Game Analytics – Game Economy Optimization

Final Progress Report

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Abstract:

Context and Motivation:

The objective of the research is to better understand creating an optimal game economy in a free-to-play (F2P) game; specifically, it aims to understand how to optimize a game economy to best incentivise the player to purchase premium currency.

Question/Problem:

The problem the research is addressing is the poor understanding of creating a successful F2P game economy. Therefore, the research will help to not only construct a better understanding for game developers but may also contribute to a framework to streamline the game design process.

Principal Ideas/Results:

To help tackle the huge amount of data to be analyzed, I broke my research into two categories:

1. Qualitative Background Research
2. Data Collection and Analysis

The qualitative research allowed me to get a better understanding of current research and how my study could add to what is available. It also helped me decide where I should collect my data from, as many articles gave examples of good and bad game economies.

Data collection and analysis aimed to contribute new data to the field of game economy design; however, the vast extent of the data necessitated that I narrow my research to source/sink gaps. I collected source/sink information from the top F2P games to try and better understand why their economies were so successful.

Contribution:

The paper's contribution to the game economy field is a better understanding of sources and sinks, the optimal time to introduce and grow a source/sink gap, and insight on how to create an effective and efficient end game. The limitations are as follows:

1. Research limited to popular F2P games
2. Difficult to collect data so many assumptions made
3. Impossible to predict how each player will play a game

Introduction

Every successful F2P must have a strong economy and proper purchasing incentives because it cannot rely on the initial purchase for revenue. Unfortunately, there is little research in F2P economy optimization. As a result, F2P developers must rely heavily on trial and error which not only wastes a lot of resources but also a lot of time.

Research in game economy optimization has the potential to both increase satisfaction from consumers of F2P mobile video games and increase profitability for developers in the F2P space. The economy of a video game plays a pivotal role in immersion and is often a contributor to player commitment long term: players are not only given goals to strive towards (fueled by the economy of the game), but the simple act of amassing in-game currency is often rewarding. Optimizing a game economy also increases profitability for developers because the optimization

will not only lead to a better player experience, thus drawing in more players, but will also lead to a potential increase in the number of players willing to spend out of pocket to purchase premium currency.

The research of this paper will aim to build upon current research in the market and will focus on three areas: source and sink optimization, source/sink gap optimization, and end-game optimization. To be more specific, how many sources and sinks is optimal for a F2P game? What types or sources and sinks generate the most revenue? Which types are the best for player retention? When is the best time to introduce a source/sink gap? How quickly, if at all, should the source/sink gap grow? How do you continue to monetize in the end-game? The research will look to answer the aforementioned questions and build a framework to help streamline the game design process for developers.

Research methodology was a combination of both qualitative and quantitative research methods. The quantitative methods focus on gathering numerical data for data analysis, analyzing source/sink data to discover insights about optimal resource generation/degeneration, create a better understanding of the source/sink gap, and gather data for creating an effective end-game. All the quantitative data will be compiled to help developers build better F2P titles. The qualitative methods focus on building a better understanding of current research, obtaining consumer insights and feedback, and to add context to data which will help to provide a more holistic understanding of research.

Data collection consisted of playing various titles and tracking progress, mining data from Wikia pages, and interviewing F2P game consumers. Following data collection, analysis was conducted on both Excel and R. Data was cleaned and organized, analyzed for source/sink insights, and aggregated into models and graphs. In addition, players of the various titles were interviewed to learn more about their playstyles, their opinions on economy balancing, and how to optimize the end-game. The responses are incorporated into both the data analysis (playstyle choices) and in the suggestions/findings of the research.

The results of the research can be divided into three segments: source/sink analysis, source/sink gap analysis, and end-game analysis. The average number of source/sinks of the titles analyzed is 4.5 but it is skewed by certain titles. The recommended number of sources/sinks is 4, each with its own unique resource loop because the resource loops allow for diversified play to keep the player engaged.

For source/sink gap analysis, there are three key insights: delaying the source/sink gap may not lead to increased profitability, introducing a large gap at 70% of the progress may be optimal, and changing gap growth depending on how far the player has progressed.

The current research data shows that each title starts the player in an immediate source/sink gap and grows the gap as the player continues to progress. Therefore, developers who delay the source/sink gap in their games may be losing revenue from early in-app purchases. Instead, the data suggests that the source/sink gap start small and exponentially grow larger. The big gap is created because source generation follows a linear growth curve whereas sinks follow an exponential growth curve. The exponential growth leads to relatively equal growth across sources and sinks until the 70% playthrough mark. After this point, sinks grow a lot faster than sources.

Lastly, the data suggests that Clash of Clans has the best end-game (based on interview responses). The combination of a restriction on resources and constant threat of resource loss (from raiding) incentivizes spending – players are forced to save, and risk losing their resources or pay for premium currency to supplement the resources they have. A close second is Candy Crush which offers frequent updates with new, unique levels that keep the player engaged and willing to spend.

Background and Related Work

Every video game, F2P or not, requires an economy. The focus of the research, both past and present, has predominantly been on a closed economy (an economy that is self-sufficient, meaning no imports are brought in and no exports are sent out). In a closed economy, consumers are provided with everything they need within the economy's borders [1] and the cost of items remains stagnant as there is no influence from inflation, conversion rates, or trade with external economies.

Source/Sink Research

Currently, there are three known forms of economic sources: generators, event-based inputs, and single inputs [2]. Generators are a background-like process that continuously generates resources. The amount of resources generated can be changed by the player. Event-based inputs generate resources only when certain conditions are met, such as gathering a certain amount of an item, or defeating several enemies. Single inputs are similar to event-based inputs, but they are not repeatable. Because of this, single inputs are usually reserved for bosses and story driven events. Similarly, there are also three known economic sinks: degenerators, event-based outputs, and single outputs.

Game Economy Optimization Research

Research on game economy optimization is scattered, but there are a few commonly accepted facts that will help as a starting point for research. First, a dual-currency mechanism is more effective than a single-currency system [3]. It allows F2P games to differentiate between real-money currency (hard currency) and in-game currency (soft currency). Second, it is important to immerse a user into the game before trying to monetize – the right time to monetize is when the player is immersed enough to pay to get ahead, but still able to progress slowly if they choose [3]. Third, diversify the consumer's ability to earn in-game currency as it is not only fun to earn currency but also to spend it towards various goals and rewards. Fourth, there should be adequate sinks so that there is incentive to continue purchases. Fifth, it is beneficial to start users with a small amount of hard currency, so they can experience the benefits. Once they run out, it is important to keep the user informed of the buying process and to make the shop accessible and dynamic. Sixth, progression should get increasingly difficult. Balancing difficulty scaling is a challenge because excessive difficulty dissuades players, but lack of difficulty removes the need for premium items. Lastly, research has shown that games with a gambling component engage users longer compared to games with a determined result [4].

In addition, research on pricing items in a video game economy has shown that there should be a positive correlation between player time and economic price – more specifically, the less experienced a player is (low time input), the less expensive the milestone should be (time-value) [2]. Research also shows that introducing an unbalanced item disrupts the flow of the game and

can disincentivize users to continue to play. However, unbalanced items/objects are generally seen as unavoidable and so assigning priority to each resource based on its influence on the game is ideal (for example, a high-level weapon that is unbalanced can cause a lot more damage than excessive iron ore, which is usually a common resource).

Creating an Optimal End-Game:

There are three commonly known types of end-game: fixed, scaling, and ascension/prestige.

A fixed ending is depicted as a final test for the player (and should usually include some of the most difficult content). It should also conclude the story of the game. A fixed ending can be difficult to optimize because it is the final touchpoint a player will have with the game. The difficulty of the final boss must be optimal: too much and the player will become too frustrated, but too little and the player will feel unsatisfied. In addition, an unsatisfying story ending will leave the player unhappy. A fixed ending is most common in AAA video game titles (games with highest budgets and levels of promotion).

A scaling ending means that the game never ends and the content scales with time – this allows the player to continually play the game, but it must be optimized to ensure the player does not become bored of the never-ending content. A scaling ending is common in F2P titles, but many are unable to create enough unique content to keep players interested. In addition, if a scaling game includes multiplayer, it often creates an unfair environment unless players can be segmented by time/premium currency spent.

An ascension/prestige ending offers the player the option to restart the game when it is completed (if they choose to restart, the player is usually rewarded a unique item). Ascension/prestige endings are common in F2P titles because it is easy for players to track progression and pursue upgrades achieved from ascension, but it is important to ensure that there is a good progression curve to incentivize people to restart. Nowadays, it is no longer sufficient to give the player a reward each time they ascend: there must be something unique from one playthrough to another, or a player will grow bored.

How to Prevent Hoarding:

Hoarding in video games is often attributed to players wanting to ensure an item/resource is available when it is “really needed”, especially if the item is in high demand or rare [6] [7]. Essentially, a player who hoards is willing to make the game harder for themselves in the short term to prepare for potential problems (very expensive item, difficult boss, etc.) the future. The limited research suggests that the main culprit of hoarding is scarcity and recommends that the more vital an item is to a player’s success, the easier it should be to acquire it. Another common technique is to limit the maximum capacity of resources and allow players to slowly upgrade it so that they can store more at later levels. A final Lastly, another technique is to develop a game that focuses on short-term use and not long-term saving. For example, health recharging after the player goes a few seconds without taking damage to incentivize fighting.

Research Gap

The information gap that this paper addresses is a lack of specific information on game economy optimization and how it relates to hoarding and the end game. The background research shows that there are steps you can take in improving your game economy, such as having multiple

sources or waiting to introduce a source/sink gap, but it does not convey how many sources are ideal or how long a developer should wait before introducing the source/sink gap. This paper will help introduce numerical data into the game economy design framework to help streamline the game creation process for developers.

Research Objectives

The overarching research goal is to contribute to the understanding of how to optimize mobile F2P video games to increase profitability for developers, streamline the game development process for developers, and to enhance the player experience by providing data on data retention and creating a good end-game.

The following objectives are essential to achieving the research goal:

1. *Data collection and analysis on F2P sources and sinks*. The research will supplement current data and provide a solid base for research on source/sink gaps. Source and sink research will also help game developers when creating a video game economy as there will be more data on optimal sources and sinks.
2. *A better understanding of when to introduce the source/sink gap.* The research will add specificity to current data that highlights the importance of delaying the source/sink gap to allow for immersion. Numerical data will allow video game developers to skip the trial and error process currently required which risks frustrating players or being too generous (offering too many resources too quickly).
3. *A better understanding of how to widen the source/sink gap after it is introduced.* Currently, it is common practice to increase the source/sink gap because it encourages more premium purchases, but there is little data to help decide how much to increase the gap by. Numerical data will help video game developers not push the gap too quickly and disincentivize players from continuing play but will also prevent developers from being too timid and not extracting sufficient value from their game.
4. *Research on F2P end-game economies with a focus on maximizing player engagement/retention and spending*. There is not a lot of research on end-game economies and even less on how to keep players engaged and still willing to spend; therefore, this paper will aim to contribute to the existing research. Video game developers will benefit because a large problem for many F2P titles is retaining players in the long term.

Concepts, Terms, Definitions, Equations, etc.

Free-to-Play(F2P): a business model for online games where the game designers do not charge the player to play the game. Instead, the source of revenue for the game comes in the form of advertisements (usually only shown to players who do not pay to remove them) or the sale of premium currency which can provide visual upgrades, in-game bonuses, or even additional content [8]. In a sense, it allows the player to try a game before deciding whether they wish to invest money into it.

Hoarding: the act of excessively saving items that other players may view as unimportant. Traditionally, people who hoard objects, whether physical or electronic, will have a great deal of difficulty parting with possessions and may develop an unhealthy attachment to them. The

hoarding referenced about in this report is usually not to the degree described above, but instead is an atypical style of play that may lead to difficulties in game balancing [9].

Premium Currency: a resource that is attainable through monetary purchase. Premium currency can often be exchanged for non-premium currency – i.e., it can be used to supplement other resources. It is common in F2P games that there are sources for premium currency, but they will generate or provide very little to force players to pay.

Source: a type of income generation (it is different from a resource or currency as these are what sources generate). As talked about in the research above, there are three types of sources that can be used to introduce resources to the player.

Sink: a type of income removal from the player. Like a source, there are three that can be used.

Farming: the act of a player performing repetitive (usually mundane) actions to gain experience, resources, or another form of benefit. In the F2P space, players can opt to purchase premium-currency to avoid farming. The act of farming is generally disliked among the video game community, but there are a few who enjoy investing a lot of time trying to find a rare resource or accumulate resources [10].

Source/Sink Gap: the difference between resource generation and resource loss. It can be used to refer to a specific source vs. a specific sink or it could refer to the total source of all resources vs. their opposing sinks. The source/sink gap is used to incentivize players to purchase premium currency to make up the disparity. If they choose not to, the player must farm resources and wait until they can progress or purchase the item they want.

Game Loops: a section of a game that is differentiated from other portions. In the case of resource generation, loops can be categorized by the type of resource you can obtain by progressing or completing a loop.

Methodology

The methodology was a combination of both qualitative and quantitative research methods focused on helping to build an understanding of how to optimize game economies. The quantitative methods focus on gathering numerical data for data analysis, analyzing source/sink data to discover insights about optimal resource generation/degeneration, create a better understanding of the source/sink gap, and gather data for creating an effective end-game. All the quantitative data will be compiled to help developers build better F2P titles. The qualitative methods focus on building a better understanding of current research, obtaining consumer insights and feedback, and to add context to data which will help to provide a more holistic understanding of research.

The quantitative research was broken down into two parts: data collection and data analysis. Data collection consisted of playing the different titles and tracking progress, searching online, and talking to players of the game. The F2P titles chosen to be played were the following: Fire Emblem Heroes, Candy Crush, Clash of Clans, and My Singing Monsters. Each F2P title was played on Andy, an Android Emulator, and downloaded from Google Play.

Each title was played for a minimum of 15 hours to better understand game mechanics, collect resource generation/usage data, and to give ample time for the source/sink gap to manifest and affect gameplay. Gameplay was tracked via logs (using OneNote) and data (buying a new item,

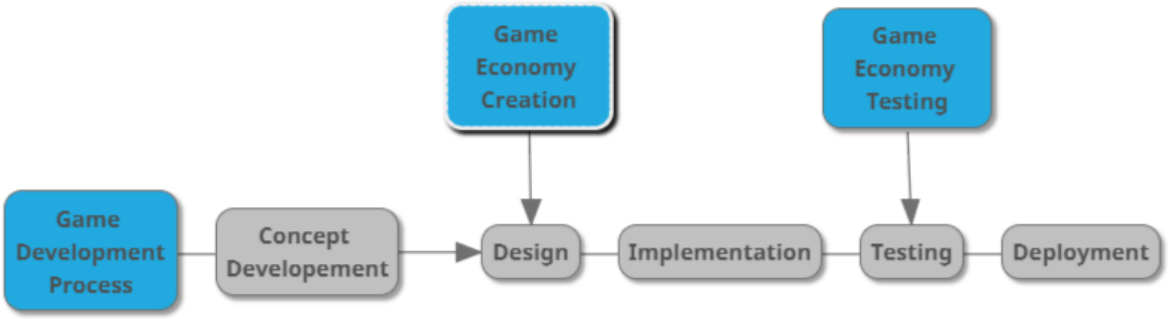
spending a resource, etc.) was all recorded into Excel sheets to keep track of the inflow/outflow of resources. Gameplay was very conservative because that is my personal style, therefore, it is important to note that data collected via personal play will be skewed. To supplement data collected from gameplay, websites such as www.clashofclans.wikia.com/wiki were probed to extract data that related to the research objective – data like cost to upgrade, resource generation at later levels, etc. Unfortunately, only two titles (Clash of Clans and My Singing Monsters) had wiki pages with a lot of data so most of this data analysis is on those titles. Finally, frequent players of the titles were consulted to better understand playstyle and resource use/management. For example, most players interviewed enjoyed spending resources as soon as possible. The information collected by players helped to predict player behavior in the data analysis.

Once sufficient data was collected from various sources, data analysis was conducted using Microsoft Excel and R (majority of analysis is in Excel as R was learned very late). First, the data had to be organized and cleaned. For example, the data collected via personal play conflicted at times with data from the Wikia. To counteract this, the data from the Wikia was used in place of play data both because play data was limited and because it helped keep data consistent. Once the data had been cleaned and sorted into manageable buckets, the data was analyzed to find source/sink information such as growth, initial building costs, etc. – the information also helped build an understanding of each game's source/sink gap. The source/sink gap was calculated for the titles with sufficient data and the gap and its growth were analyzed in further detail. For example, the specific time to introduce a source/sink gap or how quickly a source/sink gap grows was calculated. In addition, data was graphed to provide a visual depiction. Following data analysis on individual titles, all collected data was combined to see if there were any insights that applied to all F2P titles. Once R was learned, the collected data was imported to RStudio where variables could be tested for significance.

The qualitative research is limited because of time constraints. Originally, the plan was to interview players of the game, release surveys, and interview game developers. Unfortunately, time only allowed for the completion of the first of the three. Players of the various titles were interviewed to learn more about their playstyles, their opinions on economy balancing, and how to optimize the end-game. The responses are incorporated into both the data analysis (playstyle choices) and in the suggestions/findings of the research. Additionally, players were asked questions about enjoyability, time invested into the game, whether they purchased premium currency, etc. to get a better understanding of the type of player they are, but unfortunately the data was not incorporated into any conclusions. The players were talked to in-person to help create free-flowing responses.

Results

Contextual Diagram



The above diagram shows where the research will contribute to the overall development process (in "Game Economy Creation" and "Game Economy Testing"). The data analysis not only helps F2P developers better understand optimal source/sink allocation and source/sink gap implementation but will also help to streamline the design process as the research has analyzed economies of the top grossing F2P titles in the app store. In addition, it will help to reduce the duration required to test the economy. The problem with current game economy testing is that there is no structured framework to build an economy from – it is predominantly created from the ground up which requires a lot of testing to fine tune. The creation of a game economy by following industry leaders will reduce the time dedicated to the tuning process, but not eliminate it entirely as each game will be unique.

Design and Architecture

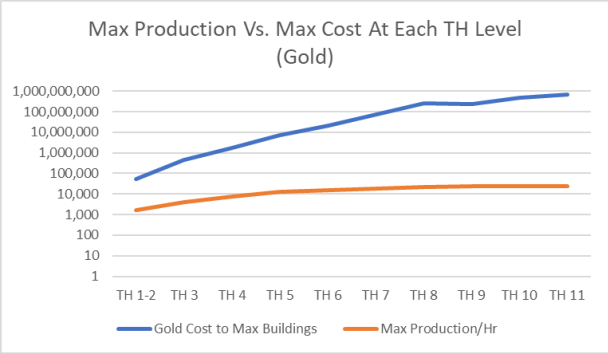
The results will be divided three sections: source/sink analysis, source/sink gap analysis, and end-game analysis.

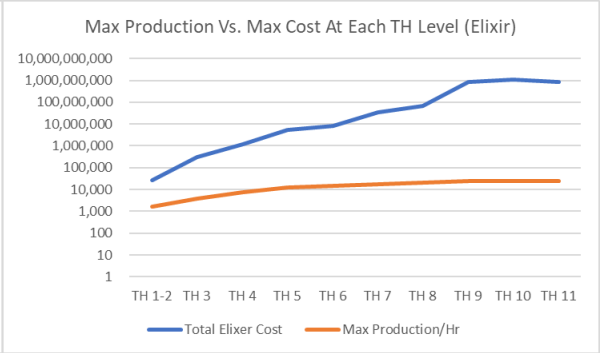
Source/Sink Analysis

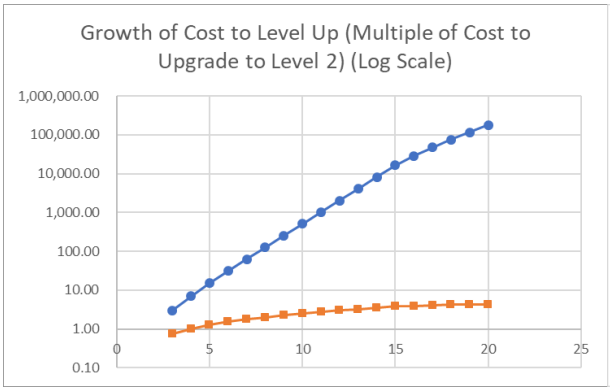
All four of the F2P titles analyzed had multiple sources and multiple sinks. Each source and sink had its own special, unique usage and will vary in value. For example, Clash of Clans has four types of currency. The non-premium currency (gold, elixir, dark elixir) and premium currency (gems). Research has shown that multiple sources/sinks helps to increase immersion, but only up to a certain threshold: too many and the player may become confused or lack the time to gather certain resources. The average number of source/sinks of the titles analyzed is 4.5 with 7 being the highest (Fire Emblem Heroes) and 3 being the lowest (Candy Crush). It is important to note that Fire Emblem Heroes may have 7 unique source/sinks, but it does not have 7 unique loops (4 of the resources are collected in the same resource loop). Therefore, the recommended number of sources/sinks is 4, each with its own unique resource loop because the resource loops allow for diversified play to keep the player engaged.

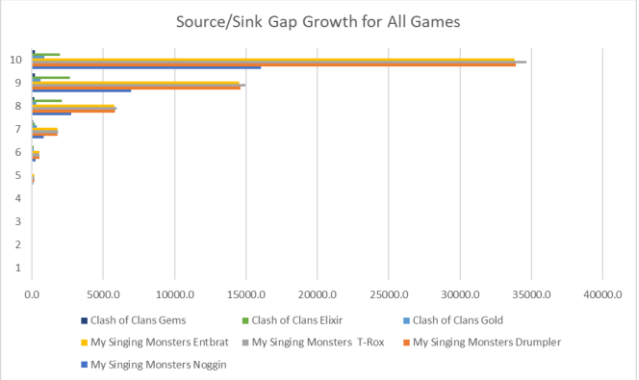
Source/Sink Gap Analysis

There are three key insights: delaying the source/sink gap may not lead to increased profitability, introducing a large, increasing gap at 70% of the progress (whether through the game, total building costs, etc.) may be optimal, and varying gap growth depending on player progression.





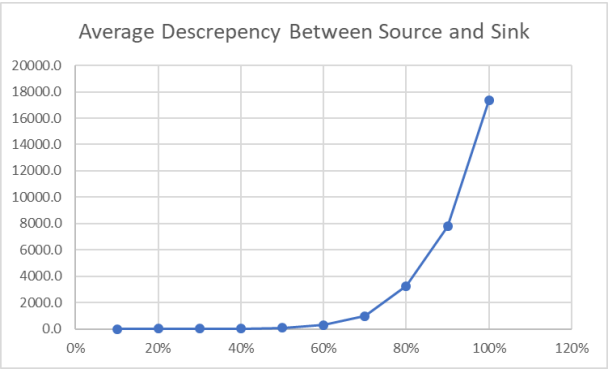




The above figures depict the max production and resources needed at each stage of the game for both Clash of Clans (top 2 graphs) and My Singing Monsters (bottom left graph). The source/sink gap growth for all titles is shown on the bottom right. In addition, despite the lack of graphical data, Candy Crush and Fire Emblem Heroes do not place a limit on currency spending so the gap is infinite from the very beginning (i.e. if the player keeps purchasing premium currency, they can keep purchasing game items). The data shows that each title starts the player in an immediate source/sink gap and grows the gap as the player continues to progress (even true for Fire Emblem Heroes or Candy Crush as the player starts with a certain amount of premium currency that is quickly used). Developers who delay the source/sink gap in their games may be losing revenue from early in-app purchases. Instead, the data suggests that the source/sink gap starts small and grows exponentially.

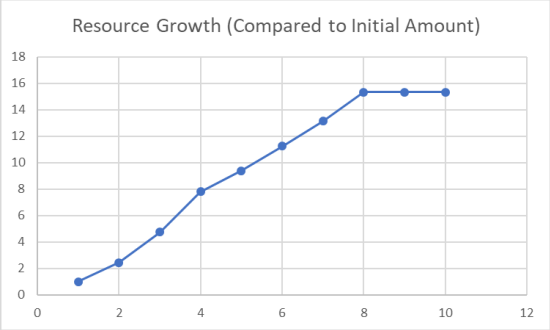
The next two figures depict the average growth of the source/sink gap (based on Clash of Clans and My Singing Monsters) as the player progresses through the game.

Progression	Average Descrepency Between Source and Sink
10%	0.0
20%	3.3
30%	10.1
40%	31.3
50%	90.0
60%	296.8
70%	977.7
80%	3256.7
90%	7783.6
100%	17343.8



The source/sink gap is the multiplicative difference between resource generation and required resource usage. For example, 3.3 at 20% progression signifies that there are 3.3 times more resources required than generated 20% into the gameplay. The calculation does not consider time as a resource, which also grows exponentially as the player progresses. The exponential growth of resource requirements vs. the linear growth of resource generation is what incentivizes the player to pay for premium currency (to make up the difference). F2P developers can follow the above table for their title's sink growth and the table below for their title's source growth (linear growth).

Playthrough %	Resource Growth
1	1
2	2.4
3	4.8
4	7.8
5	9.4
6	11.3
7	13.1
8	15.3
9	15.3
10	15.3



End-Game Analysis:

Unfortunately, there was a lack of numerical end-game data. Instead, the research relied heavily on qualitative data from discussion forums and player interviews. The data suggests that Clash of Clans has the best end-game (most players stated Clash of Clans during in-person interviews). The combination of a restriction on resources and constant threat of resource loss (from raiding) incentivizes spending – players are forced to save and risk losing their resources or pay for premium currency to supplement the resources they have. A close second is Candy Crush which offers frequent updates with new, unique levels that keep the player engaged and willing to spend. Fire Emblem Heroes was both praised and criticized for its usage of lootboxes (purchasing a box that could contain one of many items, from good to bad) because it incentivizes purchases and player engagement in the late game, but also simulates a gambling environment which may be unsuitable for younger audiences.

Implementation

Data was collected via logs on OneNote (chosen for its simplicity and availability) and from Wikia pages (data was verified by Dr. Katchabaw). F2P titles were played on Andy to allow for multiple titles to be played at once. The data was stored and analyzed in Excel and R. Most of data analysis was conducted in Excel due to time constraints (took some time to learn statistics and R). The tools were selected for simplicity in consideration of the large amount of time data collection would take. Additional insights can be excavated from the data if more powerful tools are used.

Validation

All procedures and results of the research were discussed with and approved by the thesis advisor, Mike Katchabaw, who has both extensive game design experience and is an avid player of video games.

Source/sink, hoarding prevention, and end-game analysis are supplemented with real player feedback collected both from in-person interviews or from message forums dedicated to discussing the respective F2P titles.

Discussion

Threats to Validity

The greatest threats to research validity involve both the data collected and assumptions made during data analysis. The data collected was from personal play, third-party websites, and player interviews, all of which contain inherent biases. Two problems exist with personal play: 1. my playstyle may not reflect the average player and 2. my playstyle changed depending on which title I was playing. For example, I was very conservative while playing Candy Crush and opted to wait if I ran out of lives to complete levels, but in Fire Emblem Heroes, I purchased premium currency to improve my chances of obtaining certain characters. Therefore, the Candy Crush data may reflect a slower than average playstyle whereas the Fire Emblem Heroes data may reflect a faster than average playstyle. In addition, it is impossible to simulate multiple different playstyles; therefore, the insights are limited and may not accurately reflect the general population. Lastly, the data collected from third-party websites may not be up to date or completely accurate. The data was compared to current data, but only in the stages of play I was personally able to reach – there is no guarantee later data is equally correct. To mitigate some of these risks, most of the data collected is from the Wikia. The Wikia provides a collection of data from many different types of players which helps diversify the data for analysis. There is a slight risk that the data was inputted incorrectly, but the aforementioned benefits outweigh this risk.

Due to lack of data, a few assumptions had to be made during data analysis that may weaken the significance of the insights. For example, as stated earlier, it is impossible to account for various playstyles and it would take too much time to track saving/spending for each purchasable item. Therefore, it is assumed that an item is purchased as soon as it becomes available. Because the assumption does not reflect true gameplay, the insights found may be skewed more towards players who purchase enough premium currency to afford items as soon as they are available. To help mitigate these risks, most of the data analysis was conducted on data that was not influenced by player choices. For example, the cost to upgrade vs. increase to resource generation of a building will always be the same regardless of playstyle and provides data for source/sink research.

Implications

The research in this paper will help F2P developers not only better understand game economy optimization, but also help streamline the design process by providing data supported insights into source/sink selection, source/sink gap management, and effective end-game creation. The results may lead to both an increase in player retention and satisfaction as well as increased revenue from the purchase of premium currency.

The research contributes to the same three areas in research previously discussed. Research into sources and sinks is limited to the different types of sources/sinks (no numerical data) and the recommendation that developers should include more than one of each type to help strengthen player retention. This paper expands on the research by recommending four resource loop as enough to maximize player engagement but no so much as to become confusing. Current

research into source/sink gaps is limited and does not answer questions regarding when to introduce the gap and how to grow the gap. This paper contributes to the field of study by providing numerical data that supports answers to both questions. Finally, this paper contributes research to the study of end-game optimization. The data and player feedback collected both indicate that resource restriction and proper incentivization (whether it be loss of resources or unique updates) are pivotal to maintaining players in the long-term.

Limitations

The research insights may be limited by type of video game, popularity of video game, and lack of flexibility in playstyles. The research is conducted on F2P video games with a limited scope of gameplay. The four titles cover real-time strategy, base building and attacking, and puzzle games, but there are many more genres of games that have not been analyzed. In addition, the titles chosen topped the grossing charts for both popularity and gross-revenue. The research, therefore, is limited to high performing games and therefore its recommendations may not be applicable to mediocre or poorly-designed games. Lastly, the many unique playstyles that exist are not represented in the research because of limitations in data; the recommendations may not be optimal for all types of players. To resolve these limitations, similar research should be conducted with more data, which should include games from different genres, popularity, and quality. In addition, various playstyles should be reflected in each game. The insights found could then be used to both reflect the true "average" of players and provide valuable, specific insights about target genres, playstyles, etc.

Generalizability

Unfortunately, this research is quite specific (one of its limitations) and it is very difficult to generalize its insights to other games, playstyles, or genres. This research on game economy optimization may help non-F2P titles by increasing player immersion, and the end-game research may help titles that offer ascension or scaling end-games.

Conclusions

The problem this research was designed to address is the poor understanding of how to successfully create a successful F2P game economy. This research helps to not only construct a better understanding for game developers, but the insights may also contribute to a framework to streamline the game design process and help to create more profitable, engaging titles in the future.

Research was separated into categories, qualitative and quantitative. The qualitative research aimed to help me get a better understanding of current research and how my research could add to what is available.

The quantitative research aimed to contribute new knowledge to the field of game economy design; however, there was so much data to analyze that I chose to narrow my research to source/sink gaps. Source/sink data was collected from the top F2P games to try to better understand what makes their economies so successful.

The results of the research can be summarized into categories: source and sink analysis, source/sink gap optimization, and end-game improvements. The average number of source/sinks of the titles analyzed is 4.5 but it is skewed by Fire Emblem Heroes. The recommended number

of sources/sinks is 4, each with its own unique resource loop because the resource loops allow for diversified play to keep the player engaged.

For source/sink gap analysis, there are three key insights: delaying the source/sink gap may not lead to increased profitability (First set of figures in "Source/Sink Gap Analysis"), exponentially increasing the gap so that that sinks drastically outpace sources at 70% progress may be optimal (Source/Sink Gap Growth for All Games), and how much to grow the gap depending on player progression (Second set of figures in "Source/Sink Gap Analysis")

Finally, the data suggests that Clash of Clans has the best end-game because it combines restricted resources with the constant threat of resource loss (from raiding), which incentivizes spending. A close second is Candy Crush which offers frequent updates with new, unique levels that keep the player engaged and willing to spend.

This research contributes new insights to three areas of study: source and sink allocation, source/sink gap optimization, and end-game creation. The paper expands on source and sink allocation research by recommending four resource loops as optimal because it both minimizes confusion and maximizes engagement. Current research into source/sink gaps is limited and does not answer questions regarding when to introduce the gap and how to grow the gap. The paper contributes to the field of study by providing numerical data that supports answers to both questions. Lastly, the paper contributes research to the study of end-game optimization by recommending that both resource restriction and proper incentivization (whether it be loss of resources or unique updates) are the key to maintaining players in the long-term.

The research insights may be limited by type of video game, popularity of video game, and flexibility to playstyles.

The paper provides valuable insight into certain fields of game economy optimization and offers a strong base for future work that could improve on the paper by collecting more data, using more advanced statistical software, and expanding the scope to include other games and styles.

Future Work and Lessons Learnt

Future work could further the research of this paper as follows. First, the scope of the research is limited to a few F2P titles. The F2P titles were chosen both because of their uniqueness from one-another (to try and diversify data) and their ranking in the "Top Grossing" chart (the assumption is that a high grossing F2P has an effective game economy). Future work could research smaller, low-grossing titles and medium, average performing titles to compare and contrast the results. For example, what are the key differences between a strong performing F2P and a weak performing one beyond what is discussed here? What could an average F2P title do to promote more purchases of premium currency?

Second, the original purpose of the research was to create a framework that F2P developers could rely on to streamline the game design process. Unfortunately, the task was too complex given the time allotted, but future work could attempt to create this framework. For example, the data analysis does not consider the various playstyles that are possible, which limits any framework that would be created from it. The final framework must incorporate playstyle as it directly effects resource management/usage. On the topic of a flexible framework, future work could address the lack of research on the impact of manipulating both when the source/sink gap is introduced and how quickly the gap grows. The research conducted focuses on finding the

optimal point (based on the limited selection of F2P titles) to introduce the source/sink gap, but it provides no insight into how the economy changes if a developer were to fluctuate away from what is “optimal”.

Third, the data analysis could be improved with both a higher quantity of data and a larger variety of data. The data did not contain any insight on purchase information, player demographics, etc. which could be used to find much more specific insights (e.g., do in-app purchases spike when the source/sink gap is introduced, or do they slowly rise as the gap rises?). In addition, many of the conclusions from the data analysis are heavily reliant on assumptions. The additional data could remove assumptions by providing real-world evidence and both strengthen the conclusions of this paper and lead to new insights from future work.

Last, more complex data analysis should be applied to the data to find deeper, less obvious insights. Most of the analysis was conducted in Excel which is limited in computing power. R was used near the later stages of research, but only in a limited manner. Future work could use R or Python both to conduct complex data analysis to find the statistically significant variables that drive in-app purchases, and to handle the much higher volume of data.

Lessons Learnt

The quality of the data is equally as important as the quality of the analysis. A lot of time was spent on collecting data, but unfortunately the data lacked complexity and features which resulted in insights with similar problems to the data.

It is important to track and properly label all data, graphs, etc. Organizing all information, important or not important, is vital because the amount of data only grows and grows as time continues. It does not matter if you spent hours and hours on a graph if you do not remember what it represents and what the key learnings/insights from it are.

Acknowledgements

A very big thank you to Mike Katchabaw, whose insight and guidance helped make this report possible.

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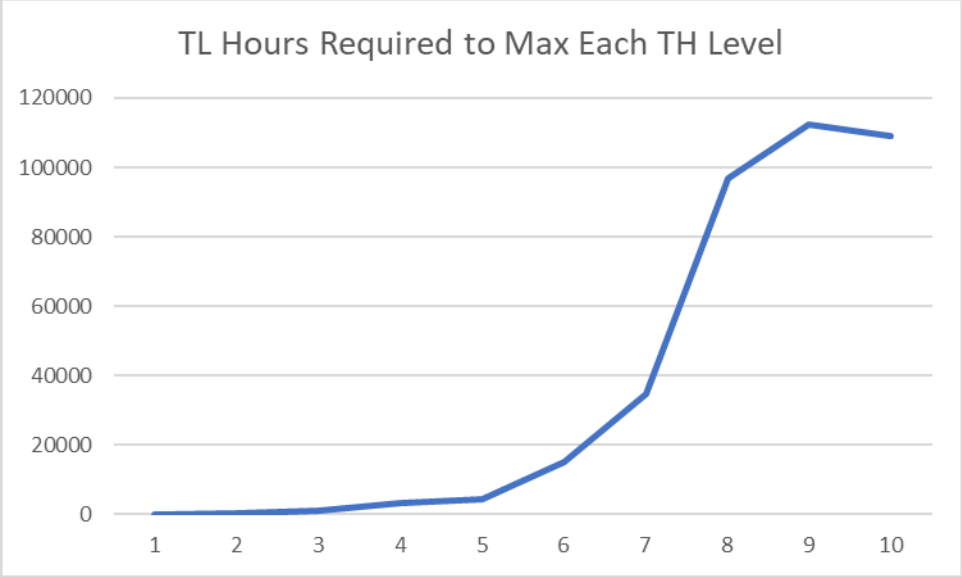
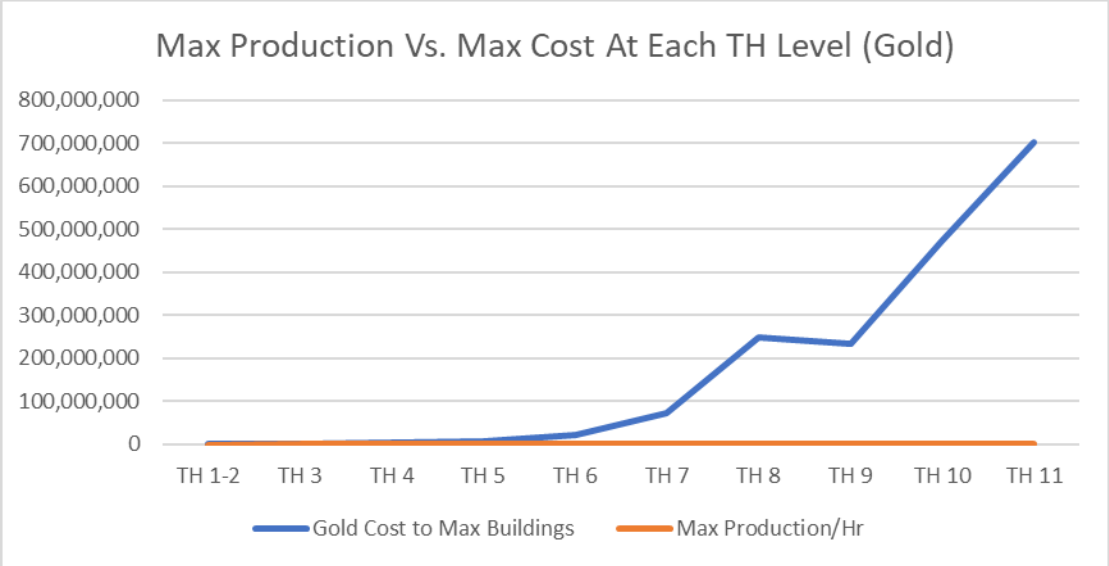
Clash of Clans Data Graphs/Data

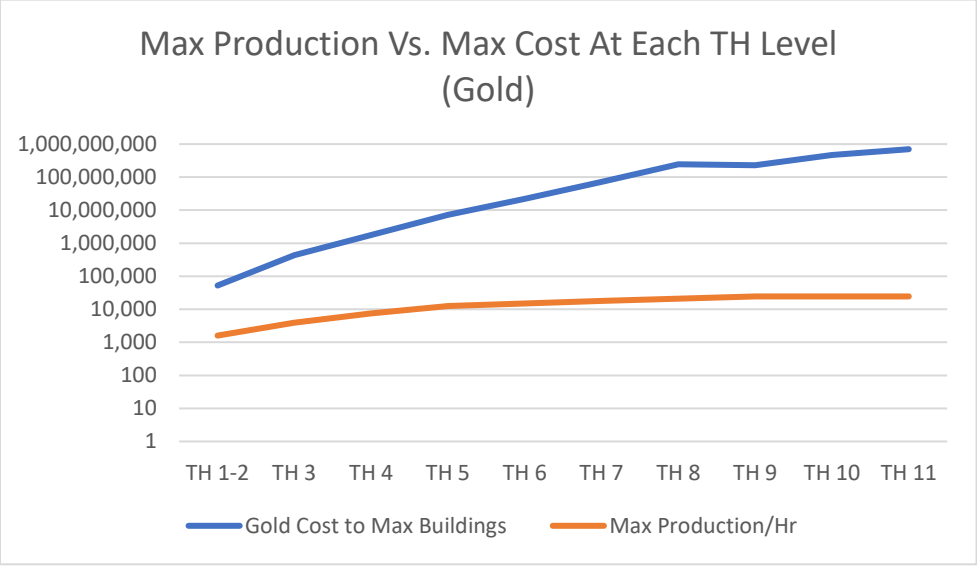
Clash of Clans: Total Hours Required to Progress to Next "Stage" of the Game



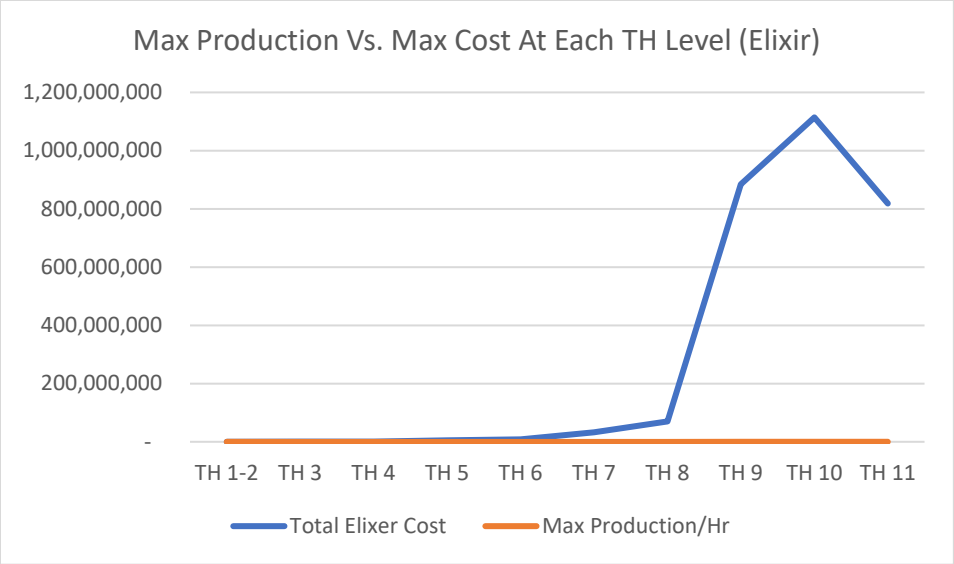
Clash of Clans: Gold Production Growth vs. Gold Requirements by Townhouse Level



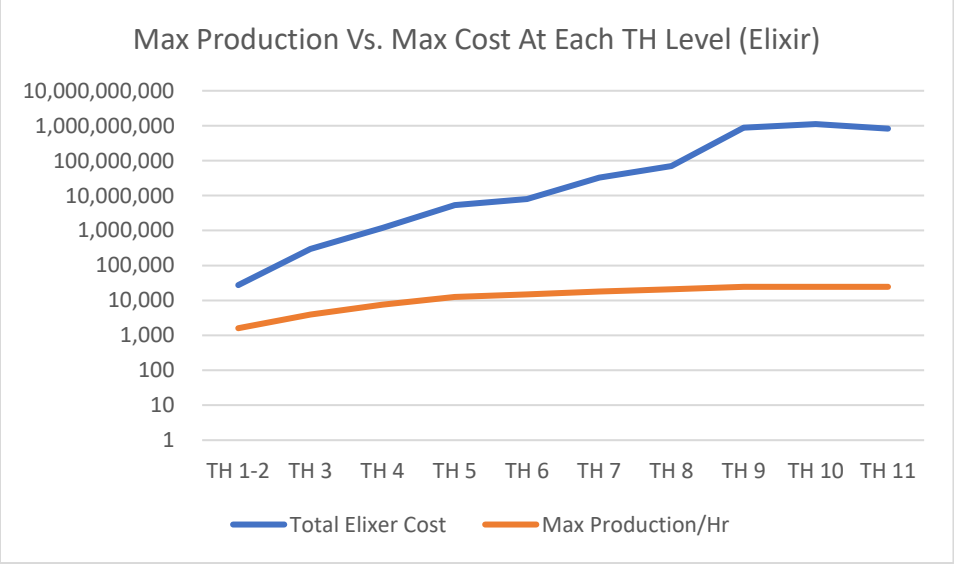
Clash of Clans: Gold Production Growth vs. Gold Requirements (Log Scale)



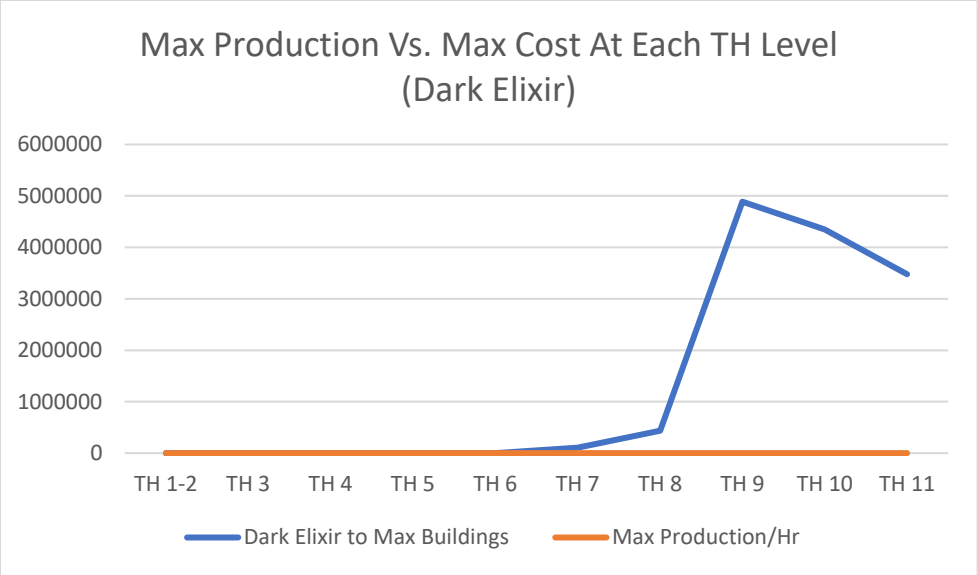
Clash of Clans: Elixir Production Growth vs. Elixir Requirements by Townhouse Level



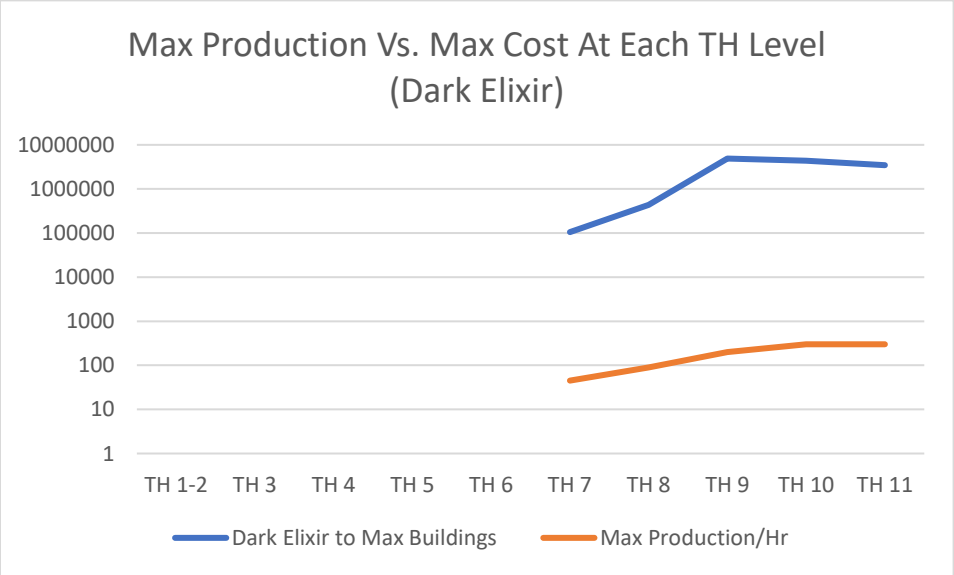
Clash of Clans: Elixir Production Growth vs. Elixir Requirements (Log Scale)



Clash of Clans: Dark Elixir Production Growth vs. Dark Elixir Requirements (Note: Dark Elixir Available After TH 7)



Clash of Clans: Dark Elixir Production Growth vs. Dark Elixir Requirements (Log Scale)

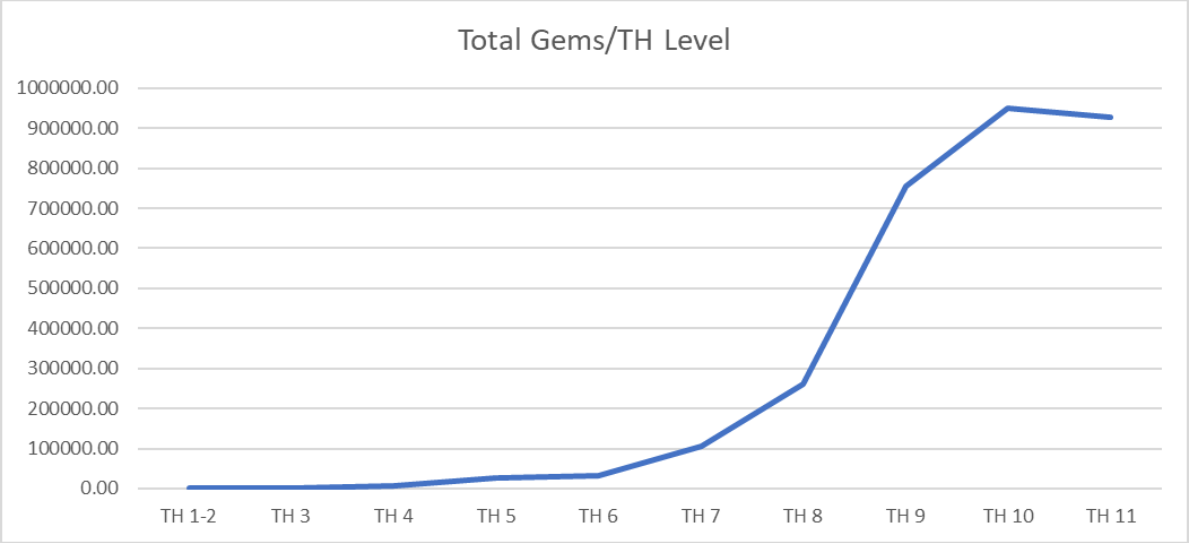


Clash of Clans: Converting Resources to Gems

Costs To Maximize Structures @ Townhouse Level												
Townhouse Level	Gold	Elixir	Either for Walls	Dark Elixir	Builder Days	Lab Days		Gold To Gems	Elixer To Gems	Dark Elixer To Gems	Days To Gems	Total Gems/TH Level
TH 1-2	52,400	27,400	0	0	1.13	-		15.78050121	8.306998104	0	294	317.89
TH 3	437,650	294,850	0	0	6.43	1.25		131.8003121	89.39118216	0	1997	2217.99
TH 4	1,778,800	1,189,250	0	0	23.5	3		535.6938083	360.5510035	0	6890	7786.24
TH 5	7,306,350	5,327,300	0	0	80.56	12		2200.340936	1615.104781	0	24066	27881.05
TH 6	22,025,300	8,014,550	0	0	79.56	11		6633.020484	2429.812104	0	23546	32608.43
TH 7	72,448,800	33,059,450	0	105,000	220.46	54		21818.28962	10022.8025	2975.340615	71360	106176.03
TH 8	247,251,550	69,414,550	0	437,500	457.01	133		74460.94245	21044.76406	12397.25256	153403	261305.56
TH 9	231,882,800	134,148,550	750,000,000	4,887,500	871.22	206		69832.57264	268051.8368	138495.0215	280077	756456.63
TH 10	472,347,050	214,148,550	900,000,000	4,350,000	968.53	361		142249.4885	337782.1129	123264.1112	345678	948973.51
TH 11	701,805,500	268,600,000	550,000,000	3,475,000	1,107.59	310		211351.9569	248179.1477	98469.60606	368573	926574.11

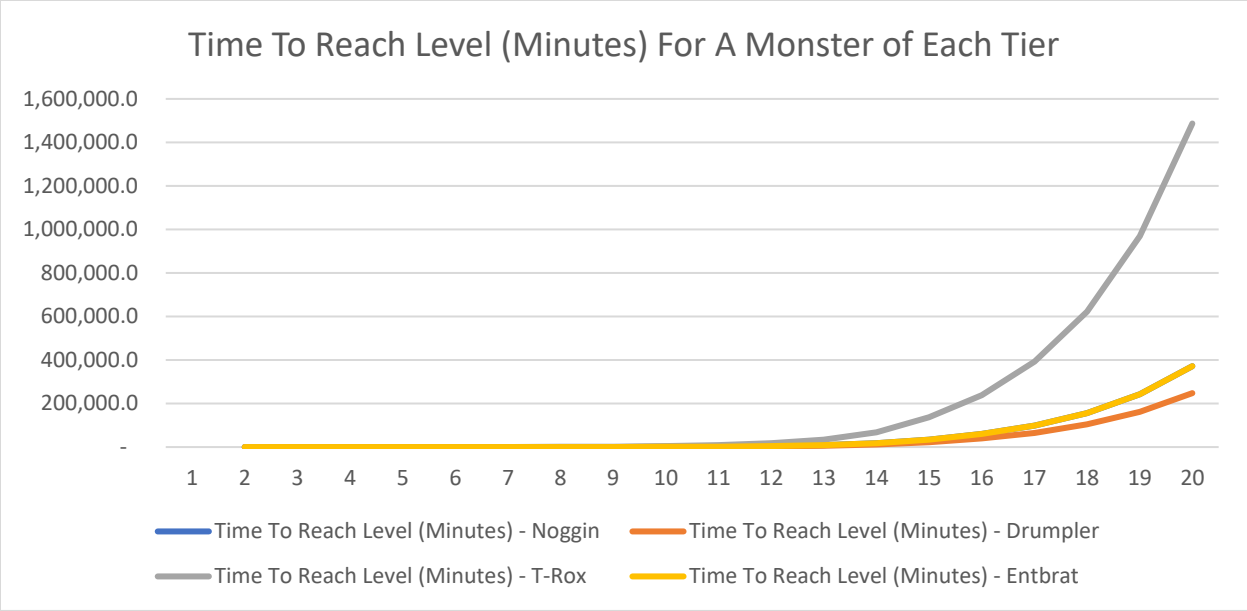
Note – although walls can be purchased with both elixir or gold, elixir is used both because it is cheaper (converted to gems) and less is required than gold (so the player will most likely not have enough gold).

Clash of Clans: Total Gem Required To Purchase Everything by Townhouse Level

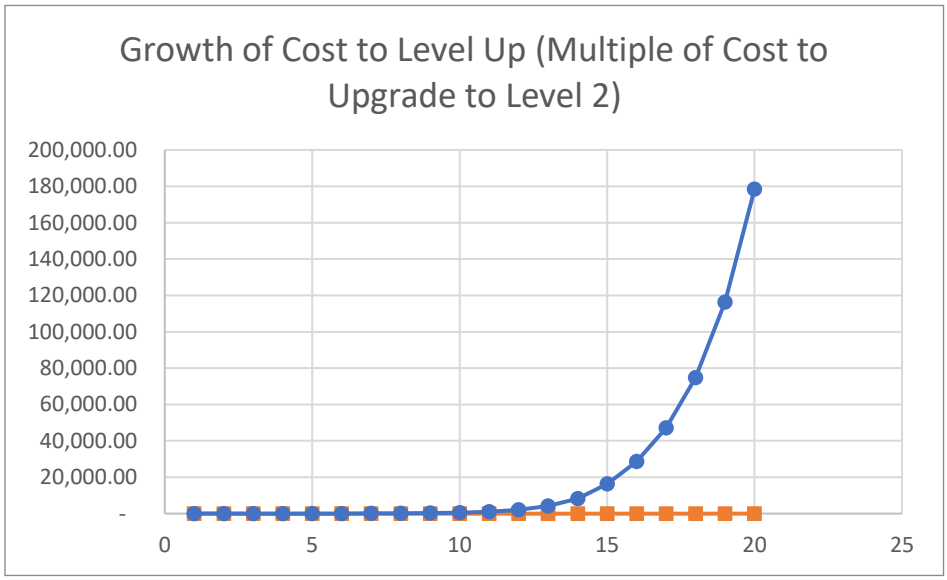


My Singing Monsters Data Graphs/Data

My Singing Monsters: Time to Reach Each Level (Minutes) For Each Monster Tier



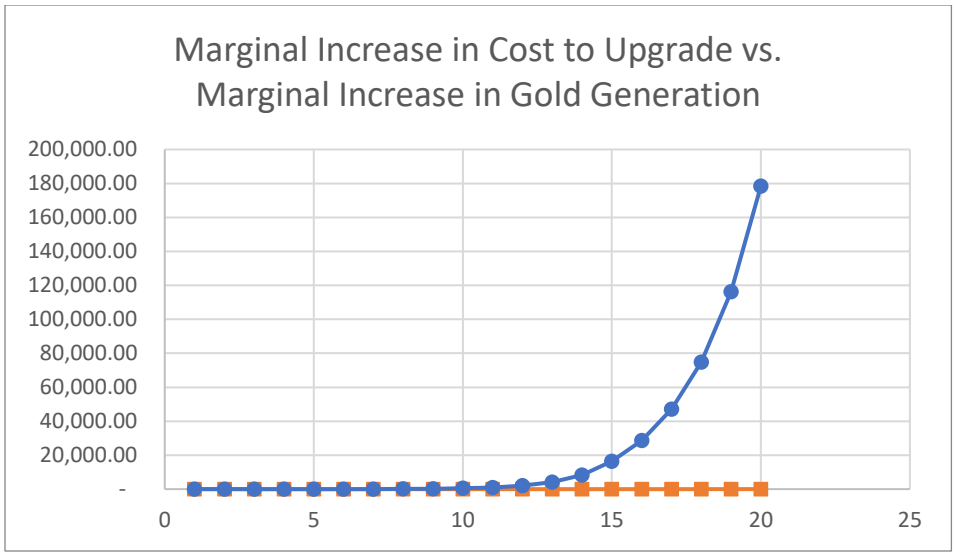
My Singing Monsters: Source vs. Sink Analysis 1 Element Monster



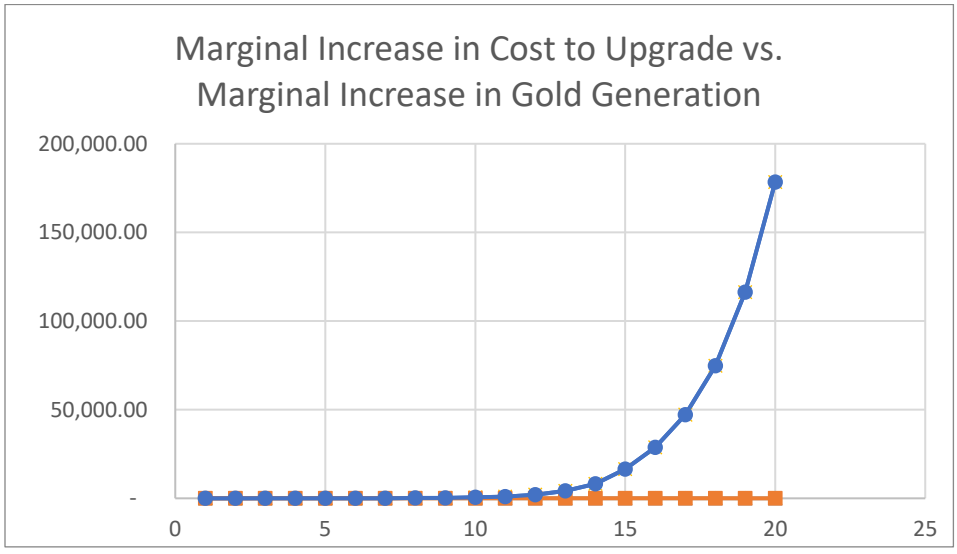
Note – monsters upgrade at a VERY similar rate, which was unexpected because the hypothesis was that higher element monsters (more expensive) would have a higher source/sink gap because they are only available later in the game.

Note – growth is measured by the cost of upgrade to level 2 so it includes costs of monsters.

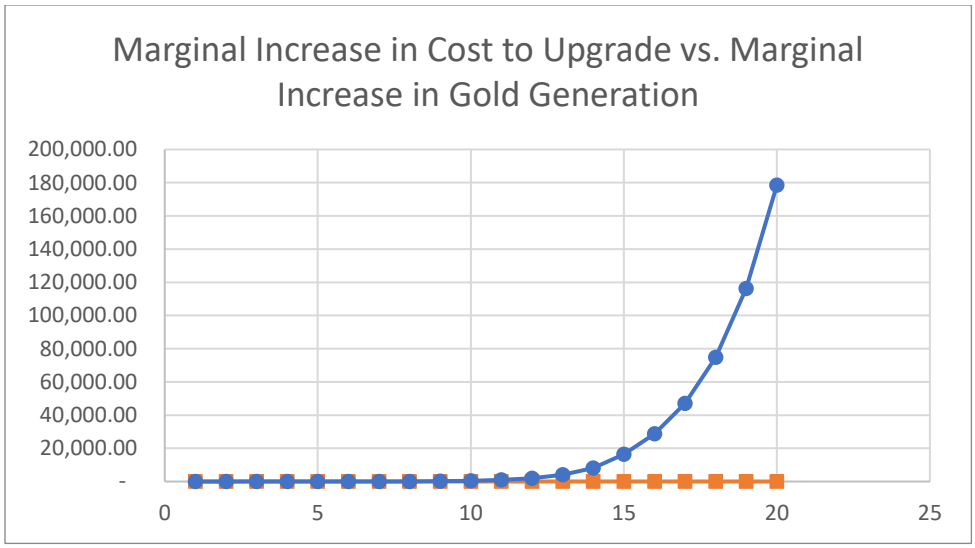
My Singing Monsters: Source vs. Sink Analysis 2 Element Monster



My Singing Monsters: Source vs. Sink Analysis 3 Element Monster



My Singing Monsters: Source vs. Sink Analysis 1 Element Monster



My Singing Monsters: Plant Island Cost Progress

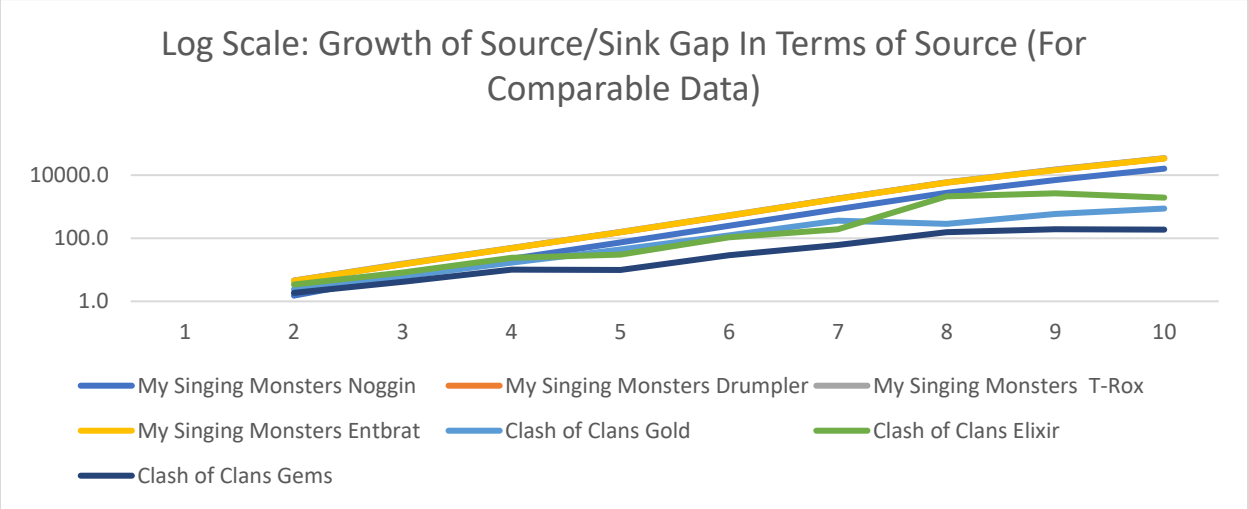
Plant Island Progress

	1	2	3	4	5	6	7	8	9	10	11	12	13
Castle	1955100												
Nursery	500200												
Breeding Structure							500200						
Bakery			100			100		5850		3000		3000	
Fuzer													80000
Time Machine													
Unity Tree													
Mini Mine								500000					
Recording Studio													
Storage													
Hotel													
Total	2455300	0	100	0	0	100	500200	505850	0	3000	0	3000	80000
	14	15	16	17	18	19	20	21	22	23	24	25	
Castle													
Nursery													
Breeding Structure													
Bakery		111000		30000									
Fuzer													
Time Machine	50000												
Unity Tree			1000000										
Mini Mine													
Recording Studio		100000											
Storage		100000			200000			400000					
Hotel		100000			200000			400000					
Total	50000	411000	1000000	30000	400000	0	0	800000	0	0	0	0	

Note – unfortunately, there is no data that shows how a typical player will progress, so it is assumed everything will be purchased as soon as it is available. For example, costs at level one are skewed because many things are available for purchase but that does not mean you will have the resources to do so.

Miscellaneous Graphs/Data

Combined Games: Log Scale Source/Sink Gap Growth



Combined Games: Data for Source/Sink Gap Growth

Level	My Singing Monsters Noggin	My Singing Monsters Drumpler	My Singing Monsters T-Rox	My Singing Monsters Entbrat	Clash of Clans Gold	Clash of Clans Elixir	Clash of Clans Gems
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	1.5	4.5	4.6	4.5	2.4	3.4	1.9
3	6.7	15.1	15.7	15.1	6.1	8.1	4.2
4	22.2	48.4	49.6	48.2	16.8	23.9	10.2
5	73.3	156.5	160.0	156.5	43.8	30.2	9.9
6	248.3	517.7	534.6	520.6	121.9	106.2	28.7
7	837.6	1787.9	1823.5	1782.9	358.5	192.0	61.5
8	2743.2	5792.3	5944.8	5768.3	288.0	2106.3	153.8
9	6947.7	14612.6	14968.8	14520.9	587.7	2654.5	192.8
10	16071.0	33886.7	34631.8	33805.1	873.7	1950.1	188.2

Example of Game Logs:

Progress:

11/7/2017 @ 12PM

Start:
- 3 Hour Infinite Lives
- 2 Mystery Chests
- Daily Prize (Generator)
  - Day 1: 1 Booster

Stage 3:
- 1 Key for Chest
- 4 Boosters
- 1 3H Infinite Life

LVL2:
- 5 Lives

Stage 6:
- 1 Random Booster

Stage 7:
- Prompt: Finish in 1 Try to Get Reward
  - Just A Visual Crown. No Hard Currency Reward

Stage 8:
- 1 Random Booster

Stage 10:
- 50 Gold Bar

11/7/2017 @ 1PM **End**

11/8/2017 @ 11:42AM

Start:
- Daily Prize:
  - 1 Random Booster

Stage 11:
- 3 Stars = 9 Gold Bars in Piggy Bank

LVL3:
- 5 Lives

Stage 12:
- 3 Stars = 9 Gold Bars in Piggy Bank
- 1 Random Booster

Stage 13:
- 1st Loss
- Paid 10 Gold Bars to Add 6 Moves (Still Lost)
- 2nd Loss
- 3rd Loss
- 4th Loss
- 3 Stars = 9 Gold Bars in Piggy Bank