# Economic Markets for Video Streaming Services: A Case Study of Netflix and Popcorn Time

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**Abstract**

Video streaming services are considered as the new standard method of delivering entertainment to the public. Netflix, one of the leading providers of video streaming, has reported that piracy continues to be their biggest competitor, referring to Popcorn Time specifically. Popcorn Time uses illegal means of providing video streaming. Popcorn Time offers a similar or even better video streaming experience compared to Netflix. In this paper, we study the competition between legal and illegal video streaming services. In particular, this paper elaborates on the analysis of network effects in relation to video streaming services and explains how an individual who uses video streaming can affect the overall value of the network where a particular video is being streamed. We propose the Competitive Video Streaming Model (CVSM), based on the Bass Diffusion model. The CVSM is applied to model the competition between Netflix and Popcorn Time. The main findings show that the timing of the onset of network effects is significant for the temporal evolution of adopters. Our results also suggest that the competitiveness of video streaming services depends on how the service provider is distributing the video streaming contents. It shows that distributing video streaming contents through P2P network subsidizes the growth of adopters to a greater extent compared to a client-server network. As such, the results of this study support the hypothesis that network effects can strengthen the competitiveness of illegal video streaming services.

## 1 Introduction

For over a decade, the world has experienced a rapid change in technology with all its advantages which has paved the way for the emergence of new types of digital media services. In particular, video streaming services such as Netflix, HBO and Amazon Prime have become new standards for video entertainment delivery. This has not only led to improvements of legal streaming services, but has also given rise to distribution of pirated movies and TV shows. These are video streaming services that are free of charge but are operating illegally. Such services are highly competitive because they offer vast selections of high quality films. Illegal video streaming services has become a major concern for governments, service providers and the entertainment market in general. The best known example of illegal streaming services with considerable market share is Popcorn Time.

The main contribution in this paper is a simple economic model for the temporal evolution of the competitive market for media streaming services based on system dynamics. Competition between two providers using basically different market strategies is studied. In order to select a realistic set of parameters, Netflix and Popcorn Time are used as examples of such competitors: Netflix offers streaming services based on client-server technology while Popcorn Time offers services based on peer-to-peer technology.

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# 2 Description of the model

## 2.1 Rational of the model

The model is founded on the diffusion model of Bass [1] applied two competing suppliers. The Bass model is also extended to include churning. To the knowledge of the authors, application of churning to the Bass model has not been reported before. Churning implies that a customer of one provider may switch to the second provider next time the service (e.g., a movie) is purchased. This gives rise to a model that can be used for studying both adoption of the service or product by new customers (the original Bass model) as well as the subsequent evolution of the market owing to competition (churning).

The model does not explicitly take into account economic, psychological, social or legal aspects. Examples of such aspects are that Popcorn Time is free of charge while charges are levied for downloading a movie from Netflix; on the other hand, Netflix is a legal service while Popcorn Time is illegal though with very small probability that the user is punished for using the service. Some users will not adopt Popcorn Time since it is illegal, while other users will adopt the service because the likelihood of being punished is small compared to the economic benefit. The reason why explicit choice functions taking these aspects into account are not included in the model is that the model becomes unnecessarily complex, shifting the attention from market evolution to why users are adopting a particular service. The latter may be explored in separate simulation models.

The adoption of services is modeled by allocating specific adoption rates to each of the competing services. The adoption rates are constant throughout each simulation. Customers that use the service for the first time are then given the probabilistic choice of either Netflix or Popcorn Time. The seminal paper by Brian Arthur *et al.* on the temporal evolution of competitive markets is based on the same simple assumption [2]. The event that users may change their mind at a later stage and download movies from the competing supplier is captured by the churning terms.

Other parameters which are included to make the model realistic are discussed in Section 3.2. All parameters are treated as variables that may have different values and dependence on time in the various simulations. Only a small set of parameter values is investigated in this paper to indicate the dependence of the market evolution on the choice of parameters.

The real market is much more complicated than predicted by the present model and will have a much more irregular behavior. For example, the total number of downloaded movies and TV shows during a certain period of time will depend on the availability and popularity of particular movies and shows. This will give rise to irregular market fluctuations as shown in Section 2.2 for the evolution of the two services in the Netherlands and in Norway. This aspect of the service is not included in our model. Our model predicts the average evolution of the market by ignoring these fluctuations.

The model may anyhow predict some features of these markets, in particular the effect of market feedback and churning on the competitive strength of the two suppliers.

## 2.2 Media streaming services

Video streaming is one-way transmission of video signals over a data network, where the transmitted video can be viewed without completely downloading the data, so that the person may view the transmitted video on a computer, tablet, smartphone, television set or similar devices while the video is downloaded. For example, a streaming program may download the first 10 seconds of the video file, store it, and then start playing it. While the first part of the file is being played, the program is downloading the next 10 seconds of the file. The program does not store more than a little bit of the entire file; and once a part of the file is played, the previous part is deleted.

**Netflix [3][4]**

Netflix operates with a complex client-server model based on own designs as well as solutions from multiple partners. The supply chain of Netflix is: Netflix (1) buys content from a studio; (2) encodes the content and perform quality checks; (3) uses Open Connect CDN for cache optimization; and (4) delivers the content to the customer.

In early 2014, many Netflix users around the world reported a steady decline in the quality of Netflix's streaming services, where some users experienced that the video they were watching were constantly buffering [5]. The reason for this may have been twofold. Some suggests that the decline in quality was because Netflix had outgrown its given bandwidth, which in turn caused congestion. Others believe that this was created by the ISP to extract fees from its content providers.

**Popcorn Time [6]**

Popcorn Time was originally developed by a group from Argentina as an attempt to offer better video services as compared to what was already on the market. It was taken down in March 2014 after pressure from the MPPA, the trade association that represents the six major Hollywood studios [7]. Shortly afterward, new teams and investors took over and started independently developing the product, which quickly became a massive success.

While traditional piracy services can be somewhat complicated and require considerable computer skills, Popcorn Time is elegant and simple to use. After an easy software installation, one can browse through a library of new and still-in-theaters movies and often watch it in high resolution [8]. Popcorn Time is an open source BitTorrent client using P2P file sharing that includes a media player [9]. The services of Popcorn Time do not actually allow for streaming contents, but rather it offers a streaming-like experience due to its sequential downloading features [10]. Every user uploads part of the video while watching, thus contributing to the overall content library. This prevents the service from free-riders, that is, users who only download content and never upload content to the network.

**Observed evolution of Netflix and Popcorn Time**

The Google search query data shows that Popcorn Time is a noticeable competitor for Netflix. This is especially true in the Netherlands, being the country with most Popcorn Time search queries, followed by Denmark and Norway. Figure 1 shows the normalized results from the Netherlands over the past year. The figure illustrates a large jump in search queries for Popcorn Time during September 2014, and in autumn and winter Popcorn Time became greater than Netflix [11]. The market fluctuates in a manner indicating the availability of particularly popular movies or video shows. On the other hand, churning may not be important since the market share of the two suppliers largely fluctuates in the same manner. However, the observation time is short so this conclusion may not be significant.

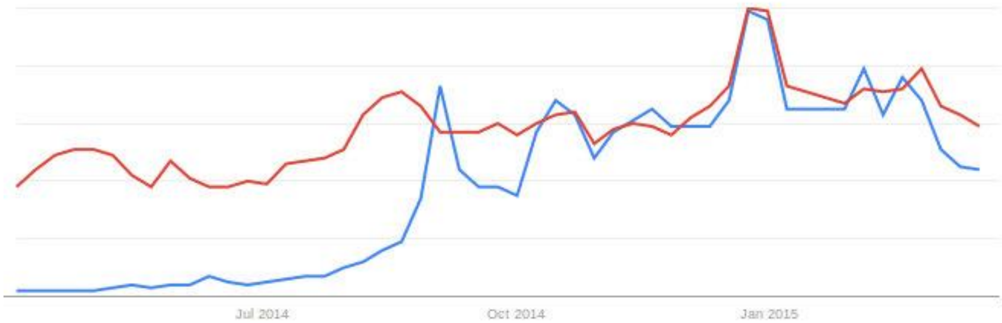



Figure 1. Google Search Query Data for the Netherlands (Netflix in Red and Popcorn Time in Blue)

The situation is slightly steadier for Netflix in Norway, although the data suggest a growing interest in Popcorn Time in recent months. See Figure 2.

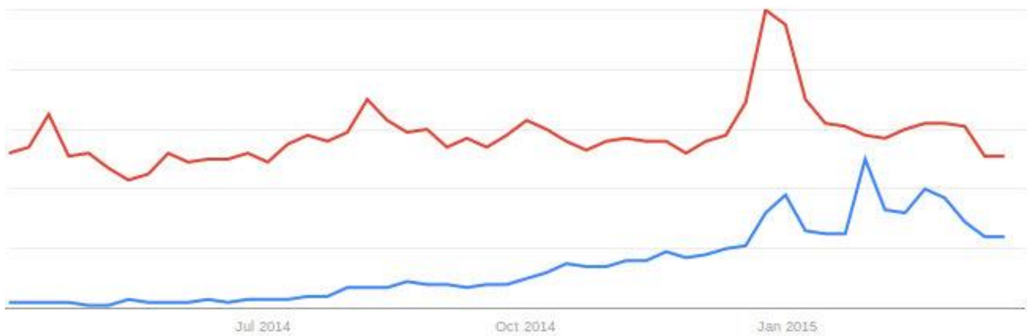



Figure 2. Google Search Query Data for Norway (Netflix in Red and Popcorn Time in Blue)

# 3 Economic models

## 3.1 Simple analytic model

Bass [1] developed a simple analytic model for the dynamic evolution of commodities markets. His model, modified for two competitors and including churning, can be expressed as two coupled first order nonlinear differential equations:

$$\frac{dA_1}{dt} = (N - A_1 - A_2)(p_1 + q_1 A_1) - c_1 A_1 + c_2 A_2$$

$$\frac{dA_2}{dt} = (N - A_1 - A_2)(p_2 + q_2 A_2) - c_2 A_2 + c_1 A_1,$$

where $N$ is the total number of potential customers, $A_i$ are the number of users having adopted the service from supplier $i$, $p_i$ are the adoption rate for innovators, $q_i A_i$ are the adoption rate for imitators, $c_1 A_1$ is the rate by which supplier 1 is losing customers to supplier 2 because of churning, and $c_2 A_2$ is the same for supplier 2. The parameters $c_i, p_i, q_i$ may be constants or be functions of market shares $A_i$ and time; the latter is exploited in the system dynamic model. Solving these equations requires numerical methods. However, what is more interesting is to determine the final state $(A_1^\infty, A_2^\infty)$ the market approaches asymptotically when $t \to \infty$. At this point, the following two conditions must obviously be fulfilled simultaneously: $A_1 + A_2 = N$ and $c_1 A_1 = c_2 A_2$. Consider the three cases 1) $c_1 = 0$ and $c_2 = 0$, 2) $c_i$ are constants, and 3) $c_1 = \gamma_1 A_2$ and $c_2 = \gamma_2 A_1$.

In Case 1), we divide the second differential equation by the first to obtain $\frac{dA_2}{dA_1} = \frac{p_2 + q_2 A_2}{p_1 + q_1 A_1}$. It follows then easily that $A_1^\infty$ is found from the transcendental equation:

$A_1^\infty = N - \frac{p_2}{q_2}\left[\left(1 + \frac{q_1 A_1^\infty}{p_1}\right)^{q_2/q_1} - 1\right]$ and $A_2^\infty = N - A_1^\infty$

In Case 2), we see immediately that $A_1^\infty = \frac{c_2}{c_1 + c_2}$ and $A_2^\infty = \frac{c_1}{c_1 + c_2}$.

In Case 3), the solution is either $A_1^\infty = 1$ and $A_2^\infty = 0$ or $A_1^\infty = 0$ and $A_2^\infty = 1$; that is, a winner-take-all market. If $\gamma_2 > \gamma_1$, supplier 1 is the winner.

Another case that can be evaluated analytically (Floquet theory, see [12]) is when the $c_i$ are time-varying functions with constant mean. Then the solution is a time-varying function around the mean value given in Case 2 where the $c_i$ are the mean values.

To compute the detailed behavior of the streaming services, this model is obviously too simple though it predicts how the market may evolve in the long term; that is, either ending up as a shared market or a winner-take-all market. We have to use numerical methods based on simulation in order to study particular effects such as nonlinear churning behavior and saturation. This is done next using system dynamics.

## 3.2 Competitive Video Streaming Model (CVSM)

The Competitive Video Streaming Model (CVSM) is based on the Bass model with the following additional assumptions.

**Independent decisions**

The CVSM model works on the assumption that a certain number of potential adopters known as innovators will start using the services of video streaming based on their own preferences without being influenced by others. These innovators will either choose the legal Netflix service or the illegal Popcorn Time service. The strength of the independent decisions is determined by the parameters $p_i$ in the model.

**Network effects**

The parameters $q_i$ in the Bass equation determine the adoption rate for imitators. This is also called network effects or, equivalently, the strength of positive feedback from the market. For clarity, we denote these network effects the *intrinsic network effects*. However, other factors need to be taken into account in order to determine the total network effects.

Popcorn Time uses a P2P network. The users of the network download information from one another so that the more users there are in the network the easier it is for other users to find interesting information in it. This is a positive network effect, the onset of which is determined by critical mass defined below.

Netflix is more complicated. Netflix uses a client-server network. In such networks, there is potentially a negative network effect: the value of the service may decrease as the number of users of the service increases so much that congestion occurs (roof point defined below). However, as long as Netflix has a moderate number of users, the network effect may be positive due to recommendations by satisfied customers (Word-of-Mouth (WOM) effect).

**Critical mass**

If there are very few Popcorn Time users, the intrinsic network effects are very small. Therefore, the number of users must reach a critical mass (m) before network effects occur. If there are fewer users than this threshold, there are no network effects.

**Roof**

The roof point (r) of Netflix is the point where the capacity of the network is exhausted, that is, additional users will reduce the availability of the service. The roof point thus determines the onset of negative network effects for Netflix. The roof point is increased twice during each simulation.

**Churning**

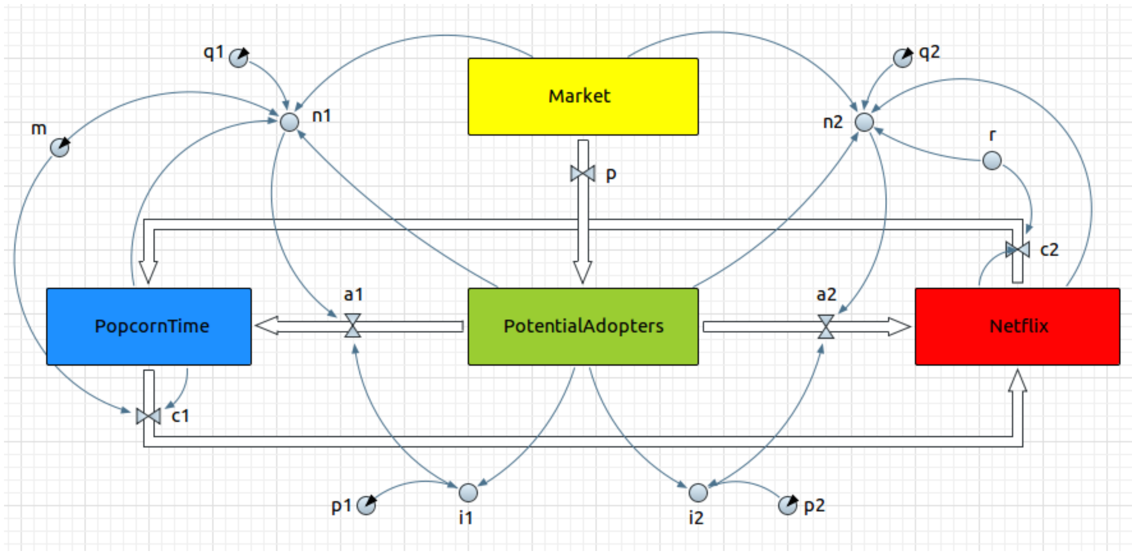
Churning may be spontaneous; that is, the churning rate depends only on the number of users of the service losing customers. Churning may also be stimulated; that is, the churning rate depends also on the number of users of the service gaining customers. In our model, only spontaneous churning is included with the following assumptions.

Before Popcorn Time has reached the critical mass, 10% of Popcorn Time adopters will churn to Netflix. There will be no more churning from Popcorn Time to Netflix after the critical mass is reached.

Before Netflix has reached the roof point, only 1% of Netflix adopters will churn to Popcorn Time. After the roof point is reached, 10% of Netflix adopters will churn to Popcorn Time.

## 3.3 System dynamic model

Figure 5 shows the implementation of the model using AnyLogic software [13]. Stocks are shown as squares and the flows are symbolized as valves. Dynamic variables are represented as empty circles and parameters are represented as circles containing a black triangle. The arrows indicate dependencies between the variables.



Figur 3. Visual Implementation of CVSM in AnyLogic

The number of people in the system is constant and is unevenly distributed across the stocks. The stock denoted Market initially holds the vast majority of people, while Popcorn Time and Netflix may hold some initial adopters. The only way a person can move from one stock to another is through a flow. Figure 5 illustrates that a person located in Market can only move to Potential Adopters since there is only one flow between Market and Potential Adopters. People located in Potential Adopters have three choices: (1) remain in Potential Adopters; (2) move to Popcorn Time or; (3) move to Netflix.

Flows determine how many people will move from one stock to another for each unit of time. The flow "new potential adopters" (p) creates a constant flow of people from Market to Potential Adopters each unit of time. The "adoption" flows, (a1) and (a2), determine the number of Potential Adopters who will move to Popcorn Time and Netflix, respectively. The "churning" flows, (c1) and (c2), determines the number of adopters that will move from Popcorn Time to Netflix and vice versa.

Dynamic variables and parameters determine the proportion of people who will be moved by the flows. For instance, the variable "independent decisions" (i1) and "network effects" (n1) determine the flow from Potential Adopters to Popcorn Time. Arrows pointing toward a variable indicate that this variable uses the value of the item where the arrow begins. Likewise, arrows pointing toward a flow mean that this flow is determined by the value where the arrow begins.

# 4 Results

## 4.1 Scenarios

Three scenarios have been analyzed:

1. The first scenario examines how small variations in the strength of independent decisions and intrinsic network effects affect the temporal evolution of adopters. Figures 6 and 7.
2. The second scenario investigates the effects of critical mass and roof points. Figures 8 and 9.

3. The third scenario looks at what happens when roof point and intrinsic network effects vary. Figures 10 and 11.

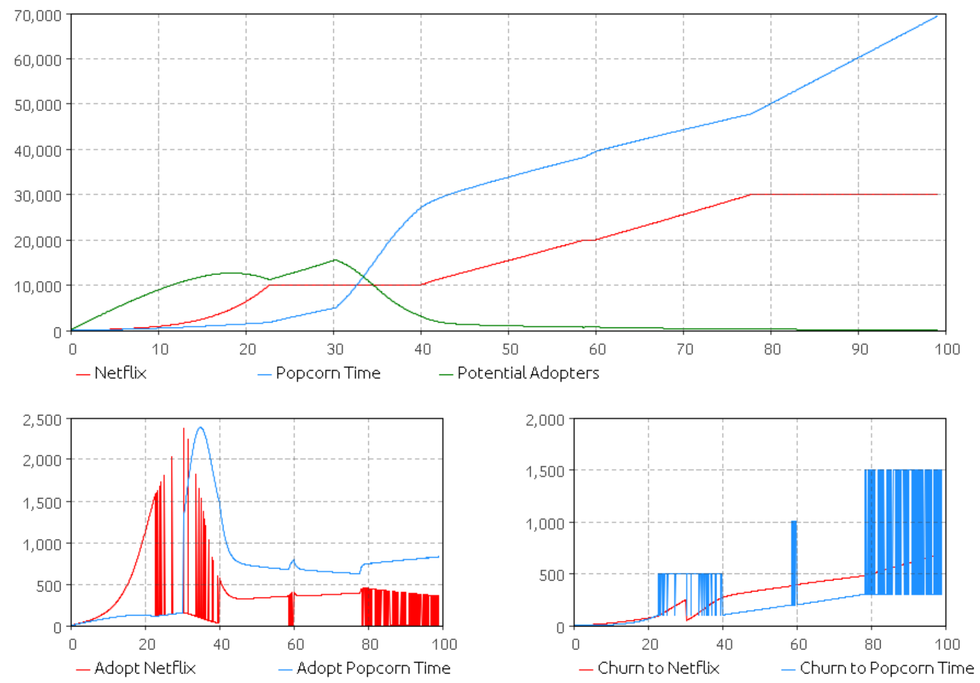
## 4.2 Simulation Results

Only a small subset of simulations is shown in this paper.

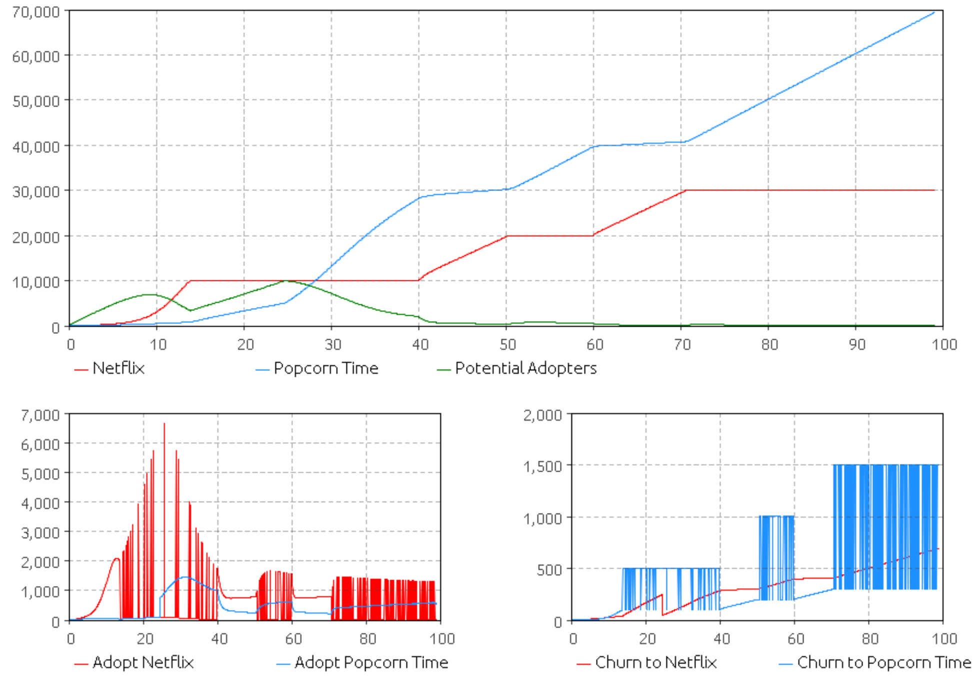
The results for each simulation are contained in a set with three graphs;

1. *The temporal evolution of adopters* shows the number of potential adopters for both Netflix and Popcorn Time as a function of time (uppermost figure).
2. *The adoption rate* Popcorn Time or Netflix per unit time, respectively (lowermost figure to the left).
3. *The churning* of people to either Popcorn Time or Netflix per unit time (lowermost figure to the right).

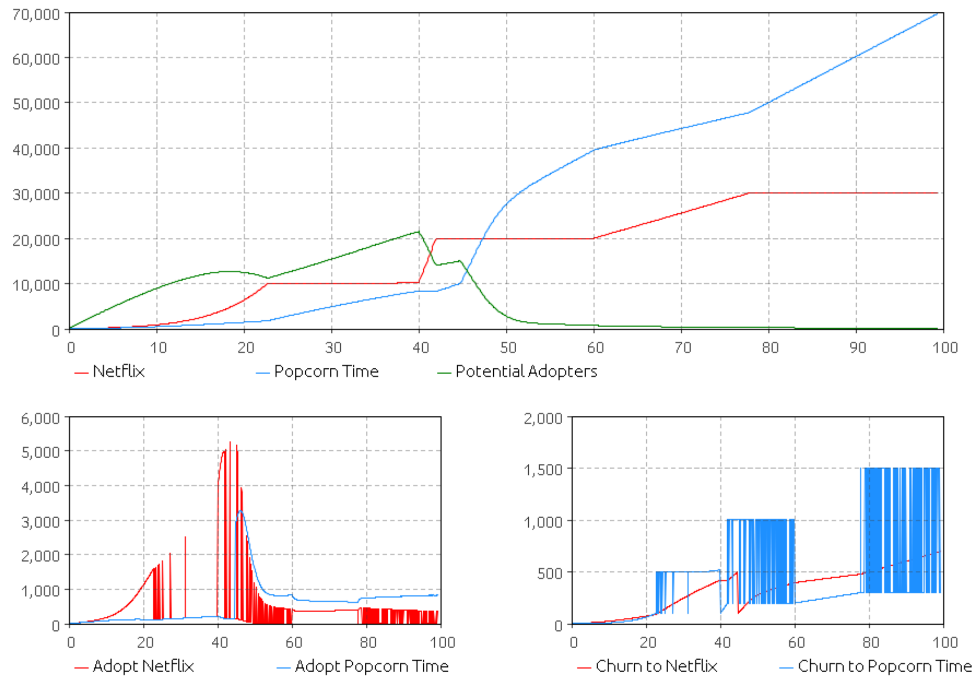
For every graph, the x axis shows the time period in days, while the y axis holds the number of adopters in thousand people (Netflix in Red and Popcorn Time in Blue). The green curve is the number of potential customers.



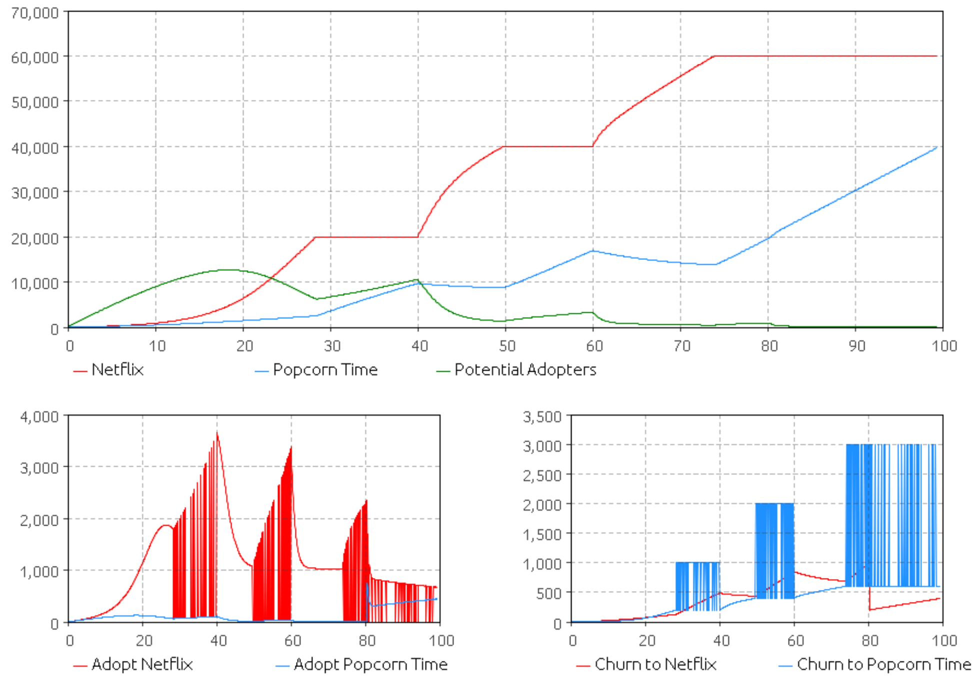

Figur 4. Independent decisions are equal and intrinsic network effects are equal. Parameters: $p_1 = p_2 = 0.01, q_1 = q_2 = 0.1, m = 5000, r = 1/2/3 \times 1000$



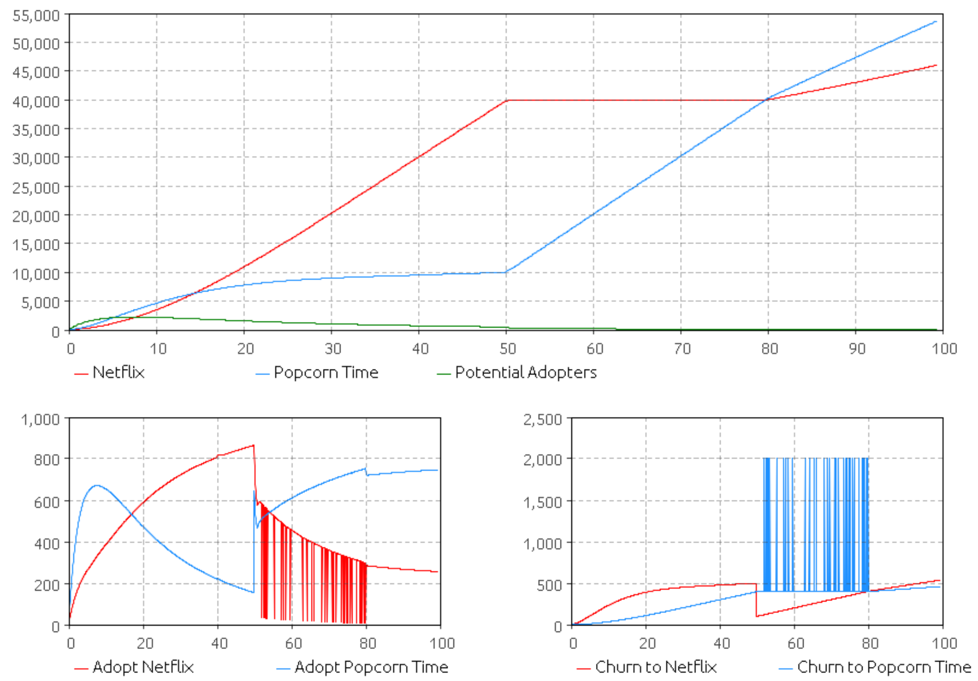

Figur 5.s Increasing the intrinsic network effect for Netflix. Parameters: $p_1 = p_2 = 0.01, q_1 = 0.1, q_2 = 0.5, m = 5000, r = 1/2/3 \times 1000$



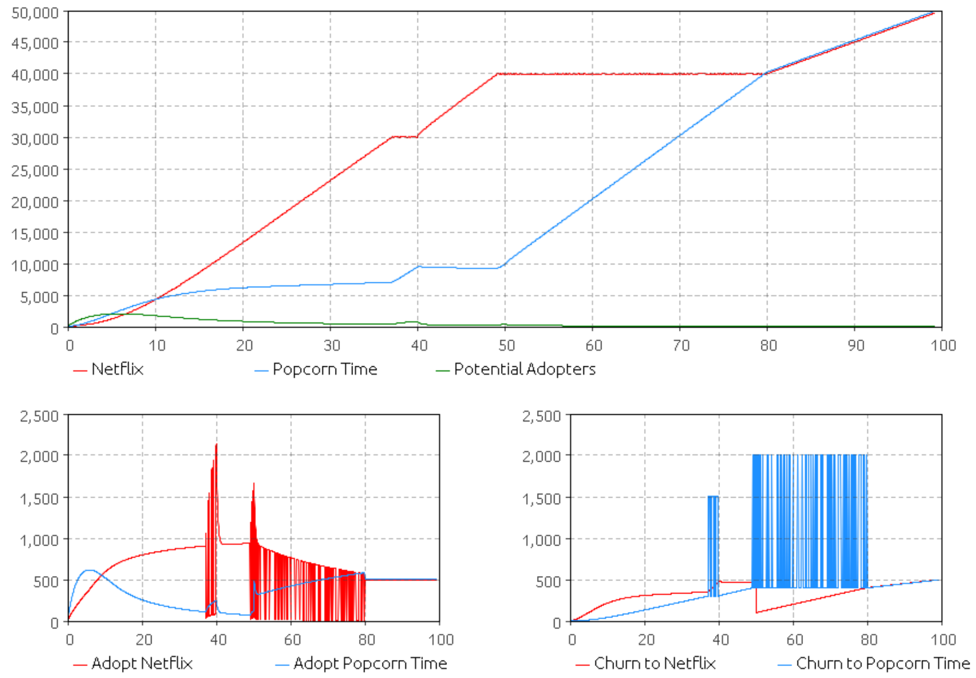

Figur 6. Increasing the critical mass of Popcorn Time. Parameters: $p_1 = p_2 = 0.01, q_1 = q_2 = 0.1, m = 10{,}000, r = 1/2/3 \times 1000$




Figur 7. Increasing the roof points of Netflix. Parameters: $p_1 = p_2 = 0.01, q_1 = q_2 = 0.1, m = 20{,}000, r = 2/4/6 \times 1000$




Figur 8. Increasing the intrinsic network effect for Popcorn Time. Parameters: $p_1 = 0.3, p_2 = 0.1, q_1 = 0.5, q_2 = 0.2, m = 10{,}000, r = 3/4/5 \times 1000$




Figur 9. Increasing the intrinsic network effects for both Popcorn Time and Netflix. Parameters: $p_1 = 0.3, p_2 = 0.1, q_1 = q_2 = 0.5, m = 10{,}000, r = 3/4/5 \times 1000$

# 5 Discussion

Comparing Figures 6/7 with Figures 10/11, we see that the parameter “independent decisions” is particularly important for the early development of the number of adopters of video streaming services. Large values of “independent decisions” mean that many people adopt a particular video streaming service regardless of network effects. Observe also that the initial growth of Popcorn Time adopters is either determined by the users’ independent decision or is a result of churning from Netflix. If the number of Netflix adopters is small initially, the majority of Popcorn Time adopters are a result of independent decisions.

Simulations not included here showed that a large number of initial Netflix adopters turned out to benefit the number of Popcorn Time adopters. This is also visible in the market today: if an existing service provider has already created a demand for a particular product, a new service provider can benefit from the accumulated demand created by the first service provider. Some of the clients of the first service provider can churn to the second service provider. Conversely, if Netflix has already created a demand for video streaming service, and when that demand has accumulated, some of Netflix clients may churn to Popcorn Time.

We also found that the video streaming provider’s ability to maintain existing adopters and acquire new adopters more rapidly depends strongly on network effects. Specifically, we found that by increasing the network effect of Netflix, the adoption rate of Netflix also increases. However, as the number of subscribers reaches its upper limit, the Netflix system becomes congested and some of the subscribers churn to Popcorn Time. This then increases the adoption rate at Popcorn Time and thus advantageous to

Popcorn Time. The reason for this behavior is that Netflix uses the client-server technology while Popcorn Time is uses P2P streaming services.

The study also reveals that both the critical mass and roof points are important because they contribute to network effects. Variations in the critical mass were found to be most influential in determining the early development of the temporal evolution. The higher the critical mass, the higher is the tendency of potential adopters to become Netflix adopters. On the other hand, the roof points were more influential in determining which service provider would have a higher number of subscribers. Specifically, by increasing the roof points, Netflix was able to obtain a larger number of adopters (Figures 8 and 9).

To what extent an illegal P2P video streaming service can benefit from network effects is thus determined by critical mass and roof points. Four basic combinations of the size of the critical mass and roof points offer the following conclusion:

- If both the critical mass and the roof points are high, the network effect will have little or no influence on the growth of illegal adopters.
- If both the critical mass and the roof points are low, both the positive and negative network effects will benefit the growth of illegal adopters.
- If the critical mass is small while the roof point is high, the positive network effect benefits the growth of illegal adopters.
- If the critical mass is high while the roof point is small, only the negative network effect will influence the growth of illegal adopters.

In effect, the lower the critical mass and roof points, the more beneficial are the network effects to illegal video streaming service providers.

# 6 Conclusions

The paper proposes a new approach toward better understanding of the way in which network effects influence the decisions of users to choose either legal or illegal video streaming services. The Bass model was modified in order to investigate the effects of churning and network effects on legal and illegal video streaming service providers. The most important feature of the model is that competition takes place between providers using fundamentally different platform techniques: P2P (Popcorn Time) and client-server networks (Netflix). Furthermore, nonlinearities such as critical mass and roof points were included in the model in order to make it more realistic.

One important conclusion is that the timing of the onset of network effects, related to critical mass and roof point, is significant for the temporal evolution of adopters. The results suggest that network effects can either benefit or challenge the growth of adopters depending on how video streaming contents are distributed. This study then confirms the hypothesis *network effects may strengthen the competitiveness of illegal video streaming services*.

The model is easily extended to study the effect of time-varying parameters, for example, to study the effect of campaigns against illegal services. The model may also be extended by stimulated churning to investigate cases where one supplier may conquer the whole market.

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