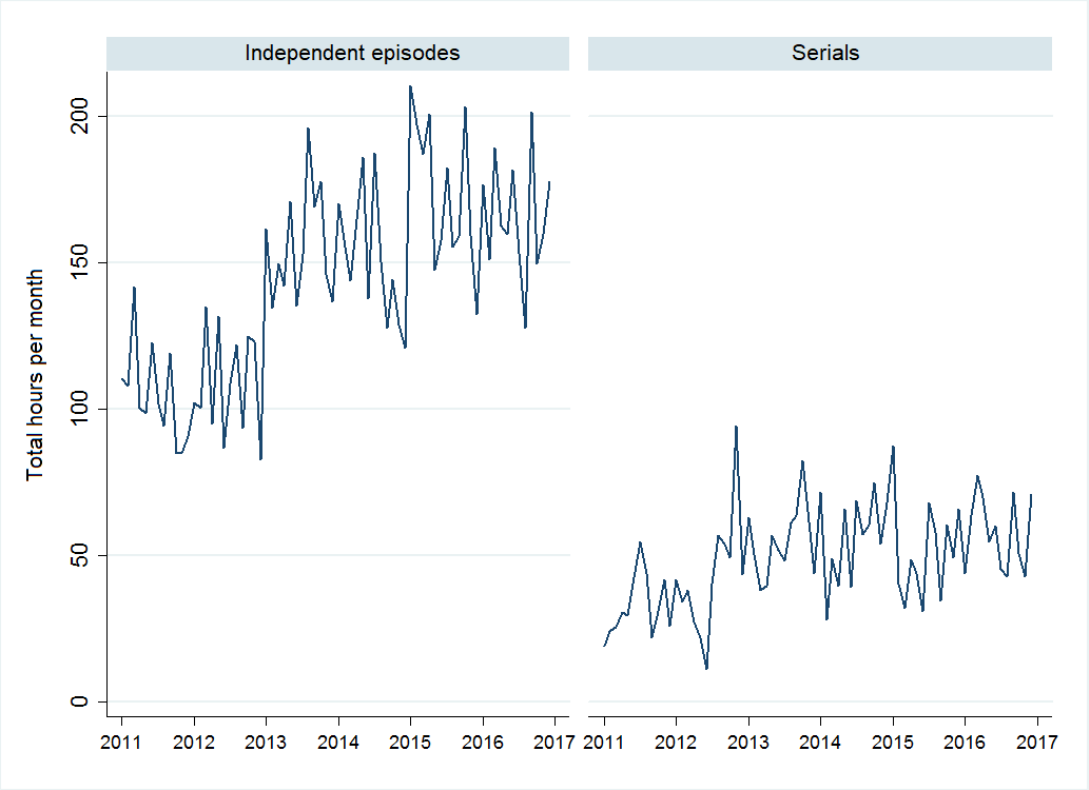

Figure 4: Evolution of TV series broadcasting

The growth in the broadcasting of series is similar for both narrative formats (independent and serials). We can deduce an increase in demand for serials from the maintaining of the average audience despite an increase in the number of episodes aired (figures 3 et 4).

3.2 Strategies and competition for the broadcasting of fiction

The volume of fiction programs aired on French television doubled between 2011 and 2016. This evolution can be explained in part by the entry of channels HD1, 6ter, Numéro 23, RMC Découverte and Chérie 25. This volume also increased within various broadcasting groups.

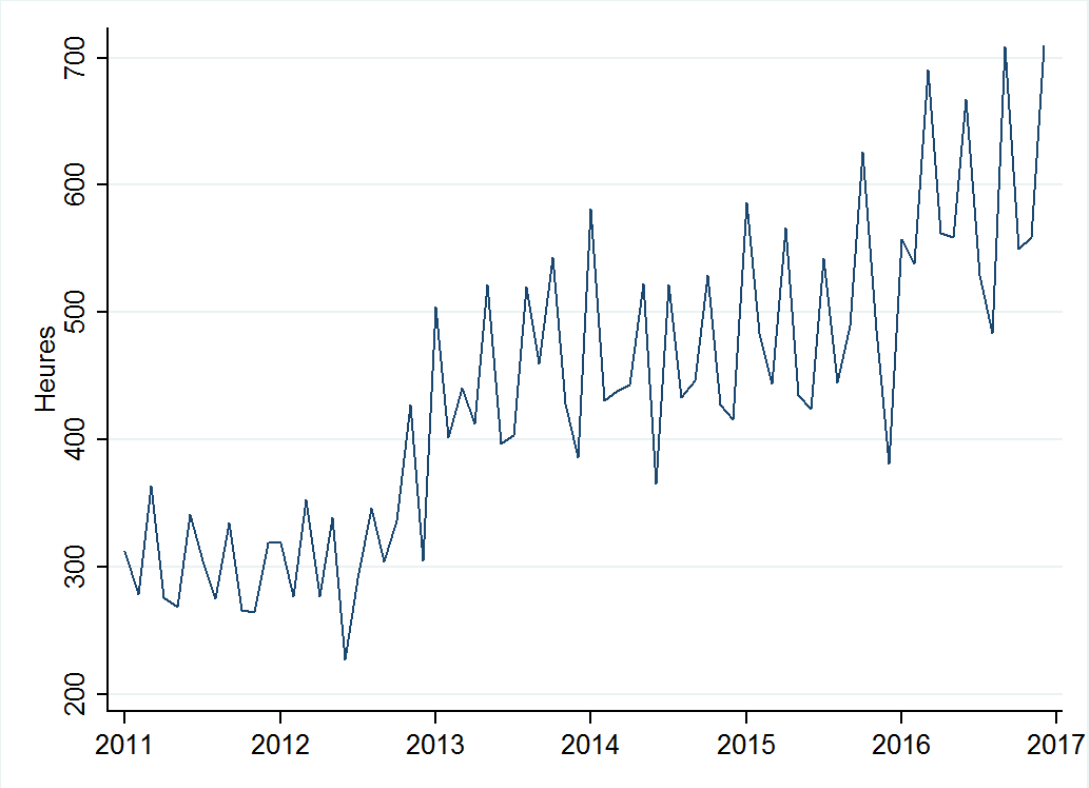

Figure 5: Total hours of fiction aired on free-TV

The strategic choice of programs does not necessarily correspond to the changes in demand highlighted in the previous section. While the demand for serials seems to be increasing, free-to-air channels tend to chose more movies since 2016.

After a transition towards serials, TF1 chooses movies as their main format for 2016 (figure 6). The same transition can be observed on the TF1 group's TNT channels.

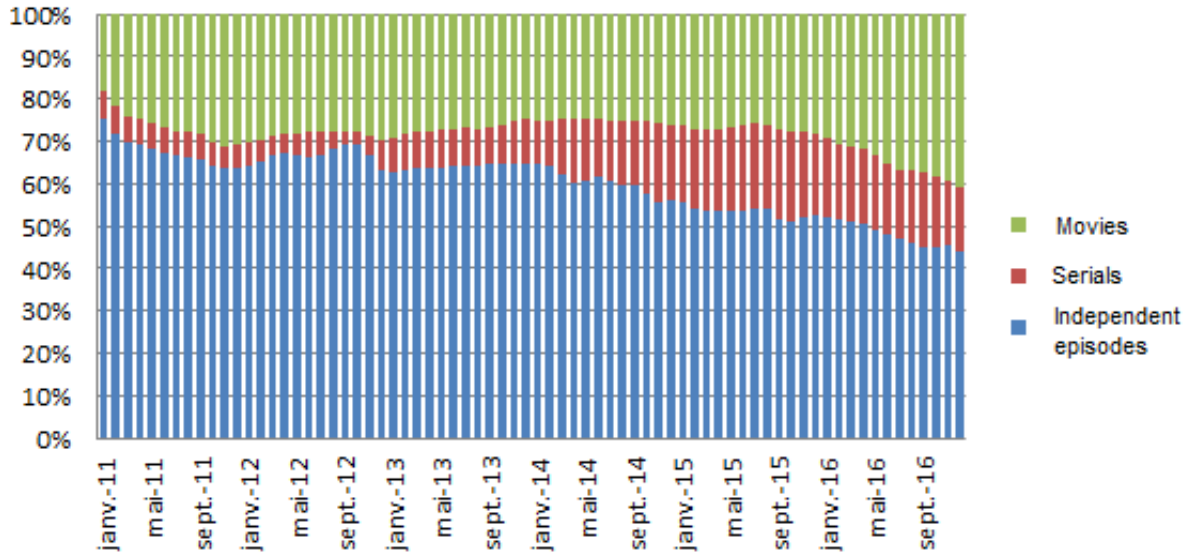

Figure 6: Program choice for TF1

M6 adopts a similar strategy, but focuses on independent-episodes series. The share of serials increases between 2012 and 2015 then drops in favor of movies.

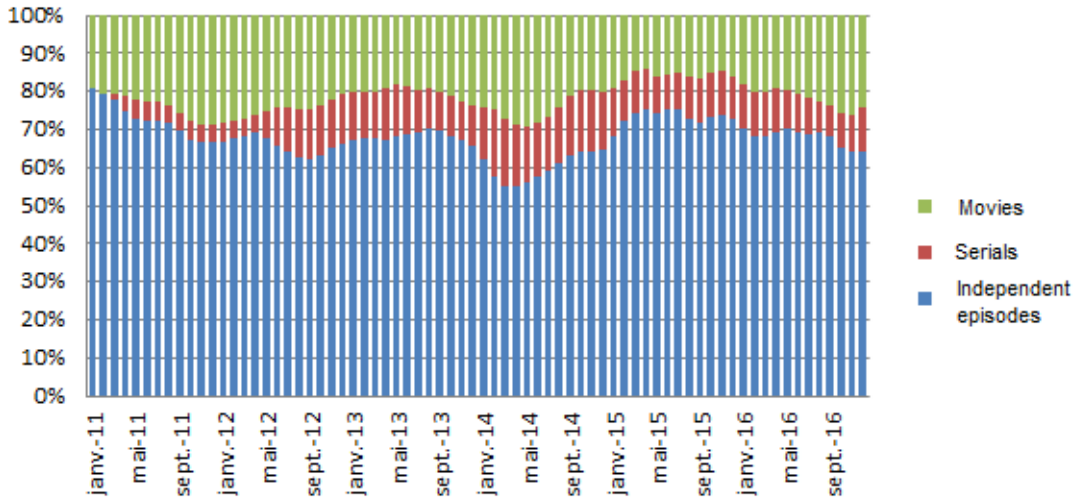

Figure 7: Program choice for M6

This strategic choice can be explained by the effects of the narrative structure on demand. Because of its potentially addictive nature, the serial can be seen as a way to

retain audience. This idea is illustrated in figure 4: serials are the only format that keeps a stable audience. However, the addictive effets of such programs, inducing behaviors like binge-watching leads to a delinearization of consumption. There is a strong correlation between the broadcasting of these series and catch-up audience (figure 8). The switch towards movies in 2016 is explained by the difficulty for free-to-air channels to make sufficient profit on their catch-up platforms. It is interesting to remark that serialized series make up the majority of catch-up audience (figure 9).

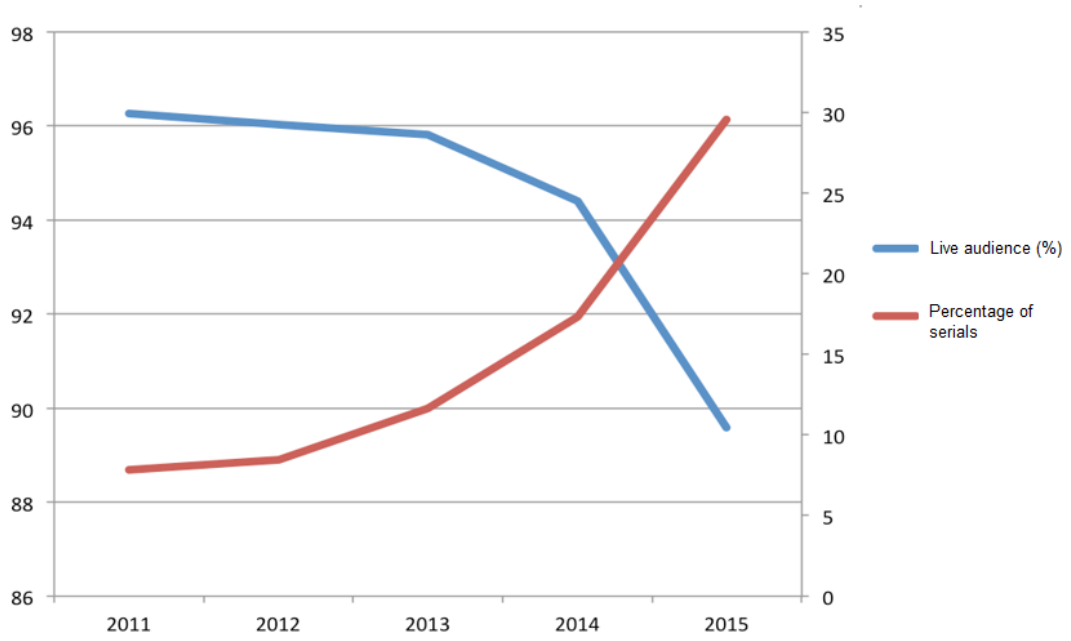

Figure 8: Live audience and share of serials in broadcasting (TF1)

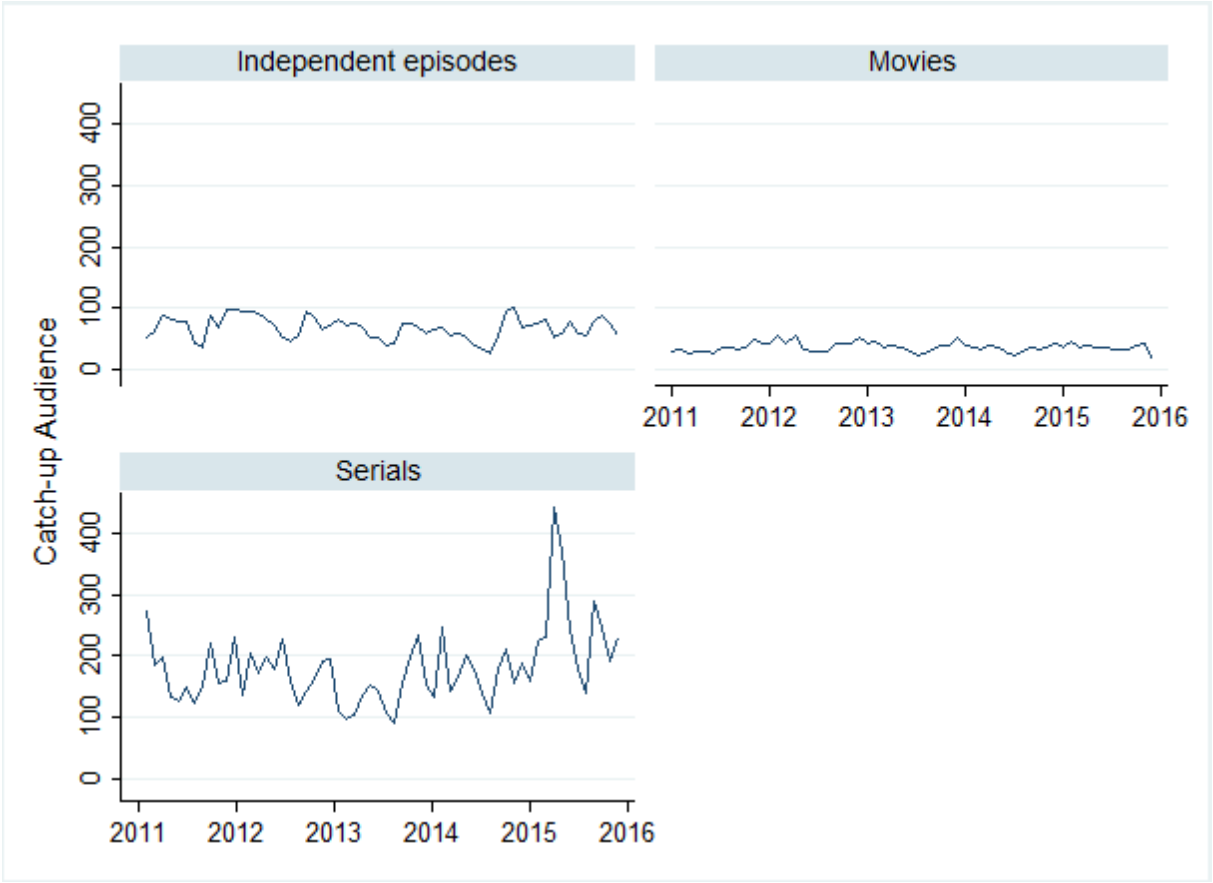

Figure 9: Catch-up audience (thousands)

The distribution of the channel's broadcasting time between the various narrative formats constitutes an axis of horizontal differentiation. Figure 10 shows a certain uniformity in the choices of main TV channels. We can see consolidation strategies of the groups with their TNT channels, diversifying the programs chosen, in order to attract consumers with different preferences. We can interpret the void in the bottom left corner of figure 10, as corresponding to the positioning of pay-TV and VOD-platforms.

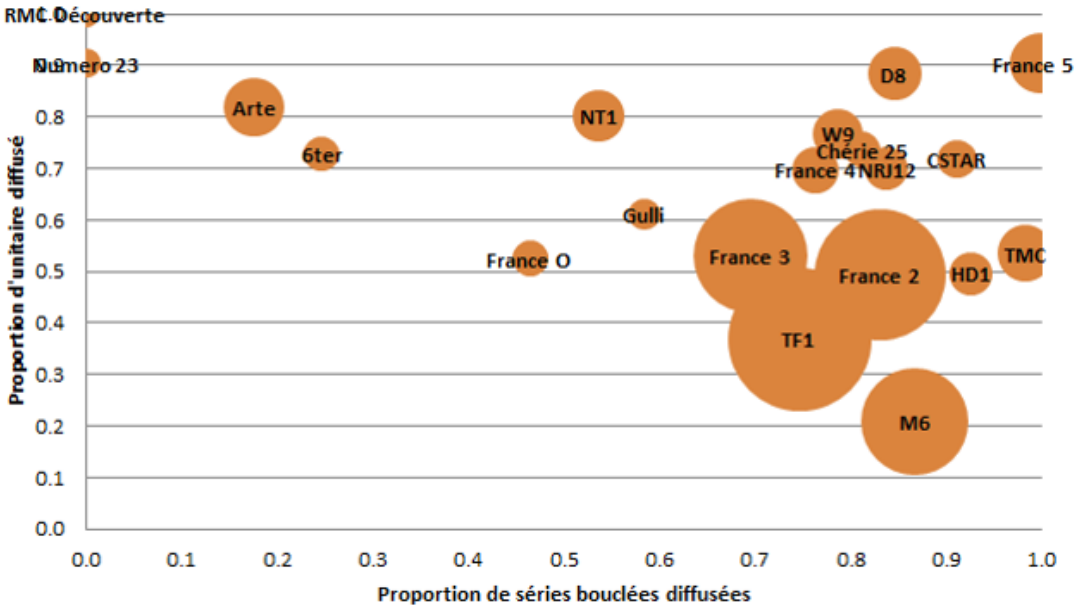

Figure 10: Channel differentiation by program type (2016)

4 The effect of narrative format on the demand for TV series

We now test the assumptions made in the previous sections. First, we try to establish a causal link between the narrative format of TV series (independant or serialized), and the mode of consumption (linear or non-linear). In order to explain this effect, we estimate several models for demand, taking into account the possible addictive effects for serials. First, we use an Arellano-Bond ([1]) generalized moments method to estimate a rational addiction. We then present a case study using SARIMA processes.

4.1 Serials induce non-linear consumption

Editorial strategies aimed at non-linear viewing and the entry of online platforms have led to a change in the series' mode of consumption. The last decade has also been marked by illegal downloading (since 2012, every year, *Game of Thrones* is the most pirated series

in the world, with an average of 14.4 milion downloads per episode[12]). These two factors contributed to move TV series away from the television screen, towards computers, tablets, mobiles or alternative devices. This induces a new way to appreciate the narrative, that we try to evaluate.

The non-linear broadcasting strategies of free-to-air TV channels are based on the development of catch-up platforms: *MyTF1*, *6play*, *M6replay* or *Pluzz* (France Télévisions).

For most channels, we report a negative correlation between the share of serials in the programmation and the share of live audience. This effect is especially strong for TF1 (-0.98) and *Arte* (-0.83).

We estimate the causal effect of the series' narrative structure on the share of live audience. We estimate a linear model, specified by equation 10. We use robust standard errors to account for heteroskedasticity in the data. Results of the estimation are reported in table 1.

$$P_{live} = \alpha * \mathbb{1}_{\text{Serial}} + \beta * t + \gamma * A + \sum_i \delta_i * \text{Ch}_i + \sum_i \zeta_i * \text{Country}_i + \sum_i \eta_i * \text{Month}_i + \sum_i \theta_i * \text{Day}_i + C + \varepsilon \tag{10}$$

With P_{live} the share of live audience in total (live + catch-up) audience, t a time variable, A total audience, $C \in \mathcal{R}$ and ε an error term. We control for several important effects. First, to account for evolution of technologies, we include a control for the year and the channel (as some channel may have better performing replay services). The month and day dummies control for the potential effect of the time of the broadcast. Finally, we control for the total volume of audience and the country of origin of the program. The

[12]Source: *Torrentfreak.com*

model is estimated on 21 808 observations.

Table 1: Estimation results with heteroskedasticity-consistent standard errors

Variable	**Coefficient**	**(Std. Err.)**
Total audience	0.00**	(0.00)
Year	-0.47**	(0.02)
TF1 (base)	0.00	(0.00)
France 2	-2.6**	(0.17)
HD1	1.5**	(0.24)
M6	0.32*	(0.13)
NRJ12	2.9**	(0.23)
TMC	2.7**	(0.21)
W9	2.9**	(0.20)
Serialized	**-4.81****	(0.11)
USA	-2.4**	(0.07)
France (base)	0.00	(0.00)
UK	-3**	(0.25)
Sweden	-4.6**	(0.74)

The results presented in Table 1 confirm that choosing to air a serial instead of a series with independent episodes leads viewers to switch towards catch-up. We estimate that *ceteris paribus*, choosing to air a serial rather than a series with independent episodes will lead to a transfer of 4.8% of the audience towards catch-up.

The trend of growing non-linear consumption can be explained by the technical progress of digital catch-up platforms. We interpret channel-specific effects as the performance, or the existence of a catch-up platform. We also remark a significant effect of the country of origin upon the mode of consumption: American, British or Swedish series are more likely to be consumed on demand that French series. It's possible that this effect actually captures the effect of popularity or quality of the series, which we do not measure.

4.2 Model of rational addiction

4.2.1 Empirical strategy

As detailed in the previous sections, our analysis is that this de-linearization of viewings induced by the narrative forms of serials can be explained by a model of rational addiction. In this section, we seek to prove that consumption of TV series on French free-to-air channels follows such a model. Specifically, we will determine whether current consumption can be explained by the past and anticipations of future consumption.

As presented in the theoretical framework section, if individuals are rational and the TV series is an addictive good, past and future consumption should have a positive impact on current consumption. From this framework, we derive the following model:

$$C_{i,t} = \beta_1 C_{i,t-1} + \beta_2 C_{i,t+1} + \beta_3 X_{i,t} + \alpha_i + \varepsilon_{it} \tag{11}$$

With C the consumption of TV series, t the episode and i the series. X stands for a vector of exogenous variables. We control for the country of origin, the TV channel which aired the series, date, advertising time during the broadcast, and the evaluation of viewers for the whole series[13]. α_i stands for fixed effects and ε the error term. We say a good is addictive or habitual when $\beta_1 > 0$, and the degree of addiction increases with β_1.

As detailed previously, numerous articles applied the rational addiction framework to explain consumption of such addictive goods as cigarettes (Becker 1994, [3]), gambling (Farrell, Morgenroth et Walker 1999, [8]) or cultural goods (Yamamura 2009 [17]). The estimation of such models has to deal with the endogeneity of past and future consumption.

[13]Source: *Allociné* data

To deal with this bias, we reproduce here the approach of Castiglione and Infante (2015) ([4]) for the estimation of the model 11. We use an Arellano-Bond estimator[14], which transforms regressors by differencing, then uses a generalized moments method. Lagged values of the dependant variable and exogenous variables are used as instruments. We use the Arellano-Bover/Blundell-Bond estimator which is a variation allowing to take into account eventual unit roots in the data.

4.2.2 Results

The model is estimated over 101 serials, for which at least 10 episodes have been broadcast. We correct for heteroskedasticity in the data using robust standard-errors. The results are shown in table 2. We estimate a model of *myopic addiction*, where the anticipations for the future consumption are not taken into account and the rational addiction model specified by equation 11.

Table 2: Estimation results: rational addiction model

Variables	**Myopic addiction model**	**(Std. Err.)**	**Rational addiction model**	**(Std. Err.)**
Audience_{t-1}	0.389^{**}	(0.119)	0.298^{**}	(0.1)
Audience_{t+1}			0.236^{**}	(0.054)
Advertising	$-13.43^{\dagger}$	(7.52)	$-14.39^{\dagger}$	(7.9)
Year	-219.7^{**}	(52.3)	-213.6^{**}	(51.8)
Grade	1.9	(481.3)	332.2	(446.6)
TF1	3987.5^{**}	(762.1)	3397.8^{**}	(867.5)
TF1 Group	-393.9	(306.4)	$-607.8^{\dagger}$	(365.0)
Season (summer)	-135.5	(139.3)	-123.0	(113.6)
France	-35.5	(162.1)	1.7	(195.1)
USA	-104.6	(244.6)	-41.5	(196.4)
M6 Group	-320.0	(407)	-289.8	(321.4)
M6	1595.0^{**}	(317.2)	1294.7^{**}	(314.7)
France TV	900^{*}	(413.9)	$634.3^{\dagger}$	(381.0)
N	2473		2473	

[14] see [1]

The results shown in table 2 support the hypothesis that TV series viewing follows a model of rational addiction: both effects from past and future consumption are positive and significant. The effect of advertising is negative and significant at the 10% threshold. When the error terms are independent and identically distributed, their first order differentiations are serially correlated. So, as expected, the Arellano-Bond test rejects the hypothesis H_0 for the first order of differentiation:

$\mathcal{H}_0$: *There is no autocorrelation of residuals*

H_0 is no longer rejected for second order differentiation. Thus, we don't detect any specification problem in the estimated model.

Estimating the model with catch-up audience (table 8 in the appendix) proves a significant effect of the series' appreciation by spectators. We find a significant and positive effect of past *live* viewing on the present catch-up consumption.

We also estimate this model on a similar database of independent-episodes series. The results are presented in the appendix. We find a significant effect for both past and future consumption, though lower than for serials.

4.3 Case study: *Plus Belle la Vie*

In the previous section, we provide evidence for an addictive effect on TV series demand. This effect is characterized by the strong influence of viewing episode $n-1$ in viewing episode n, and explains the link between serials and non-linear consumption. This autoregressive aspect of demand supports the modeling using ARIMA processes and time-series methods. The main limit to this methodology is we can study only one series at a time.

We propose here a case study of the French serial, or *soap opera Plus Belle la Vie*.

This choice is mostly due to the high number of observations (more than 1300 episodes), and to the fact that its broadcasting was uninterrupted for the whole period. This series gives a good example of *habitual* effects, as defined by equation 5, as most of the audience is live, and the broadcasting pattern each day at a precise hour establishes an *appointment* for consumers.

Table 3 presents the evolution of live audience (actual and differentiated) over the period. We observe peaks in the audience, that we interpret as *season's finale* effects. Negative peaks can be interpreted as rebroadcasts of old episodes, independent from the current narrative. We reject the presence of a unit root in the data using an augmented Dickey-Fuller test.

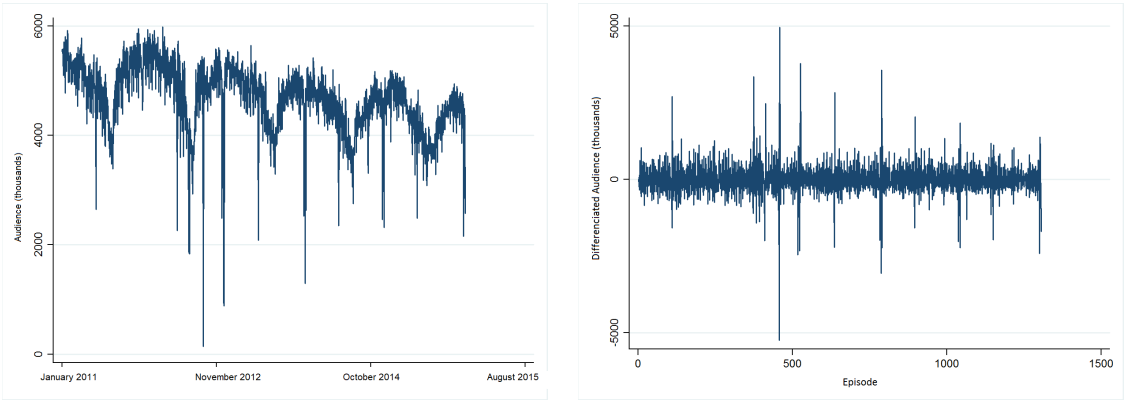

Table 3: Live audience for *Plus Belle la Vie* and first-difference series

The model we chose to estimate is a seasonal autoregressive integrated moving average process. The autoregressive part (AR) indicates that we regress the dependant variable on its own lagged values. This allows us to take into account the effects of addiction or habits. The moving average (MA) equation allows to smooth out short-term fluctuations of the error term, as well as serial correlation between these residuals. The autocorrelations and

partial autocorrelations diagram, presented in the appendix (figure 10) support a strong weekly seasonal effect. The ARMA model can be written as follows:

$$\left(1 - \sum_{i=1}^{p'} \alpha_i L^i\right) X_t = \left(1 + \sum_{i=1}^{q} \theta_i L^i\right) \varepsilon_t \tag{12}$$

Where L is the lag operator, α_i the parameters of the AR part, θ_i the parameters of the MA part and ε_t the error terms, assumed to be independant, identically distributed variables drawn from a normal distribution with zero mean.

As the series has positive autocorrelations out to a high number of lags, we also estimate the model on the differenciated series. Representations of the live audience for *Plus Belle la Vie* are shown in figure 3. The model is estimated with different specifications for robustness checks, and inclues a seasonal component of 5 days. Results are shown in table 4

Table 4: Estimation of live audience as a seasonal autoregressive process

	(1) A_{live}	(2) ΔA_{live}	(3) ΔA_{live}
ARMA			
AR(1)	0.599**	0.499**	0.441**
	(26.67)	(56.06)	(34.64)
AR(2)			0.0129
			(0.90)
AR(3)			0.0125
			(0.63)
MA(1)	-0.125**	-1.000**	-0.959**
	(-4.73)	(-71.84)	(-114.51)
$ARMA_5$			
AR(1)	0.886**	0.0978**	0.142**
	(45.91)	(3.76)	(6.26)
MA(1)	-0.601**	-0.764**	-0.833**
	(-24.16)	(-33.56)	(-42.03)
sigma			
	440.5**	449.6	450.3**
	(144.27)	(.)	(134.72)
N	1306	1300	1300

t statistics in parentheses

$^{\dagger}p < 0.05$, $^{*}p < 0.01$, $^{**}p < 0.001$

The results presented in table 4 confirm those of the previous rational addiction model. Previous consumption, modeled as the AR(1) term is significant and strong, between 0.4 and 0.6, both for the non-differentiated and the differentiated model. The second and third lags of live audience do not appear to have a significant effect on current consumption. The seasonal component of the model is significant as predicted.

We estimate a similar model for catch-up audience. We include the live audience of the

previous episode as an exogenous regressor. Results shown in table 12 support an effect of the live audience of the previous episode for both the differenciated and non-differenciated models. The autoregressive and moving average terms are significant and of comparable size as the estimates for the rational addiction model of the previous section.

Table 5: Estimation of catch-up audience as a seasonal autoregressive process

	(1)	(2)
	Δ Replay Audience	Replay Audience
Δ Live Audience$_{t-1}$	0.00904*	
	(3.12)	
Live Audience$_{t-1}$		0.00890*
		(3.15)
ARMA		
AR(1)	0.267**	0.910*
	(11.69)	(3.25)
AR(2)	0.00890	-0.138
	(0.35)	(-1.50)
MA(1)	-1.000	-0.641†
	(-0.00)	(-2.32)
ARMA$_5$		
AR(1)	0.157**	1.020**
	(5.41)	(23.62)
AR(2)	0.0598†	-0.0680†
	(1.97)	(-1.98)
MA(1)	-0.863**	-0.759**
	(-40.45)	(-20.27)
sigma		
	78.72	78.11**
	(0.00)	(71.29)
N	1299	1305

t statistics in parentheses

$^{\dagger}p < 0.05$, $^{*}p < 0.01$, $^{**}p < 0.001$

These results provide evidence of strong habits or addictive effects in the consumption of TV series. This holds in the case of independent-episodes series but these effects are significantly lower than when the narrative develops over the whole season.

5 Conclusion

The evolution in broadcasting technology, and the growth of online video services, led to a change in the demand function for TV series. We show how new consumption patterns, free from the constraint of the linear television program are conducive to the emergence of addiction effects.

The existence of addictive effects for certain types of TV series results in a delinearization of consumption. These effects can explain the competitive dynamics observed in the market for free-to-air fiction broadcasting. Channels that do not strongly value their catch-up platform are rely more on the broadcasting of movies or series with independent episodes.

These results have strong industrial and policy implications for the French TV market. The new forms of the demand function structures a captive audience for online platforms. The decline in popularity of the independent-episodes series and increased competition lead to a fall in profitability for free-to-air broadcasters. Their difficulty to monetize their non-linear viewers makes it less profitable for them to finance serials. As those channels represent one of the main investors in the French audiovisual industry, it is possible that the production of serials in France is suboptimal. Giving free channels better incentives to invest in such programs by reforming the partition of rights could help in re-orienting the industry towards serials.

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Appendix

Variable	
Date	
Time of broadcast	
Duration	
Channel	
Program name	
Program label	
Genre	32 modes (thriller, animation etc.)
Live audience	
	-Older than 4
	-4-14 years-old
	-15-24 years-old
	-25-34 years-old
	-34-49 years-old
	-50 and more
	-Men
	-Women
	-Lives in Île de France
	-Lives outside of Île de France
Global audience	
	-Older than 4
	-4-14 years-old
	-15-24 years-old
	-25-34 years-old
	-34-49 years-old
	-50 and more
	-Men
	-Women
	-Lives in Île de France
	-Lives outside of Île de France

Table 6: Description of the database

Type	Definition	Examples
Independent episodes series	Episodes are independent. The unity of the series is due to the presence of recurring characters or places.	*Columbo, Navarro, The Simpsons*
Serialized series/serial	The story takes place over a season or more. The viewer must watch all episodes in order to understand the narrative	*Game of Thrones, Desperate Housewives*
Soap opera	Particular case of serial. Features family-type intrigues, romances and moral conflicts. Generally broadcast on a daily basis	*Plus Belle la Vie, The Young and the Restless.*

Table 7: Definition of narrative structures

5.1 Rational addiction model

Table 8: Rational addiction model on catch-up audience

Variable	Coefficient	(Std. Err.)
Audience_{t-1} (catch-up)	0.163*	(0.070)
Audience_{t+1} (catch-up)	0.120*	(0.053)
Audience_t	0.089**	(0.016)
Publicité	0.325	(0.369)
Year	15.193†	(8.638)
TF1	-17.045	(75.364)
TF1 Group	-65.615	(45.112)
Summer	-7.279	(11.939)
France	22.982	(24.892)
USA	2.162	(26.136)
M6 Group	-70.599	(59.445)
M6	6.094	(43.776)
France TV	-57.019*	(29.050)
Note	128.469**	(39.985)

Table 9: Rational addiction model: Independent-episodes series

Variable	Coefficient	(Std. Err.)
Audiencet_{-1}	0.229**	(0.051)
Audiencet_{+1}	0.101**	(0.034)
Year	-83.648	(53.068)
TF1	4000.792**	(407.804)
TF1 Group	117.537	(236.826)
Summer	-311.691**	(68.447)
France	-305.212*	(130.647)
USA	431.298†	(236.203)
M6 Group	-176.585	(347.082)
M6	2188.294**	(314.153)
France TV	1984.754**	(340.142)
Episode	-1.314	(3.786)

Table 9 presents the estimation results on the database for independent episodes series. The effect of past and future consumption is still significant, though lower than for serials. In addition, the effect of future (anticipated) consumption is very low compared to this of the serials, which suggests that consumption of series with independent episodes is more of a habit than an addiction.

5.2 ARIMA Models

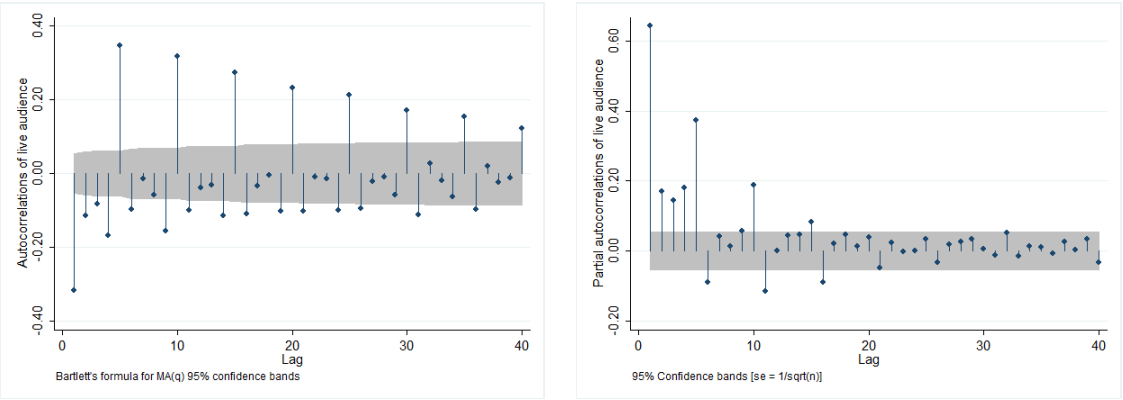


Table 10: Autocorrelations for live audience (*Plus Belle la Vie*)

In the previous models, we take into account a one-week diffusion cycle. The evolution of audience, presented in the figure 11 shows longer variations, on a seasonal scale. We provide a modelling of the audience on a monthly basis.

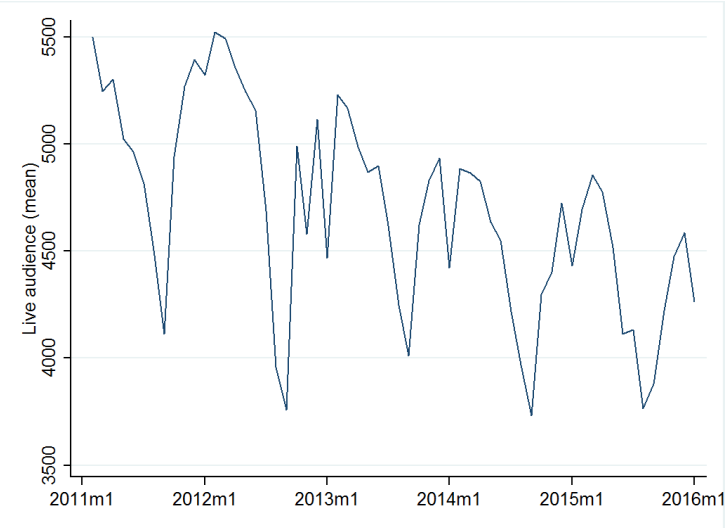


Figure 11: Mean of monthly audience

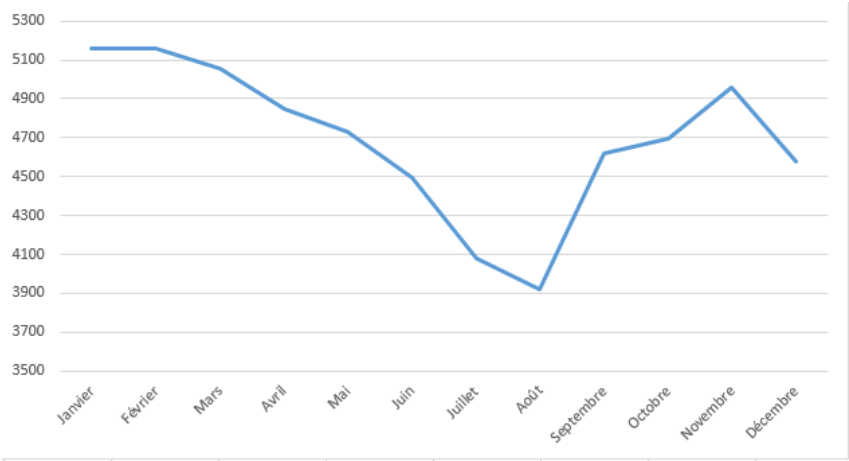
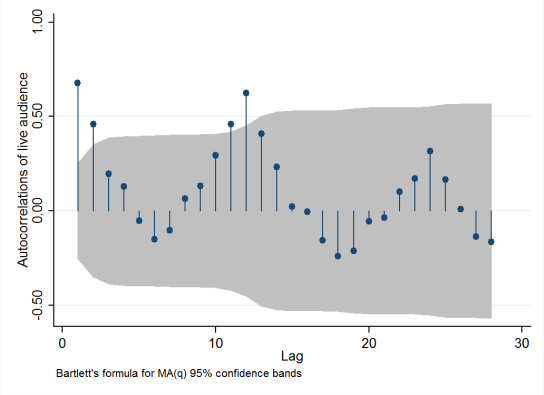


Figure 12: Monthly live audience for *Plus Belle la Vie* (2011-2015)



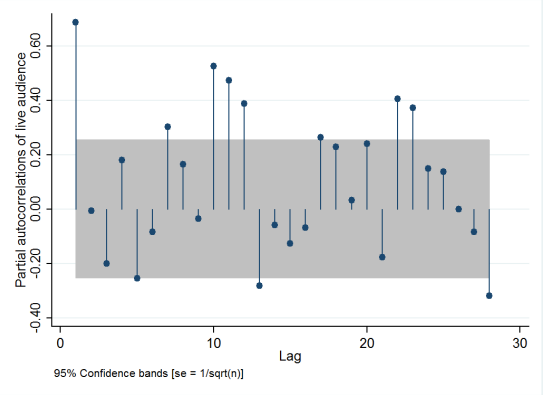


Table 11: Autocorrelations for monthly live audience (*Plus Belle la Vie*)

Table 12: Estimation results : arima

	(1) ARIMA$(1,0,0)\times(1,0,0)_{12}$	(2) ARIMA$(1,0,2)\times(1,0,1)_{12}$
Live audience		
Intercept	4690.4**	4679.4**
	(26.37)	(10.08)
ARMA		
AR(1)	0.630**	0.878**
	(5.99)	(7.61)
MA(1)		-0.432*
		(-3.08)
MA(2)		0.0745
		(0.52)
$ARMA_{12}$		
AR(1)	0.715**	0.942**
	(8.31)	(14.02)
MA(1)		-0.449
		(-1.59)
sigma		
Constante	230.0**	201.7**
	(12.04)	(9.73)
N	60	60

5.3 Case study: *Desperate Housewives*

We provide here a time-series analysis of the series *Desperate Housewives*, broadcast by M6 between 8.50 and 10 p.m, for two seasons (2011 and 2012). This program is an American comedy and drama series, roduced by ABC Studios and Cherry Production and aired from 2005 to 2012 in France. The viewing of this series follows a different pattern from *Plus Belle la Vie*. First, its broadcasting is on a weekly basis rather than daily. The narrative structure of *Desperate Housewives* is widely different from this of France's favourite soap opera. Seasons are shorter, episodes are longer and more closely linked within a season.

Results from the ADF test attest for the presence of a unit root in the data. Thus, we will work only on the differentiated series.

Table 13: Test de Dickey-Fuller augmenté

Spread	Critical value for the 5% threshold	Test value	p-value
2	-2.966	-1.939	0.3141
3	-2.969	-1.780	0.39065
4	-2.972	-1.435	0.5655
5	-2.975	-1.420	0.5725

We estimate an ARIMA(1,1,1) model to account for the live audience of the series. This corresponds to the following specification:

$$\Delta A_n = \Delta\alpha A_{n-1} + C + \varepsilon_n + \theta\varepsilon_{n-1} \tag{13}$$

Results are presented in table 14

Table 14: ARIMA model for *Desperate Housewives*

	Estimated coefficient	Test value
C	-15.64	0.06
AR(1)	0.49	0.007
MA(1)	-1	0.00

Test values for Bartlett and Ljung-Box fail to reject the hypothesis: $\mathcal{H}_\prime$*: The residual follow a random noise distribution.* We interpret the presence of a unit root in the series as the fact audience is susceptible to both positive and negative shocks, and does not go back to an equilibrium level after such a variation. The means that the broadcasting of a program with such an audience profile is very dependent on the presence of a catch-up offer, which smooths consumption and avoids shocks.

Another consequence is that if a popular program (such as a sport game or another TV series) is broadcast on a competing network, it could result in a persisting negative shock for the series. The channel thus has incentives to shift the broadcast to a more convenient time, or rely on its catch-up platform. This effect highlights the better adequation of the SVOD and VOD platform broadcasting technology for such series, as they insure against the risk of a negative shock.

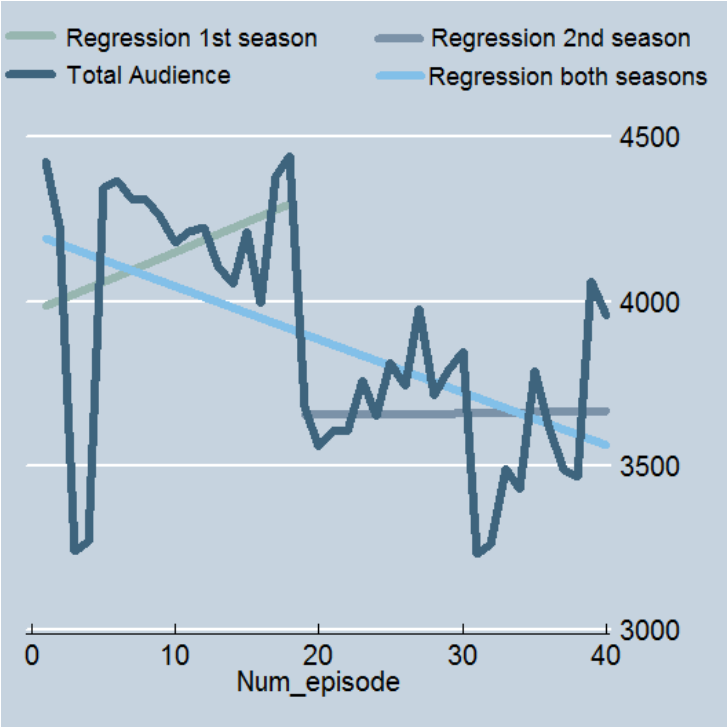


Figure 13: Testing for rupture in the estimation

We test for rupture in the estimation between season 1 and 2 using the chow test. The test hypothesis is:

$\mathcal{H}_0$: *Estimated coefficients in season 1 and 2 are equal*

We reject $\mathcal{H}_0$ at the 5% threshold.

It is interesting to note that the consumption models for season 1 and 2 are different. This can be explained by the rational addiction framework: the consumption stock depreciates with time. If too much time passes between the broadcast of the 2 seasons, some consumers will stop watching the series. The audience base should stabilize around the *core* viewers after a number of seasons.