Two-Sided Platforms with Negative Externalities and Quality Investments - An Application to Media Markets

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Introduction

Two sided platforms have a wide range of interesting application possibilities, where the results of classic economy theory models like Cournot, Hotelling (1929) or Salop (1979) fail to explain some certain characteristics, which are important for the understanding of the choices made by the participating agents. The most important characteristics which are considered in the case of two sided platforms, are network effects and the existence of a third party in addition to consumers and producers, the platform owner. Network effects can be observed on many platforms, where consumers and/or producers interact with each other. For example there are network effects in social network platforms like Facebook, in specific, the utility of a Facebook member is growing with the number of his friends and other people who are also using Facebook. So there exists a positive externality, which members exert on each other.

One of the first applications of two sided markets with positive externalities can

*Nima Jouchaghani received his degree in Economics (B.Sc.) from the University of Bonn in March 2013. The present article refers to his bachelor thesis under supervision of JProf. Dr. Eugen Kovac, which was submitted in March 2013.

be found in Rochet and Tirole (2003). They find out that the structure of credit card and video game markets fits into the theory of two sided platforms with positive externalities. In the case of credit cards, consumers using a credit card have a higher utility, if there are many stores, which accept the card. On the other side the stores benefit from a growing number of consumers who are using the credit card which is accepted by them. So the agents in this model exert a positive externality on each other.

Up to this point we have only mentioned positive externalities, but there are also platforms in which we have the case, that one side benefits from a growing number of agents on the other side, while the other side exerts negative externalities. Consider the Facebook example again, companies are able to put advertisement banners on the website. Since members use social media networks mostly to interact with friends and other people, they dislike a growing number of advertisement. Therefore the companies exert a negative externality on the users, while they have benefits from a growing number of users at the same time.

In this work we deal with an application of two sided platforms with negative externalities, in specific we analyze the structure of competition in television stations. An early contribution to this topic can be found in Anderson and Coate (2005). They analyze broadcasting markets in order to find out if there is too much advertisement in matters of welfare, such that regulation is needed. Another paper to this topic is given by Reisinger (2004), whose work has a new feature given by viewers being able to choose the time they want to spend on a platform, so the utility they gain by using the platform is not given by a constant as in Anderson and Coate (2005).

This work is based on the model which is used by Reisinger (2004), but there are two modifications in case of competition structure. While Reisinger (2004) models two competing platforms, which can set a price for advertisement slots in order to maximize profits, we consider one monopoly platform owner. The reason for the modification is that the goal of this work is to develop a model, which will be compared with aggregated stylized facts of the television market in Germany.

The next central feature of this model refers to the decision variables of the platform owner. While in recent models the owners always choose a price for advertisement slots, we consider a new variable, the quality investment. The program of television stations mostly contains movies, series, talk shows, sports, documentaries and news. Since television stations benefit from a rising number of viewers[1], they try to offer a broad range of high quality content. This means in the case of movies for example, they try to buy licenses for the newest or most popular movies in order to attract more viewers.

The structure of this work is organized as follows: First the reader will be shown data for the German television market where we point out on some developments. Afterwards the model which is used to describe the market will be presented and solved for subgameperfect Nash equilibria. Finally we try to find a connection between the empirical facts and the predictions of the model.

The German Television Market

The German television market can be divided into the private and public television stations. Figure 1 shows that in the case of private television stations there are two mentionable companies which represent almost the whole private sector, the RTL Group and ProSiebenSat1 Media. In contrast to the public sector, the only way for private television stations to finance their programs, is by selling

[1] The more viewers they attract to the television station, the more valuable it is for advertisers to put advertisement on it. Since in Germany there is a limit of 12 minutes of advertisement per hour (see § 45 RStV,NI (1) for private television stations, § 16 RStV,NI (3) and § 16 RStV,NI (1) for public television stations),the only way to make more profit is to rise the value of advertisement time.

advertisement slots. The public broadcasting sector in Germany is represented by ARD and ZDF, who are mostly financed by fees.

In this work, we focus on the previously listed television stations due to the fact, that they represent over 87% of the market share of the German television market, which is sufficient for the comparison to a model, in which a monopoly platform owner sets the amount of advertisement and the level of quality investment.

The problem occurring at this point is, what kind of data to consider for the level of quality investment. Since there is a limit of advertisement per hour, both have an incentive to increase the value of advertisement time. This can be achieved by purchasing licenses or with good "in-house productions", in order to attract more viewers. So the factors we consider for the level of quality investment are: purchase/leasing of licenses, personal and material costs.

Figure 5 pictures the total amount of quality investments for the years 2001-2011. One can see that there is an obvious trend of increasing quality investments over the years, with a structural discontinuity at 2009, which might be a delayed consequence of the financial crisis. So we observe an almost constant growth of quality investments.

The next development refers to the total amount of advertisement in German television. Figure 2 shows that the amount of advertisement started climbing steadily, with a structural discontinuity at 2009, which might also be a consequence of the financial crisis[2]. Nevertheless there is a clearly defined pattern to this figure, showing that the amount of advertisement has been growing steadily, in specific it almost doubled from 2001-2011.

figures 3, 4 and table 1 refer to developments on the viewers side. While figure 3 shows, that the average viewing time per day is increasing almost continuously,

[2]Consider that usually advertisement slots are bought by companies from the industry. Since the financial crisis brought many companies into difficulties, it might be that there has been a scarceness of demand for slots due to liquidity shortfall

figure 4 points out that the percentage of television spectators started slightly growing at 1994, peaking at 2004 and then began dropping again.

Another development, which is quite important for the decision making of television stations and the viewers, is illustrated in table 1. The basic assumption of our work is given by viewers disliking advertisement, since they watch television mainly to enjoy the offered content. But there might be changes in matters of how negative the effect of advertisement is received from the viewers perspective. Figure 5 pictures a questionnaire with a sample of 31447 persons, representing the German population. The main result is given by both general and television advertisement beeing received less negative over time. An explanation might be that over time, there could be a "learning effect" on the advertiser's side. In order to maximize the sales, advertisers need information about the viewers, in specific they need to know about the preferences and the behavior of viewers. So by advertising and afterwards observing the sales, advertisers can operate more efficiently in matters of on which television stations to advertise on, at which point in time and with what type of advertisement. Therefore, our assumption at this point is given by viewers aversion for advertisement decreasing over the time.

Model

The model used in this work, is based on the model given by Reisinger (2004). Besides the changes, including only one platform owner and the extension with quality investment, we also consider a concrete function for the utility of participating on the platform, given by $v(t)$.

Platform

There is a monopoly platform owner, which on the one side can set a price p

for advertising on the platform, but on the other side can't exclude viewers from using it. Before setting the price, the platform makes a quality investment I, in order to attract more viewers. The profit function is given by

$$\Pi = np - I \tag{1}$$

where n is the amount of advertisement. The platform owners' object is to maximize profits.

Viewers

There is a mass M of viewers, who are utility maximizing individuals. They are uniformly distributed on the interval [0,1], where the platform is located at point 1. Viewers can choose the time t they want to spend on the platform. The more time they spend on the platform, the higher is the utility they gain. We consider $v(t)$ as an increasing, continuous and concave function, given by $\sqrt{t}$. Viewers also gain utility from the investment I of the platform, given by I^α. For now we only assume that I^α is also an increasing, continuous and concave function. The utility of the time, a viewer spends on the platform is decreasing by the amount n of advertisement on the platform.

Viewers have total time T to spend on the platform, or on other activities. Given t, the time a viewer is spending for other activities is given by $T - t$. The utility a viewer gains for spending time on other activities is normalized on 1 per time unit.

The maximization problem of a viewer who is located at x is given by:

$$\max_t \quad U(t,x) = (T-t) + \sqrt{t} I^\alpha - \gamma t n - \mathbb{1}_t \tau (1-x)$$

where τ represents the transportation costs as given in a classic Hotelling model and γ is a parameter which measures the negative externality which advertisement exerts on the viewer. The indicator function $\mathbb{1}_t$ has value 1 for $t > 0$ and 0 for $t = 0$.

Consider that viewer gain no utility from the platform, if either t, I or both are zero.

Solving for t yields:

$$t(n, I) = \frac{I^{2\alpha}}{4(1 + \gamma n)^2} \tag{2}$$

The next step is to find the marginal viewer, who is indifferent between participating on the platform and not. Viewers, who do not spend any time on the platform gain utility T. So we search for $\hat{x}$ such that $\mathrm{U}(t, \hat{x}) \overset{!}{=} T$, in specific :

$$(T - t) + \sqrt{t} I^\alpha - \gamma t n - \tau(1 - \hat{x}) \overset{!}{=} T \Longleftrightarrow \hat{x} = 1 - \frac{\sqrt{t} I^\alpha - \gamma t n - t}{\tau}$$

Since Viewers are uniformly distributed on [0,1], the demand of the platform is given by

$$(1 - \hat{x}) = \frac{\sqrt{t} I^\alpha - t(1 + \gamma n)}{\tau} = \frac{I^{2\alpha}}{4(1 + \gamma n)\tau} \tag{3}$$

The aggregated demand is given by $M(1 - \hat{x})$.

Advertisers

Advertisers are monopoly producers of differentiated products, for which a fraction β of users has a reservation value of K, while a fraction of $(1 - \beta)$ has a reservation value of 0.

Since advertisers are monopolists, they set the price for their product on K in order to gain the whole surplus from viewers[3].

With buying an advertisement slot, they can inform the viewers about their product. The profit of an advertiser, who decides to buy a slot on the platform is given by

$$\pi = MK\beta(1 - \hat{x})t - p \tag{4}$$

[3]We assume that viewers always have an income $\geq$ K

where $MK\beta(1-\hat{x})t$ is the gross value of advertisement on the platform and p is the price an advertiser has to pay for a slot. For simplicity, we stick to Reisinger (2004) with the assumption, that advertisers do not have any production costs for both the product and advertisement, considering that this does not change the qualitative results.

Timing and structure of the game

In the first stage, the platform owner decides about how much he wants to invest into the platform quality and the price for advertising slots. Since we have a monopoly platform owner, he can choose the optimal amount of advertisement instead of the price, without changing the results in equilibrium. In the next stage, the price for advertising is determined and viewers decide about how much time they want to spend on the platform.

Solving for Equilibrium

In this section we solve the described game for subgame perfect Nash equilibria. We assume that advertisers who do not put any advertisement on the platform, have a profit of 0. Hence the monopoly platform owner sets a price in equilibrium, such that advertisers are indifferent between participating on the platform and not. Therefore in equilibrium we have

$$p \overset{!}{=} MK\beta(1-\hat{x})t = \frac{MK\beta I^{4\alpha}}{16\tau(1+\gamma n)^3} \Longleftrightarrow np - I = \frac{MK\beta I^{4\alpha} n}{16\tau(1+\gamma n)^3} - I \qquad (5)$$

where the right term is equal to (1), which represents the profit function of the platform.

In order to derive the optimal amounts of advertisement and quality investment, we solve (5) for the maximization problem of the platform given by :

$$\max_{n,I} \quad \Pi = \frac{MK\beta I^{4\alpha} n}{16\tau(1+\gamma n)^3} - I \tag{6}$$

Solution

In equilibrium,we assume $\alpha{=}\frac{1}{8}$ such that the optimal amounts of n and I are given by

$$n^* = \frac{1}{2\gamma} \;\; and \;\; I^* = \frac{(MK\beta)^2}{\tau^2\gamma^2 46656} \tag{7}$$

which are sufficient for maximum[4].

Next, with this expressions, we can derive the optimal amount of time, spent by the viewers and the demand function of the platform in equilibrium. They are given by:

$$\begin{aligned} t^* &= \frac{(I^*)^{\frac{1}{4}}}{4(1+\gamma n^*)^2} = \frac{\sqrt{MK\beta}}{\sqrt{\tau}\sqrt{\gamma}\sqrt{17496}} \\ and \;\; (1-\hat{x})^* &= \frac{(I^*)^{\frac{1}{4}}}{4(1+\gamma n^*)\tau} = \frac{\sqrt{MK\beta}}{\tau^{\frac{3}{2}}\sqrt{\gamma}\sqrt{7776}} \end{aligned} \tag{8}$$

For our discussion, it is important to observe that increasing transportation cost, has a stronger impact on the demand function, than on the viewing time[5].

Discussion

In this section we are going to compare the results, given by our model and the empirical data which was presented before. We try to find explanations for the developments which took place on the German television market in connection with the prognostication of our model. Furthermore, we make assumptions about the long time behavior of the exogenous parameters in our model and explain why

[4]See appendix A, we have to assume $\alpha \leq \frac{1}{4}$ in order for (n^*, I^*) to be sufficient for maximum

[5]We observe that $(1-\hat{x})^*$ is decreasing faster in τ than t^*

there should have been a change. Consider that we restrict our explanations on the time interval of 2001-2011 due to limited data.

First recall the developments of the German television market. We observed an increasing amount of quality investment, viewing time and amount of advertisement, while the viewing rate remained constant. Therefore we are going to discuss, what possible explanations there could be for the viewing time increasing, while the percentage of television spectators stays almost constant, as shown in figures 3 and 4.

First reconsider the argument, that the nuisance parameter γ is decreasing over the time. The results in equilibrium of our model forecast, that investments I, viewing time t , percentage of television spectators $(1-\hat{x})$ and amount of advertisement n should increase. So in order to find an explanation for $(1-\hat{x})$ staying constant we need to make assumptions about the development of the other parameters. The percentage of television spectators, or in our model the demand of the platform in equilibrium given by (3) is decreasing in τ, considered as the transportation cost. In ordinary Hotelling models, the transportation cost represents the level of product differentiation, meaning that the higher τ, the more difficult it is for firms to attract new consumers. Since viewers can only choose between joining the platform and spending time on other activities, we have to explain why τ should increase in our model. For an explanation of this development we need to consider that "other activities" also includes the use of internet.

Since the beginnings of the internet, there have been lots of technical improvements, which offer new possibilities for internet users. In the present, users can watch almost all the television contents online at no cost[6] , so the internet has become a kind of substitute for television. Reisinger (2004) brings up the argu-

[6]Even if we do not consider the illegal possibilities, all television channels in Germany do have websites where the program can be watched at any time for a specific time period

ment, that over time, "people form habits", such that they will not switch easily from one platform to another. This could be a possible explanation for τ rising in our model, since a viewer who watches television gets used to this process more and more over time, which implies that he will not switch that easily to the internet as a platform.

Consider that we could also argue that τ should be decreasing over the time, since the contents of the internet and television became similar, which should be an indicator for a decreasing level of product differentiation. But we have to take into account that over time, the internet even over exceeded the possibilities of television. In specific there is more content available on the internet, than on television. Online platforms like Youtube even allow users to create own channels such that there is much more variety for the viewers, than given by television. Regarding figure 4, we can see that percentage of television spectators reaches the maximum at 2004, and then begins to decrease slowly until 2011. There might be a relation between the developments in the case of Youtube[7], which was founded in 2005 and grew constantly since then, and the decreasing percentage of television spectators. If we also consider that over the time the download speed has been increasing, the possibilities of enjoying media on the internet have also grown.

So assuming that τ begins increasing at 2005, this might be an explanation for the stagnation of the percentage of spectators. If we take a look at $(1 - \hat{x})$ in equilibrium, we see that it is the only variable, where the effect of τ rising is stronger than the effect of the decreasing nuisance parameter γ. So if we consider γ decreasing stronger then τ increasing, there is still a possibility for the

[7] We could assume that Youtube represents the internet as a media platform. Consider that there are several other ways to enjoy media in internet, like video on demand websites or even the websites of the television stations, but they all require almost the same technology, so we could take the development of Youtube as an approximation for the development of the whole media sector in internet

negative effect of the transportation cost to dominate over the decreasing nuisance parameter. This means in specific that in the case of our model, there is the possibility for I and t to increase, while $(1 - \hat{x})$ is almost constant or even decreasing.

But what about the remaining parameters? Consider the mass of viewers M. The match for M in reality can be assumed as the total population. Since there has not been any big change in matters of the total population in Germany, considering our time interval, we can assume that M is constant.

Next we take a look at the reservation value K. Since most advertisement in television is made for consumption goods, the inflation rate could be a good approximation for the changing of K. For Germany the average inflation rate each year[8] is approximately given by 1,6%, so for the time interval of 2001-2011, K has been increasing about 19%. So besides the decreasing of γ, we have a second parameter which has an increasing effect on the variables.

The remaining parameter β was defined as the fraction of users, who have a reservation value of K for the advertised products. If we take a look at table 1, we see that the rate of viewers suggesting "advertisement helpful for the consumers" is increasing, the same goes for the rate of viewers claiming that "Television advertisement is quite informative". A growing affirmation for this two statements could be an evidence for advertisement to have an increasing influence on the viewers. Therefore there is evidence for β increasing over time.

Next we are going to discuss, if our model is able to explain the developments on the German television market, under the assumptions which we made considering the parameters. Reconsider that the optimal amount of advertisement in equilibrium was given by $n^* = \frac{1}{2\gamma}$. Since we argued that γ is decreasing, our model predicts that n^* should be increasing. If we take a look at figure 2, we see that

[8] For the years 2001-2011

this is the case until 2008, where we argued that the reason for this structural discontinuity could be a delayed consequence of the financial crisis.

The amount of investments in equilibrium was given by $I^* = \frac{(MK\beta)^2}{\tau^2\gamma^2 46656}$. The changes in γ, β and K increase investments in equilibrium, while τ decreases them. So the positive effect could overweight the negative effect of τ, such that our model forecasts that I^* should be increasing. Regarding figure 4, we see that on average the quality investments are increasing until 2008. The reason why there is a structural discontinuity, beginning in 2009, could also be an effect of the financial crisis.

Viewing time and demand of the platform in equilibrium were given by $t^* = \frac{\sqrt{MK\beta}}{\sqrt{\tau}\sqrt{\gamma}\sqrt{17496}}$ and $(1-\hat{x})^* = \frac{\sqrt{MK\beta}}{\tau^{\frac{3}{2}}\sqrt{\gamma}\sqrt{7776}}$. As mentioned before, we observe that for $(1-\hat{x})^*$ the impact of τ is stronger than any other parameter, while for t^* we have the same properties as for I^*. So in matters of our model, there exists a situation, in which an increase of β,K and a decrease of γ dominate over the effect of growing τ for I^* and t^*, while $(1-\hat{x})^*$ is decreasing. By looking at figures 3, 4 and table 1 we observe, that this is exactly the case for the years 2005 - 2011, if we exclude the effects of the financial crisis on the investments.

Conclusion

The goal of this work has been to develop a model in order to describe the developments of the German television market. We argued that the theory of two sided platforms with negative externalities provides a good approximation of the structure of television markets. It has been shown that our model can explain the developments, if we make certain assumptions about the parameters. Therefore the application possibilities are restricted. Extensions of the model could be given by relaxing the fact that there is only one monopoly platform. Considering a model with two or more competing platforms would be a more realistic assumption concerning the German television market and could lead to much more accurate statements.

References

AGF (2012a): "Marktanteile 2012," `http://www.agf.de/daten/zuschauermarkt/marktanteile`, Accessed: March 26, 2013.

——— (2012b): "Seher 1988-2012," `http://www.agf.de/daten/zuschauermarkt/seher`, Accessed: March 26, 2013.

——— (2012c): "Verweildauer 1988-2012," `http://www.agf.de/daten/zuschauermarkt/verweildauer`, Accessed: March 26, 2013.

Anderson, S., and S. Coate (2005): "Market Provision of Broadcasting: A Welfare Analysis," *The Review of Economic Studies*, 72(2), 947–972.

Hotelling, H. (1929): "Stability in Competition," *Economic Journal*, 39(153), 41–57.

Reisinger, M. (2004): "Two-Sided Markets with Negative Externalities," http://epub.ub.uni-muenchen.de/478/.

Rochet, J., and J. Tirole (2003): "Platform Competition in Two-Sided Markets," *Journal of the European Economic Association*, 1(4), 990–1029.

Salop, S. (1979): "Monopolistic Competition with Outside Goods," *Bell Journal of Economics*, 10(1), 141–156.

STA (2011): "TV-Werbeminuten in Deutschland 2002-2011," `http://de.statista.com/statistik/daten/studie/4769/umfrage/tv-werbesekundenin-deutschland-seit-2000/`, Accessed: March 26, 2013.

ZdW (2010): "Werbeklima 2007-2010," `http://www.zaw.de/index.php?menuid=66`, Accessed: March 26, 2013.

Appendix

Proof of the Solution

The problem of the platform was given by

$$\max_{n,I} \quad \Pi = \frac{MK\beta I^{4\alpha} n}{16\tau(1+\gamma n)^3} - I$$

By deriving the first order conditions we get

$$\frac{\partial \Pi}{\partial n} = \frac{\frac{MK\beta}{16\tau} I^{4\alpha}[(1+\gamma n)^3 - 3\gamma n(1+\gamma n)^2]}{(1+\gamma n)^6} \stackrel{!}{=} 0 \tag{9}$$

$$\Leftrightarrow (1+\gamma n) - 3\gamma n \stackrel{!}{=} 0 \Longleftrightarrow n^* = \frac{1}{2\gamma}$$

and

$$\frac{\partial \Pi}{\partial I} = \frac{\frac{MK\beta}{16\tau} 4\alpha I^{4\alpha-1} n}{(1+\gamma n)^3} - 1 \stackrel{!}{=} 0 \tag{10}$$

$$\Leftrightarrow I^* = \left(\frac{(1+\gamma n)^3}{n \frac{MK\beta}{16\tau} 4\alpha} \right)^{\frac{1}{4\alpha-1}}$$

using $n^* = \frac{1}{2\gamma}$ we have

$$I^* = \left(\frac{27}{\frac{MK\beta\alpha}{\gamma\tau}} \right)^{\frac{1}{4\alpha-1}}$$

The next step is to proof that (n^*, I^*) is sufficient for maximum. Therefore we need to show, that the Hessian matrix of the the second-order partial derivations of Π is negative definite in (n^*, I^*). By simplifying (15) we have

$$\frac{\partial \Pi}{\partial n} = \frac{MK\beta}{16\tau} I^{4\alpha} \left(\frac{1-2\gamma n}{(1+\gamma n)^4} \right)$$

Deriving the second-order partial derivation yields

$$\frac{\partial^2\Pi}{\partial n^2} = \frac{MK\beta}{16\tau} I^{4\alpha} \left(\frac{-2\gamma(1+\gamma n)^4 - (1-2\gamma n)4\gamma(1+\gamma n)^3}{(1+\gamma n)^8} \right)$$

$$\Leftrightarrow \frac{\partial^2\Pi}{\partial n^2} = \frac{MK\beta}{16\tau} I^{4\alpha} \left(\frac{-2\gamma(1+\gamma n) - (1-2\gamma n)4\gamma}{(1+\gamma n)^5} \right)$$

using $n^* = \frac{1}{2\gamma}$ yields

$$\left.\frac{\partial^2\Pi}{\partial n^2}\right|_{n=\frac{1}{2\gamma}} = \frac{MK\beta}{16\tau} I^{4\alpha} \left(\frac{-2\gamma - \gamma - 4\gamma + 4\gamma}{(\frac{3}{2})^5} \right) = -\frac{2MK\beta I^{4\alpha}\gamma}{81\tau} \tag{11}$$

In the next step we need to derivate (16) with respect to I

$$\frac{\partial^2\Pi}{\partial I^2} = \frac{MK\beta 4\alpha(4\alpha-1)I^{4\alpha-2}n}{16\tau(1+\gamma n)^3}$$

using $n^* = \frac{1}{2\gamma}$ yields

$$\left.\frac{\partial^2\Pi}{\partial I^2}\right|_{n=\frac{1}{2\gamma}} = \frac{MK\beta 4\alpha(4\alpha-1)I^{4\alpha-2}}{32\tau\gamma(\frac{3}{2})^3} = \frac{MK\beta\alpha(4\alpha-1)I^{4\alpha-2}}{27\tau\gamma} \tag{12}$$

At this point the reader might see that we need to assume $\alpha \leq \frac{1}{4}$ in order for the Hessian matrix to be negative definite[9]. For simplicity we assume $\alpha = \frac{1}{8}$ such that (17) and (18) are given by

$$\left.\frac{\partial^2\Pi}{\partial n^2}\right|_{n=\frac{1}{2\gamma}} = -\frac{2MK\beta\sqrt{I}\gamma}{81\tau} \quad and \quad \left.\frac{\partial^2\Pi}{\partial I^2}\right|_{n=\frac{1}{2\gamma}} = -\frac{MK\beta I^{-\frac{3}{2}}}{432\gamma}$$

[9]Furthermore if we take a look at (16), we see that this inequation has to be strict in order for I^* to be an inner solution

The last step is to derive the cross derivatives of Π. Using the symmetry of second derivatives and $\alpha = \frac{1}{8}$ we have

$$\frac{\partial^2 \Pi}{\partial I \partial n} = \frac{\partial^2 \Pi}{\partial n \partial I} = \frac{\frac{MK\beta}{16\tau}(1-2\gamma n)}{2(1+\gamma n)^4 \sqrt{I}} \overset{n=\frac{1}{2\gamma}}{=} 0$$

Using the second order derivatives for the Hessian matrix we have

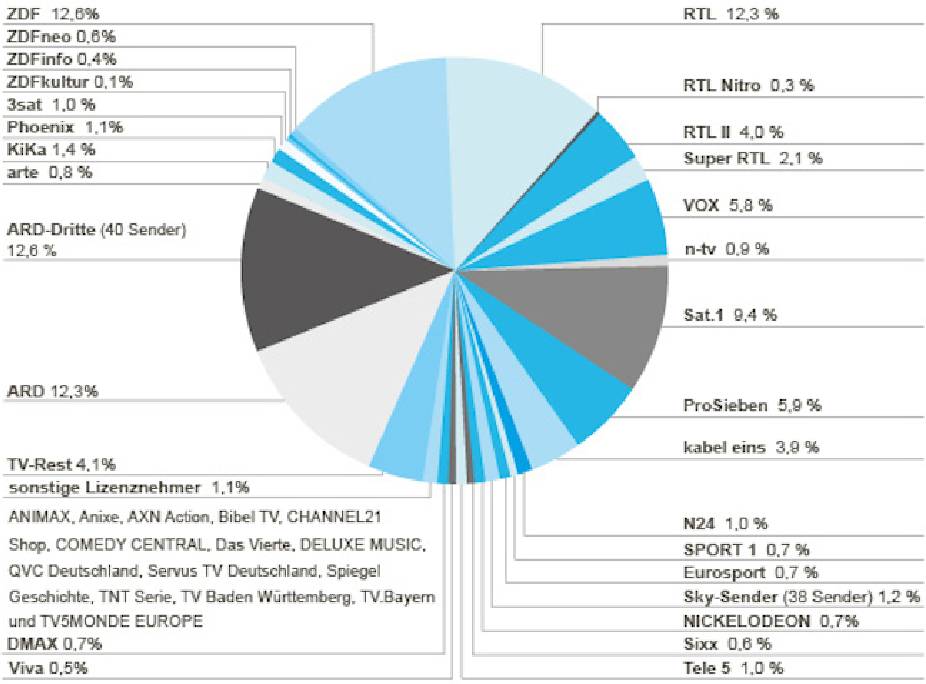
$$\mathcal{H} = \begin{pmatrix} -\frac{2MK\beta\sqrt{I}\gamma}{81\tau} & 0 \\ 0 & -\frac{MK\beta I^{-\frac{3}{2}}}{432\gamma} \end{pmatrix}$$

In order for (n^*, I^*) to be a maximum, it has to be shown that for all real valued column vectors $\mathbf{x} \in \mathbb{R}^2$ we have $\mathbf{x}^T \mathcal{H} \mathbf{x} < 0$, therefore $\mathbf{x} = \begin{pmatrix} x_1 \\ x_2 \end{pmatrix}$ yields

$$\mathbf{x}^T \mathcal{H} \mathbf{x} = -x_1^2 \frac{2MK\beta\sqrt{I}\gamma}{81\tau} - x_2^2 \frac{MK\beta I^{-\frac{3}{2}}}{432\gamma}$$

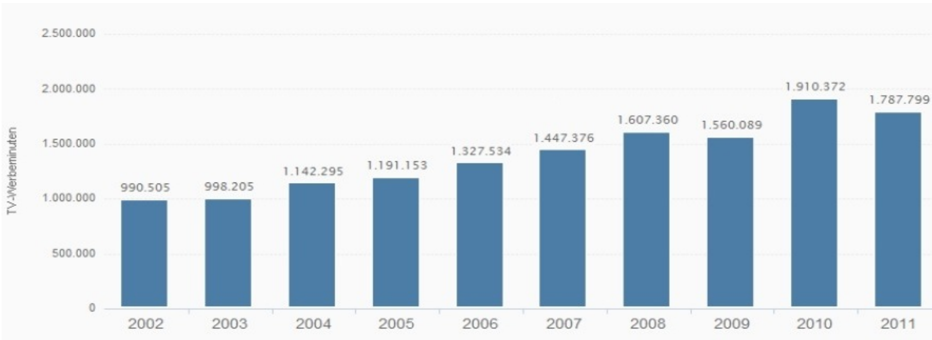
which is < 0 since $I^* > 0$ for the given parameters. $\square$

Figures



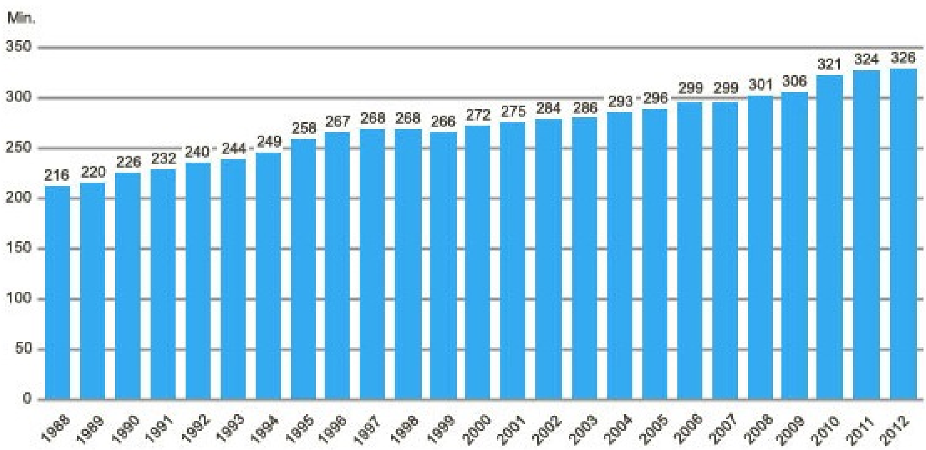
Source: Arbeitsgemeinschaft Fernsehforschung, AGF (2012a)

Figure 1: Market share of German television stations , based on daily average for 2012



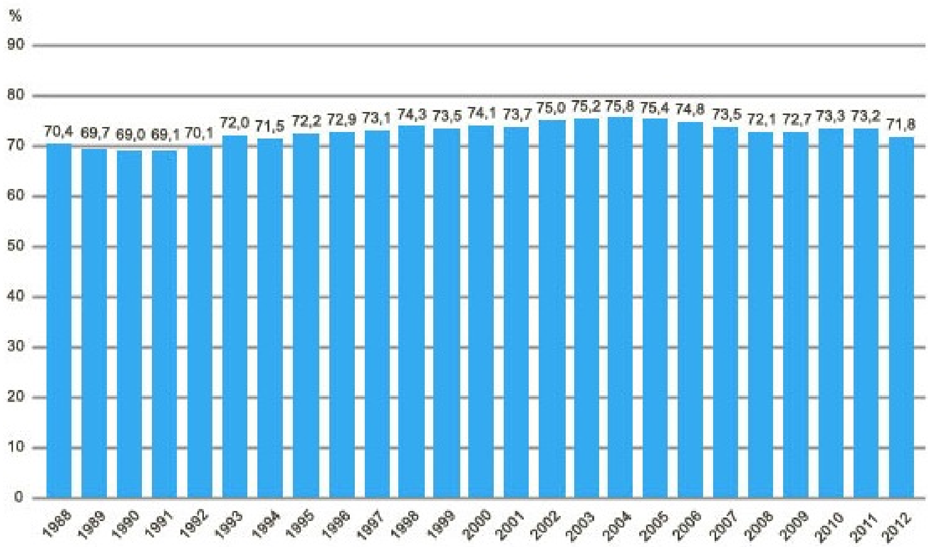
Source: Statista

Figure 2: Total amount of advertisement minutes in German television for 2002-2011



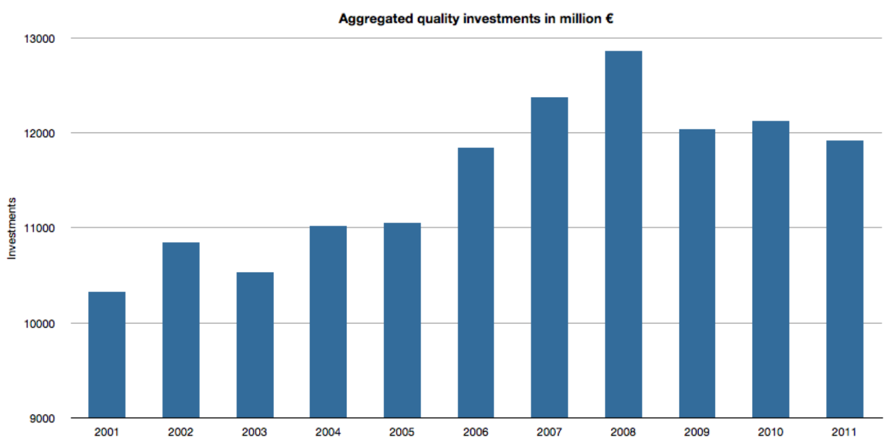
Source: Arbeitsgemeinschaft Fernsehforschung, AGF (2012c)

Figure 3: Average viewing time of a viewer per day in minutes for 1988-2012



Source: Arbeitsgemeinschaft Fernsehforschung, AGF (2012b)

Figure 4: Percentage of television spectators on an average day for 1988-2012



Source: Own illustration and calculation

Figure 5: Aggregated quality investments of German television stations in million €

Tables

Statement	2007	2008	2009	2010
Advertisement gives useful hints for new products	53,2%	57,0%	60,8%	63,2%
Sometimes advertisement is helpful for consumers	45,3%	51,9%	58,6%	61,2%
Mostly advertisement is amusing	35,9%	41,1%	43,6%	45,5%
I like watching television advertisement	33,3%	35,6%	37,2%	40,6%
Television advertisement is quite informative	36,6%	40,6%	43,2%	46,2%

Source: Zentralverband der deutschen Werbewirtschaft, ZdW (2010); Own illustriation

Table 1: Attitude towards advertisement, the percentages represent the relative amount of interviewed persons saying: "I totally agree" or "I mostly agree"

Sources and Calculation of Quality Investments

Company	2001	2002	2003	2004	2005	2006
ProSiebenSat1.Media	1908,7	1902,3	1695,5	1576,5	1620,2	1672,4
RTL Group	3458	3716	3702	4092	4306	4732
ZDF	1251,5	1359,9	1273,3	1364,3	1326,7	1443
ARD	3705,4	3870,3	3860,2	3981,9	3796,6	3994
Σ	10323,6	10848,5	10531,0	11014,7	11049,5	11841,4

Company	2007	2008	2009	2010	2011
ProSiebenSat1.Media	2335	2850,9	2310,8	2341,7	2159,2
RTL Group	4737	4738	4535	4382	4537
ZDF	1386,4	1490,1	1431,3	1508	1419,8
ARD	3920,7	3785,6	3759,5	3892,7	3806,5
Σ	12379,1	12864,6	12036,6	12124,4	11922,5

Table 2: An overview of the individual quality investments for each company for the years 2001 – 2011

Since the accounting method differs from company to company, we give a separate overview about the sources and the calculation methods. In general we used the annual financial statements of the companies for collecting the data we needed to calculate the quality investments. Values were rounded up to one decimal place.

ProSiebenSat1.Media

The annual financial statement for each year is available online at

`http://www.prosiebensat1.com/de/medialounge/downloads/publikationen/2012` [accessed 26.03.2013]

The underlying variables for calculating the quality investments were:

Programm- und Materialaufwand + Personalaufwand + Abschreibungen[10]+ Sonstige betriebliche Aufwendungen, for 2001 (p.71)[11], 2002 (p.46), 2003 (p.42)

Herstellungskosten + Vertriebskosten + Verwaltungskosten, for 2004 (p.62), 2005 (p.68), 2006 (p.172), 2007 (p.68), 2008 (p.90)

Umsatzkosten + Vertriebskosten + Verwaltungskosten, for 2009 (p.114), 2010 (p.115), 2011 (p.130)

RTL Group

[12] The annual financial statement for each year is available online at

`http://www.rtlgroup.com/www/htm/annualreport.aspx` [accessed 26.03.2013]

The underlying variables for calculating the quality investments were:

Consumption of current program rights + other operating expense, for 2001 (p.72), 2002 (p.72), 2003 (p.72), 2004 (p.80), 2005 (p.84), 2006 (p.110), 2007 (p.110), 2008 (p.112), 2009 (p.105), 2010 (p.139), 2011 (p.164)

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[10] The depreciation was only considered due to the fact, that for the years 2004 - 2011 it was integrated in "Herstellungskosten" and "Umsatzkosten". So in order to make the different underlying variables comparable, we needed to include the depreciation for 2001-2003

[11] Example: Can be found in the annual financial statement of 2001 on page 71

[12] Consider that the RTL Group also owns television and radio stations in other countries than Germany, but since we are more interested in changes of investments than in absolute values, it should still be a good approximation for the german television channels

ARD

The annual financial statement for each year is available online at

`http://www.kef-online.de/inhalte/berichte.html` [accessed 26.03.2013]

The underlying variables for calculating the quality investments were:

Programmaufwendungen + Personalaufwendungen

for 2001 – 2003 see Report 15 vol.1, p.26 and p.35[13]

for 2004 – 2007 see Report 17, p.64 and p.77

for 2008 – 2011 see Report 18, p.50 and p.77

ZDF

The annual financial statement for each year is available online at

`http://www.kef-online.de/inhalte/berichte.html` [accessed 26.03.2013]

The underlying variables for calculating the quality investments were:

Programmaufwendungen + Personalaufwendungen

for 2001 – 2003 see Report 15 vol.1, p.29 and p.35

for 2004 – 2007 see Report 17, p.67 and p.77

for 2008 – 2011 see Report 18, p.52 and p.77

[13] Example: Can be found in the 15. Report, volume 1, page 26 for "Programmaufwendungen", page 35 for "Personalaufwendungen"