

OTDK-DOLGOZAT

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**BOT NUKE DAY:
OR SHOULD I STILL TORMENT THOSE DEMONS?
THE EFFECT OF MACROS ON ECONOMIC AGENTS IN A
VIRTUAL WORLD**

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1. INTRODUCTION

Massively multiplayer online role-playing games differ from other computer games in that the economic decisions made by each individual affect the entire player base. They have a living, changing, player-driven economy similar to real world economies. Therefore the principles of economic analysis can be used to study them.

One of the most substantial problems these games have to face is the use of third-party softwares (also known as macros or bots) to produce virtual goods which are later sold for real money. They are used to do repetitive tasks that players are reluctant to engage in. As such, the existence of macros in a virtual economy has extensive effects on the economic decision-making of all players. So far, studies have only been done on how this affects the gaming communities as a whole and researchers are yet to develop a unanimous scholarly consensus on the issue. Most of them have also ignored players who do not partake in real money trading and their reasons for doing so.

Even the researchers who recognise the fact that not all gamers participate assume that real money trade's overall affect is largely negative on them and cannot back this up by numbers. While I do not argue with this, macros should be gone for good from MMORPGs, I would like to further categorise players based on their in-game activity. The reason for this is that some of them can benefit from real world trading without engaging in it, while others bear more costs than the disturbance to the game's atmosphere.

The way I classified players was whether they do repetitive tasks to accumulate wealth or turn to more entertaining options. One might assume that, based on these two characteristics alone, gamers always choose the amusing alternative. Yet, there are some who pursue the monotonous tasks. I came up with my own hypothesis: less pleasurable activities offer a proportionate gain for the utility loss they cause, hence they are more profitable. I named this proportionate gain *tedium premium*. However, I do not want to make the mistake of oversimplification, as I recognise that the player base is heterogeneous. Players with starting characters have less options available than those possessing elite characters. Therefore I chose to examine tedium premium in the case of high-level players, because if we are able to identify tedium premium in their case that would conclusively demonstrate its existence.

The paper connects macros and tedium premium: it discusses the effects of real money trading on players' money-making choices. Its main question is whether tedium premium exists and if so, whether macros have eliminated it by performing the repetitive

tasks themselves. In studying this, I will observe one specific MMORPG: RuneScape created by Jagex Games Studio. The choice of concentrating on a single game is validated by Jagex's success in banning macros on the infamous "Bot Nuke Day." The banning of the bots means I can analyse the effects of macros on tedium premium by looking at two states of the same game. I identified a challenging money-making method available to elite players: killing Tormented Demons. I investigate how the profitability of this activity has been changed by Bot Nuke Day, and based on that I will be able to draw conclusions both on tedium premium and how macros effect player well-being by limiting their choices.

The reason why I chose this topic was that the problems of botting and acquiring game items as efficiently as possible are relevant to millions of gamers. So far, researchers have only studied the effects of macros on the gamer community as a whole and nobody has stopped to look at the individual. I find that these individuals are not negligible, especially since they can always opt for quitting the game. Therefore I pick out a specific group with their unique skills and preferences and analyse their situation.

2. GAME MECHANICS

In this chapter I introduce all the features of the game which are relevant for the research project so that even readers unfamiliar with RuneScape or even the concept of MMORPG games can understand the basis of the paper's argumentation.

2.1. MMORPG GAMES

This acronym stands for massively multiplayer online role-playing game. It is a game type where a large numbers of players (in the case of some games, over millions) can interact with each other in a virtual fantasy environment. Each player has a so-called avatar or character, which is how she is seen by other users. Nevertheless, not only real players exist in the game, there are also a number of NPCs or non-player characters. They can give quests, run shops or even fight on the players' sides. However, not all of them are friendly. Aggressive monsters are also an essential part of MMORPG games.

An interesting trait of MMORPGs is that there are a number of tasks in them, but there is no superior goal that dominates all others. Some players prefer to improve their characters by levelling up skills, others choose to go on adventures or battle dangerous monsters in order to acquire items dropped on the ground on their deaths, which are therefore called "drops" or "loot". There are even players who just hang out in populated areas and chat with other gamers.

Based on their choice of in-game activity and behaviour, Burke (2002) puts economic agents into three categories: utility-maximizers, exploiters and the moral economy faction. The utility-maximizers are the ones most affecting the economy, while the influence of the other two is negligible. Their existence enables me to consider RuneScape players rational and model their behaviour based on that.

2.2. RUNESCAPE

In this subchapter I would like to briefly introduce all the features that are unique to RuneScape and are relevant to this paper. First of all, I would like to mention that even though RuneScape is widely considered to be a free MMORPG, the vast majority of the content is available to members only. In my research I focus on money-making methods which are only accessible to paying subscribers.

As one of the analysed vocations is battling monsters, I find it important to explain how this is done. There are three types of combat a character can master: melee, ranged, and magic. They all deliver different types of damage. They are aided by further combat

skills, namely prayer and summoning. Characters with a high level in prayer can ask their gods to protect them from a certain type of damage. However, they cannot be immune to more than one combat style at a time. There are also a few monsters in the game that possess this ability; one of them is the Tormented Demon, the focus of my research. High level summoners can call spirits to come to their aid. To do this they need a spirit pouch. These familiars can also deliver a special attack, provided the summoner has the necessary scroll to invoke it.

2.3. REAL MONEY TRADING

MMORPG games have a large community. By the nature of the game, their players are urged to spend considerable amount of time playing the game in order to acquire game gold and items. Some of them are not only willing to spend time on acquiring their characters' gear and the virtual money needed to buy them but real money as well. In other words, there is a large consumer need for virtual items. Unsurprisingly, some economic agents have decided to make money by satisfying this need. They either create third-party softwares, also known as macros or bots, to obtain the highly-desired items, or they hire cheap labour, mostly from China and Korea. In that case, there are real people sitting behind the computer. They are mostly referred to as gold farmers. Once the game gold is acquired, either by macros or people, it is sold to players who are willing to pay for it. In the gamer community, this process is known as real money trading or real world trading. Most MMORPG games prohibit real money trading, but they rarely succeed in actually preventing it.

2.4. GRAND EXCHANGE

RuneScape has two characteristics that make it particularly suitable for scholarly investigation. One is the fact that item prices are determined by supply and demand. The other is that data on prices are available to all players and outsiders as well. These features would not exist without the centralised trading system, also known as the Grand Exchange. It is accessible to all players, although members get six offer slots whereas free players get only two.

Economic agents can use the system for buying and selling all tradeable items. Assuming the player no longer needs an item, she can put it in the Grand Exchange on the smallest price for which she is ready to sell it. Then the system finds a buyer who is willing to pay at least the given amount of money and connects these offers. The only thing

economic agents need to do in this situation is put in the offer and wait. There are no transaction costs when using the Grand Exchange. It also eliminates the costs of looking for other players who want to trade the ware in question.

If an item is traded frequently enough, the system calculates the equilibrium price and displays it in the trade interface for all economic agents to see. Naturally, offers can be made at different prices; the equilibrium price is merely a suggestion. Furthermore, data on these prices dating back 180 days can be viewed on the RuneScape website in the Community section under the “Grand Exchange” tab. There are charts illustrating the recent price histories. The advocates of technical analysis ought to find this extremely useful when trying to determine future price shifts.

2.5. TYPES OF VOCATION

There are countless ways of making game gold. If I had a gold piece for every time I was asked how I made my money I would probably be the proud owner of a blue partyhat (one of the most expensive RuneScape items). One way to categorise money-making methods is by assessing how tedious they are. There are repetitive tasks that can be done by nearly everyone and there are more challenging options available to players with more developed characters.

But what makes something tedious or challenging? This depends on gamers’ preferences and is probably a little different for everyone. However, I have never heard a player say “let’s pick up snake grass from the ground, it will be fun!” Therefore it is safe to assume that doing the few same movements over and over again, also known as grinding, is the most boring task imaginable to the vast majority of players. To represent the enjoyable tasks, I picked boss hunting. They are considered a great way of earning money, but some players do it because of the challenge it poses.

2.6. TORMENTED DEMONS

Tormented Demons are monsters players can encounter after completing the quest While Guthix Sleeps. They belong to the category of “boss monster,” which means they are exponentially stronger than regular foes within the game world, but also have a small chance of dropping extremely valuable loot.

When slaying a monster, the fighter has to be prepared to receive damage. However, as strange as this might sound, the damage can be healed by eating food or drinking magic potions. So when fighters get hit, they just gobble down a shark and instead of a

stomach ache they get some life points replenished. Owing to this, boss hunters fill their inventory with magic potions and sharks or other fish before taking on Tormented Demons.

Food is not the only thing fighters need. They are strongly advised to take potions that boost their combat skills. There are also a number of items that are a must when encountering this boss. Players need a sapphire lamp to help them get to the demon area, a special sword, the Darklight to weaken the demons and at least two different types of weapons, as demons become invulnerable to any attack type that is used on them for too long.

2.7. DROP MECHANICS

On death, monsters (all monsters, not just Tormented Demons) drop an item. This item is not completely random, as there are only a limited amount of outcomes with a probability, also known as the *drop rate*, assigned to them. Some items are more common than others. The rare ones also tend to be more expensive, not only because the supply is smaller, but also because Jagex purposefully makes the items with bigger bonuses rarer. This makes the distribution very skewed, given that the smaller values occur more frequently, whereas the extreme values are tremendously rare. However, this might even add to the fun of monster hunting. Some might argue that it is gambling, but usually with a positive expected value.

3. THEORY

I have mentioned all features of RuneScape that are relevant for this research. Naturally, the game is much more complex, comprising of a wealth of unrelated content and game-play mechanics, but I opted to omit these in order to focus on mechanics pertaining to economic analysis only. I am now moving on to introducing the previous research done on the influence of macros and my own theories on the subject as well.

3.1. PREVIOUS FINDINGS

In this subchapter I am going to introduce previous research on the effects of real money trading. Even though it has implications in both the real and virtual worlds, I am going to focus on its influence on virtual economies, as this is the part relevant to my paper. Unfortunately, there has not been enough research done on the subject as the authors looking into botting or real world trading do not differentiate between different groups of players in terms of how they have different economic goals and preferences and how their decision-making is affected by these phenomena.

First of all, I would like to mention Yamaguchi's (2004) analysis of virtual currencies. In it, he uses microeconomic tools to show why players participate in RMT, or as he calls it, *eBaying*. Players with a lower opportunity cost of time caused by lower real-world incomes can allocate more time to playing the game and consequently they are able to obtain virtual items more easily. On the other hand, users with higher real-life salaries can acquire money with less effort. Both parties have the incentive to exploit their comparative advantage and engage in real money trading. Huhh (2008) also explains real money trading as a kind of optimising behaviour in a model of allocating resources between two worlds: real and virtual. He also claims that real money trading could not exist without the high opportunity costs of playing an MMORPG. Even though these models are able to explain the reasons behind real-money trading, they have the same problems all microeconomic models have: they oversimplify things. They stick to financial incentives and completely overlook the moral reasons that cause certain players not to engage in real world trading, thereby uniformising a diverse player-base.

Now that we have examined the reason behind real money trading, we ought to move on to its effects. I would like to start this by mentioning Huhh's research done in 2006, in which he claims that real money trading could have Pareto-improving results at the social level. He applies the argument of a network externality, saying that the majority

of the fun in an MMORPG game stems from communication between users. The real money trade market functions as a way of “internalizing” this externality, widening the range of options available and attracting more players. This paper also has the problem of assuming that none of the players are reluctant to engage in real money trading. If this were true, then real world trading could in fact be Pareto-improving. However, if a player decides not to engage in it, then she could end up only bearing the costs and not enjoying the benefits. For a change to be considered Pareto-improving it needs to satisfy a very strict condition: none of the economic agents can be worse off after the alteration. Therefore all I need to disprove Huhh’s (2006) statement is to find a single player or group of players whose utility is higher in a world without macros.

Castronova (2006) comes to the exact opposite conclusion as Huhh (2006). He says that some welfare effect of the real money trade fall on the players not participating in it. He lists four ways in which this externality lowers the value of the game for players: it disrupts the game’s fantasy atmosphere, increases inflation, leaves less territory for the actual players and causes spam in the form of the gold farmers’ advertisements. Developers also suffer from the practice, as their service provision costs are increased. He reaches the conclusion that the level of the occurring gold sales is higher than the socially optimal level. While I agree with the main conclusion, I would also like to point it out that players are not a homogenous group and therefore the activity of macros affect them differently. The net buyers of items produced by macros can enjoy the lower prices, whereas net sellers suffer from it. I do, however, understand that this classification overcomplicates Castronova’s (2006) model and is not necessary when looking at the gamer society as a whole. For the purposes of my paper, though, it is important, as I look at a specific group.

Castronova (2008) also worked with other researchers to test whether fantasy gamers conform to the law of demand. Even though this is not directly connected to macros, I find it noteworthy, as it shows that there is indeed a relationship between item price and quantity demanded in virtual worlds and this is a key assumption for my paper. They created two almost equivalent worlds, the only difference being in the price of the health potion, which was twice as expensive in one world than in the other. They found the amount of potions purchased was 43.1 percent lower in the world that had the pricier potion. This suggests that the law of demand holds in virtual worlds.

3.2. MAIN HYPOTHESES

Previous work in the field has been mostly theoretical and there have not been enough empirical work, data and hypothesis testing on the subject. This is why I chose to study the measureable effects of macros on the game, and I will do this through examining the profitability of different money-making methods in RuneScape. Earning RuneScape gold pieces is not only important to gold farmers. Players need gold whenever they want to train skills, fight bosses or just buy a decorative but useless outfit for their character.

In the “Types of Vocation” subchapter I have already categorised money-making methods into repetitive and challenging. While one only engages in grinding if it causes a significant increase in either experience points or bank value, both of which are highly sought after, players would probably do the pleasurable activities for just the fun of it. In other words, users are *boredom-averse*. Consequently, the monotonous tasks should somehow compensate the players for the utility loss they cause by offering a commensurate gain. From now on, I am going to refer to this “commensurate gain” as the tedium premium, which is the incremental expected gain from taking on a boring activity.

The repetitive activities have another thing in common besides causing utility loss for boredom-averse economic agents: macros can be easily programmed to do them. This was the case in pre-“bot nuke” RuneScape. During this period of time, there were thousands of bots picking up snake grass, cutting yew trees and even killing tamer monsters, such as green dragons for their bones. Setting bots to gather easily accessible resources significantly increased the supply of the items farmed, whereas it left demand unaffected. As a result, the prices of the aforementioned items dropped, decreasing the profitability of bottable activities.

While autonomous tasks can be easily performed by third-party softwares, the same cannot be said of entertaining money-making methods. In my paper, these challenging activities will be represented by killing boss monsters. This vocation requires strategy and the undivided attention of the player. While these traits make boss-hunting enjoyable and earn the fighter a great deal of respect, they also make it impossible for bots to pursue it.

However, this does not mean their profitability is unaffected by macros. On one hand, bots produce some of the items required for facing bosses, lowering the costs of the fighter. On the other hand, they also reduce the number of highly profitable money-making methods available for players by mass-producing certain items. Due to this reduction in fiscally productive activities, even players who would not normally go near a boss

could decide to kill them, making this vocation more competitive. These two effects influence the profitability in the opposite way. Reducing costs has a positive, while increasing competition has a negative effect. To determine the outcome, one needs empirical research, which I will do later on in this paper.

By swarming the game, bots disrupt incentives to do repetitive tasks. Tedium premium cannot exist in a world where macros are ubiquitous. But would it exist if there were no macros to influence the economy? Has tedium premium been obliterated by bots or was it illusionary in the first place? My main hypothesis is that in a world without macros economic agents would receive a proportionate reward for pursuing monotonous tasks. I will look at this question from the perspective of a high-level player. Users with characters advanced enough to engage in combat with Tormented Demons have already put considerable resources into levelling. If tedium premium indeed exists, this could turn out to be a sunk cost. Does the removal of macros mean that even high players would be better off mining coal? I hope to answer this question by the end of the paper.

4. METHODOLOGY

Having introduced the theories, both previous and my own, I am eager to move on to actually proving or disproving hypotheses. In this chapter I will describe my research methodology and the reasons for picking these tools.

4.1. RESEARCH METHODS

My research question about tedium premium requires the comparison of two mutually exclusive scenarios. One way to do this would be to examine two MMORPG games (one, such as Runescape, where macros can and do enter the game, and one lucky MMORPG where players are spared the constant onslaught of massive, automated cheap labour). However, the results would most likely be incommensurable. Another option is to examine the economic situation in the same game, once in a bot-free and then again in a bot-infested state of the in-game economy. This may sound impossible to execute, since bots appear gradually and there is no clear line between the two states. However, RuneScape's Bot Nuking Day offers the perfect solution to this problem.

4.2. BOT NUKING

On October 25th 2011 Jagex succeeded in banning 98% of RuneScape bots. What is more, this change was not just temporary, as even in March 2012 the number of bots does not even compare to the pre-nuking state. At Runefest 2011, at the "Breaking The Bots" insider session on October 29th it was revealed by Mark Gerhard, the CEO of Jagex, that 1.5 million gold farming and macroing accounts were banned on Bot Nuking Day, and they were also planning to ban another 7.7 million accounts by the end of the 30th. RuneScape used to have over 750,000 accounts registered from China and Korea per month, and it was these accounts that bore the brunt of the gold farming effort, but the week after Bot Nuking Day, only 953 were created in these two Asian countries. Percentagewise this means that the overall number of players decreased by 60%.

4.3. OBSERVED TIME PERIOD

Thanks to Bot Nuking Day, I will be able to observe both a bot-infested and a bot-free economy within the same MMORPG game and examine the relationship between the lucrativeness of various money-making methods. My observed time period starts on September 26th 2011 and ends on February 10th 2012. The reason for this is that I intend to exclude a number of other factors that could distort the data and lead to misleading results.

One of the factors I decided to filter out is the semiannual Bonus XP Weekend. In the beginning of every March and September, players get the opportunity to earn significant amounts of bonus experience for three days. Unsurprisingly, the vast majority of the community decides to train expensive skills during the weekend, as in the first two and a half hours one can earn more than twice the usual experience with the same amount of resources. This means that everybody wants the same items at the same time. Due to such increased demand, prices skyrocket before and during the Bonus XP Weekend, while immediately afterwards, prices for the self-same items plummet, further skewering the results. Unfortunately, the items that are so desired at this time period overlap with the resources mass-produced by bots. As a result, I had no choice but to leave these periods out of the observed time interval.

Another thing I had to take into consideration is the fact that bots only re-entered the game after February 1st 2011. Between December 10th 2007 and February 1st 2011, there was a game-wide trade limit in effect, technically preventing all players from making “unbalanced” trades. The main reason behind this was to put a stop to ubiquitous real money trading and destroy incentives to create bots. However, the system was so unpopular that Jagex finally decided to bend to the community’s will and reintroduce free trade. As free trade came back, so did the bots. However, their arrival happened gradually, and in the first few months, their influence on the economy was negligible. It would make no sense to include this time in my research as it is halfway between the bot-infested and the bot-free period, and my goal is to show a clear contrast between two pure-culture states.

4.4. APPROACHING THE DEMONS

In comparing the two states of the economy, I am going to focus on one vocation in specific: killing Tormented Demons. But why this boss and not any other? First of all, I wanted something that is considered profitable and available only to high-level players, since they are the focus of this research. These two criteria left me with three options: Nex, the Corporeal Beast and Tormented Demons. I immediately ruled Nex out as she was only released last year, meaning the prices of her drops have not settled yet. I decided not to examine the Corporeal Beast, as it is mostly killed by groups, which only complicates the research. Furthermore, its drops are tremendously rare, which would require taking an extremely larger sample of kills. This leaves me with the choice of Tormented Demons.

These monsters are suitable for my research because through this one example I will be able to determine how the profitability of both types of activities (repetitive and

challenging) has changed. The reason for this is that most of the items needed to kill these monsters are produced by bots, therefore their prices will be factored into the costs of demon-slaying. Repetitive tasks also represent the opportunity costs of boss hunting.

To calculate how much profit is turned by killing the demons, I have to examine both the revenue and the costs and how they change when bots are taken out of the game. First, I will focus on the revenue, which is determined by the items dropped by the demons and, of course, their possibility of being dropped. It is easy to get data on the prices by data mining, however, the exact drop rates are not disclosed by Jagex. To calculate them, I am going to rely on drop logs created by RuneScape players using a sample of 9484 drops. This enables me to estimate the revenue generated by hunting demons.

The costs of killing boss monsters can be divided into explicit and implicit costs. “Explicit costs are a firm’s direct, out-of-pocket payments for inputs to its production process during a given time period such as a year. [...] However, firms use inputs that may not have an explicit price. These implicit costs include the value of the working time of the firm’s owner and the value of other resources used but not purchased in a given period” (Perloff 1999. p. 196.). In the case of the demons, explicit costs consist of potions used to make players stronger and food to heal the damage caused by the demons. These items all come from activities that can be performed by third-party softwares, and their prices skyrocketed after Bot Nuke Day. Boss hunting also has implicit costs. Players need to invest in expensive armour and weapons. Even though these can be resold any time (provided there is sufficient demand), the owner still forgoes the opportunity to invest the money elsewhere. To ascertain how much money we are talking about, I am going to examine other investment methods in the game. I am also going to calculate the opportunity costs, which are defined as not choosing to spend time doing any other money-making method, including the ones that became exponentially more profitable after the banning of the bots.

Being able to identify both explicit and implicit costs also means that two types of profit can be calculated. Accounting profit is the difference between revenue and explicit costs, whereas economic profit also takes the implicit costs into account. This means that accounting profit underestimates costs and overestimates profit. It also gives less information than economic profit.

Since economic profit includes implicit costs, turning zero economic profit means that the economic agents could not have done better had they chosen a different method of accumulating wealth. Economic profit does not only reveal information regarding other opportunities for money-making, but also about market structure. In perfect competition, it

is impossible to earn economic profit in the long run. In the long run, all of the input factors can be varied, economic agents can leave the market or new ones can enter. In this paper, I am going to define long run by the time it takes for a new player to get all the requirements for killing Tormented Demons.

4.5. PROCESSING DATA

In processing data on both revenue and costs, I sought to remove all the outliers that are caused by a daily shock and are not part of the economic trend. Then I smoothed out the remaining data by using a centred moving average. I found it best to use 15 data points, as this is enough to smooth out the shocks that last for days and yet the contrast between the two periods still remains clear. Although this meant having 14 less numbers to work with, the data was not completely lost, since it was factored into the moving average. In the end, this meant having 114 pieces of data to process.

5. REVENUE

Having discussed the methodology used in answering my research question, I am now moving on to detailing the actual calculations, starting by estimating the amount of revenue earned. The reason why players keep slaying Tormented Demons is that every time they die they drop an item which is usually referred to as a “drop”. There is no way to know what the drop will be before the actual kill. However, there are only a limited amount of outcomes, each of which has a probability assigned to it, showing the chance of it being dropped. Determining the drop rates and collecting data on the prices will enable me to calculate the weighted average of all possible values, also known as the expected value.

When calculating the drop rates, I relied on information provided by other players. Some boss hunters take note of their drops and publish their results. After going through public drop logs on the RuneScape forums, I was able to collect data on over 9000 kills, which can be considered a big sample (Drop logs #1–6 in the primary sources). Based on this, I was able to estimate the drop rates. Data on prices is comparatively more accessible. There are huge databases available on various fan sites with prices, including the largest and most extensive, RuneScape Bits and Bytes, whose database has records reaching back to 2009, that is to say, over three years. After procuring all the necessary data, I will calculate the revenue for each day in the observed time period.

5.1. DEMON DROPS

Tormented Demons have four drops which are worth over a million gold pieces: Dragon claws, Ruined dragon armour slices, Ruined dragon armour lumps and the Ruined dragon armour shards. These are the most important financial incentives for players to kill the demons, also known as the main drops. The rest of the drops can be put into two categories: drops worth picking up and those that are completely worthless. The latter are left on the floor by hunters and therefore do not add to the expected value of the revenue.

5.2. DROP RATES

There are only a limited amount of items that can be dropped by Tormented Demons. Each outcome has its own probability of occurring, known to the gamers as the “drop rate.” We do not know much of these drop rates as Jagex prefers not to disclose them. Nevertheless, they do announce changes in drop rates on a few occasions, especially when the aforementioned adjustments are so momentous as is the case with the most expensive

drops of these demons. The last time Jagex announced an alteration of the Tormented Demon drop rates was in December 4th 2008, when they posted the following on the RuneScape website: “We also made an error when we calculated how many demons players would normally be able to kill over a certain period of time, which resulted in the dragon platebody parts being dropped at a more frequent rate than we had intended. [...] The drop chances of the individual dragon platebody pieces have been reduced to give the drop rate we intended, considering the frequency at which they are killed.” Therefore, we have reason to assume that Tormented Demon drop rates have not changed significantly since then, including the observed time period.

It is a common misconception among players that a drop rate of $\frac{1}{n}$, where n is the number of monsters killed, guarantees the item to be dropped once in n kills. The truth is that drops are independent, and they only reveal the odds of getting the given item in one kill. Basic mathematics tells us that the probability of getting the item at least once in n kills is the same as 1 minus the probability of not getting it, or $1 - (1 - \frac{1}{n})^n$.

5.2.1. Data Sources

Fortunately, curiosity regarding drop rates is ingrained in RuneScape’s gamer community, and some fighters try to acquire this information by “logging” their drops (writing them down, or using a drop logger program to do this for them). Besides procuring the data for themselves, they also share it with other players on the RuneScape forums and on various fansites.

One might argue that this data is not the most reliable and that is true to some extent. Lack of accuracy might come from several areas. One area might be that humans are generally boastful and would want to embellish their own achievements. They could also try to make demon hunting look less attractive by deliberately reporting less frequent drops to avoid competition. Even though there is no way to ascertain if someone is lying, one can always check if the data is consistent with the drop rates published on the community-approved RuneScape Wiki. That way the logs with great distortions can be ignored. Another problem could be that even well-meaning players could make unintentional mistakes while logging their drops. However, the odds of that happening are negligible. It does not require any skills to create drop logs when there are sophisticated programs to do the lion’s share of the work.

Despite knowing these limitations, the paper will still rely on player-reported drop tables because they are easily accessible and they are still the most extensive data avail-

able. The only alternative would be to rely on the drop rates of The RuneScape Wiki, but its categories are very coarse-grained. It puts drop rates into five categories. The main drops of Tormented Demons all fall into the category of “rare” which can be anything from 1 in 101 kills to 1 in 512 kills. This is by no means accurate enough to form the basis of my paper’s data.

5.2.2. Processing Data

As I have mentioned before, I am working with data collected by other boss hunters. To be more specific, I am using six separate logs created by six different players. I copied all the logs into an Excel file. The challenging part was standardizing nomenclature because of the ubiquitous nicknaming of the items which is so prevalent in MMORPG circles. For example, an adamant battleaxe is referred to as an “addy b axe” in some of the logs. Fortunately, I could easily replace these arbitrary titles with the original name of the item using Excel. Correcting spelling mistakes proved to be even more arduous, as these changes had to be effected manually.

After making sure that every item is classified under its designated name and therefore is identifiable, I could then move on to counting the amount of each object in the compiled log. The way I did this was by putting the actual drops in a column and the list of all possible drops in a row, defining a matrix created by the data. I filled this matrix with logical data types. A cell would be given the value of 1 if the appropriate row and column had the same text in them and 0 otherwise.

This system has a built-in control function. If there are no mistakes, the sum of all rows should be 1, meaning that each item has been identified and only identified as one thing. This was a great deal of help when I was checking for spelling mistakes, as the sums that turned out to be 0s marked drops that had not been accounted for. The sums of the columns revealed to me the quantity of each item dropped. Comparing these to the amount of all items in the sample gave me the drop rate of each object.

5.2.3. Statistical Background

I used statistical tools to estimate the drop rates from the sample proportion. In the population the drop rates take a form of $P = \frac{K}{N}$, where K is the number of items possessing a certain trait and N is the size of the population. When we talk about the sample proportion we denote it by $p = \frac{k}{n}$.

I have previously mentioned that the drops of Tormented Demons are independent. This means that the drop logs constitute a simple random sample. “In simple random sampling different samples of the same size in the population have an equal chance of being selected” (Mendenhall et al. 1989. p. 173.). In the case of a simple random sample, the sampling distribution of the sample proportion can be modelled by a binomial probability distribution. When the sample size n is large, then due to the Central Limit Theorem the sampling distribution of $\hat{p}$ is approximately normal with p mean and standard deviation $\sqrt{(p \cdot (1 - p))/n}$.

But what n can be considered large? It all depends on the P we are trying to estimate. If it is around 0.5, then a smaller sample is accurate enough, but if it is close to 1 or 0, then we need a bigger sample. Hunyadi and Vita give the following rule of thumb: the smaller of $n \cdot P$ and $n \cdot (1 - P)$ has to be at least ten. If the drop rate of claws is around 1/250, as it is claimed to be by a number of hunters, then n has to be at least 2500. However, armour parts are rarer, claimed to be around 1/500, making it necessary to use a sample of at least 5000 kills. My compiled log contains 9484 kills which should be large enough for its purpose.

On a 95% confidence level, the interval is $p \pm 1.96 \cdot \sqrt{p \cdot (1 - p)/n}$. I calculated this interval for every drop that is picked up by hunters. My results are shown in Table 1. In my further calculations, I am going to use p , the middle of the interval, but later I am going to look at a scenario where the drop rate of the most valuable drop, the Dragon claws is at the lower end of the interval.

Table 1. Sample proportions

Name	Lower	Mid	Upper
<i>Dragon Claws</i>	0.0025	0.0037	0.0049
<i>Ruined Dragon Slice</i>	0.0005	0.0012	0.0018
<i>Ruined Dragon Lump</i>	0.0005	0.0012	0.0018
<i>Ruined Dragon Shard</i>	0.0004	0.0011	0.0017
<i>Rune Sq Shield</i>	0.0331	0.0369	0.0407
<i>Rune Chainbody</i>	0.0063	0.0081	0.0099
<i>Prayer Potions</i>	0.0084	0.0104	0.0125
<i>Sharks</i>	0.0273	0.0308	0.0343
<i>Diamonds</i>	0.0758	0.0813	0.0868
<i>Death Runes</i>	0.0621	0.0672	0.0722
<i>Law runes</i>	0.0406	0.0448	0.0490
<i>Coins</i>	0.0490	0.0536	0.0581

Source: edited by the author

5.3. PRICES

Now that I have determined the drop rates of all the relevant items, I am going to proceed with finding data on the prices. In our preceding discussion of the Grand Exchange, it was mentioned that the RuneScape home page provides data on the price history of all tradeable RuneScape items. However, it only supplies information about the past 180 days. Therefore I had to rely on data provided by a RuneScape fan site, RuneScape Bits and Bytes. The site tracks the Grand Exchange price of objects, creates charts and enables registered users to create their own portfolio.

I used the HTML code of the charts to get the price history of Tormented Demon drops. Prices in the code look like this: 1319587200: "20990799". The first number is a time stamp, it marks the seconds elapsed since January 1st 1970. In this example, the time stamp describes the exact date of October 25th 2011, 7:00:00pm EST. The second number in quotation marks is the item price. Both numbers contain relevant information and with a few handy Excel functions they can be easily separated. After collecting all the relevant prices, I have now everything necessary in place to calculate the expected value of revenue earned from killing a Tormented Demon.

5.4. CALCULATING REVENUE

The revenue greatly depends on the number of demons the slayer can kill each hour. This is affected by the levels of the character and the skills of the human player sitting behind the computer. Experienced boss hunters can easily achieve over 45 kills an hour, whereas beginners can struggle with reaching 20. As I am studying demon slaying as a money-making method, I am going to assume that the person doing it is capable of slaying 30 demons per hour. Later on, I will come back to how the number of kills influences profit, but for now I am going to calculate with 30.

If we multiply the price of each drop with the probability of receiving it, then we can see how much it adds to the expected value of a kill. Adding up these figures gives us the expected value of money earned by slaying a demon. It is therefore interesting to see each item's contribution. In the observed time period, the mean of the expected value was 74613 gold pieces and the Dragon claws drop alone was responsible for 60783 coins. That equals an 81% contribution from which we can conclude that the revenue earned greatly depends on the amount of claws dropped.

When we multiply the money made on each kill with the number of kills per hour, we get the total revenue made per hour. Figure 1 shows the changes of revenue using a

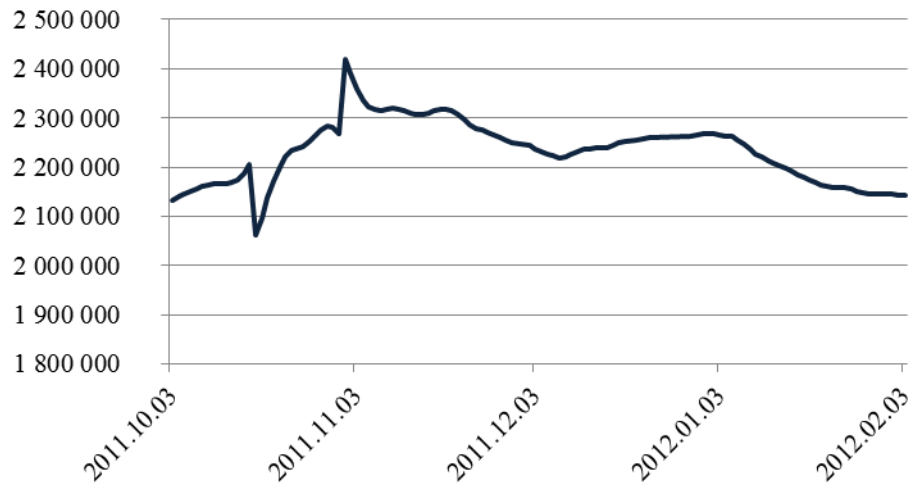


Figure 1. Revenue

Source: drawn by the author

centred moving average. I should note that I only removed the outliers and smoothed the data out after I calculated both revenue and costs. Nevertheless, I do find that this is the appropriate point to illustrate the shifts in revenue. I would also like to draw attention once more to the fact that, since drop rates have not been altered since 2008, the prices alone are responsible for these changes.

6. COSTS

With all the relevant discussion of revenue behind us, we can now turn to analysing costs. As I mentioned in the “Research Methods” section, I will put costs into two different categories: explicit and implicit costs. They show us whether there have been monetary exchanges between two economic agents. However, one can also categorise costs based on how they are influenced by the level of goods produced. We can talk about two different types of costs: fixed and variable costs. Fixed costs are not influenced by the level of production. Variable costs change with the quantity of output produced. My paper also categorises costs according to this logic.

6.1. COST DRIVERS

All items necessary for killing demons are potential cost drivers, even though the effect of some of these is negligible. In this subchapter I am going to introduce all the items.

In our previous discussion of Tormented Demons, it has been established that fighters need food or magic potions to heal their wounds. They have a wide range of options available. Food that gives more life points also tends to be more expensive, but it enables the user to hunt more demons in one round and cuts down on the time spent on transportation and supplying the character with consumable goods. Since these healing items are perfect substitutes, their prices positively correlate, meaning that the choice of food does not influence the result significantly. Due to this property of healing items, I decided that instead of considering all options and making the model exponentially more



Figure 2. Inventory setup

Source: www.runescape.com

complicated, I am going to pick out an efficient inventory setup and work with that. This is illustrated in Figure 2.

Players have 28 inventory spaces so they must carefully consider the items to take. In the preceding discussion, I have already referred to certain items that are indispensable when fighting demons: a sapphire lamp, the Darklight and a second weapon. In my case, this extra weapon is the Chaotic rapier, which has a repair cost of 200,000 gold coins for every ten hours of combat. Considering that it is not the only weapon used during demon killing, I shall resort to calculating with a repair cost of 5000 for an hour of demon slaying. Another cost that has to be taken into account is that of the attack scrolls used for the summoned combat familiar, which also require an inventory spot. Placing the four essential objects in the inventory, there remains room for 24 healing items and stat-boosting potions. For combat skill boosts, I decided to take Overload potions. A dose of Overload grants boosts for five minutes, and each vial can hold up to four doses, so for one hour three vials are needed.

It is strongly advisable to take an Enhanced Excalibur to utilise its life point replenishing special attack. The rest of the healing is covered by eight vials of Saradomin brew, which are capable of restoring 5392 life points, provided the fighter has achieved the maximum of 990 life points. Unfortunately, these brews reduce certain combat skills. This effect can be cancelled out by the use of Super restore potions, four of which is enough for an hour of demon slaying. The remaining eight spaces are filled with Super



Figure 3. Equipment

Source: www.runescape.com

prayer potions that are sufficient for a player to use the highest level prayers for an hour. All of the potions are used up in the hunting process and therefore they contribute to the variable costs.

With the inventory setup done, I move on to picking out the worn gear. There are twelve equipment slots available, each of which has its special purpose. My choice of combat equipment is shown in Figure 3. I would like to start by noting that some of the Diamond bolts (e) are destroyed in the hunting process, so they also belong to the variable costs. The rest of the gear only needs to be purchased once. The expensive armour pieces are the Amulet of fury, the Armadyl chestplate, the Armadyl chainskirt and the Dragon boots. The remaining items are so cheap that their long time effect on costs is negligible.

6.2. EXPLICIT COSTS

Explicit costs always involve some sort of monetary payment. In the aforementioned setup, the Steel of legend scrolls, the Diamond bolts (e) and the potions constitute the explicit costs. One might assume that armour pieces belong here as well, since obtaining them requires serious amount of RuneScape money. The reason why I am not adding them to the explicit costs is that they are liquid items, which can be resold any time. Consequently, their real cost is not their Grand Exchange price, but the opportunity cost of the invested money, which is an implicit cost.

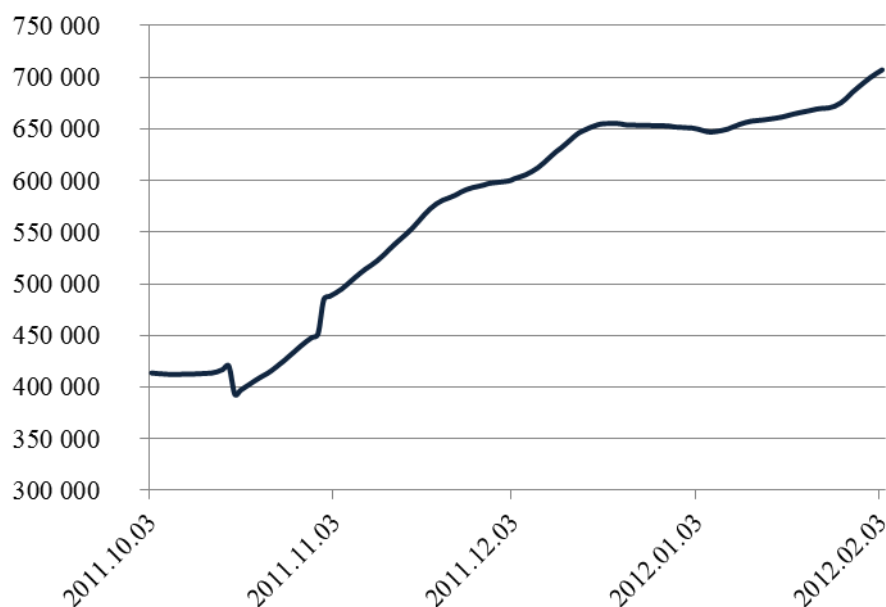


Figure 4. Explicit cost

Source: drawn by the author

In the “Cost Drivers” subchapter I already listed the amount of different items used in demon slaying. To calculate the total cost, I still need their prices. I used the same data mining technique I did when I determined the prices of the drops. I copied data from the HTML code of RuneScape Bits and Bytes and edited them in Excel. I also used moving average smoothing here, the result is illustrated by Figure 4.

6.3. IMPLICIT COSTS

Implicit costs entail no money transactions but they do affect economic profit. In the case of demon slaying, these are forgoing the opportunity cost of money by investing millions into armour and sacrificing the profit that could have been earned by other money-making methods.

6.3.1. Armour

Over the observed time period, boss hunters had an average of 38.3 million gold pieces invested in armour. This seems to be a large amount of money, but how high is its opportunity cost? To answer that question, we have to observe RuneScape’s money market. The opportunity cost of capital is the rate of return that could have been achieved with a similar investment. Similar refers to length and risk both. Investing in armour can be considered an extremely short-term investment, as the market has a high degree of liquidity and the items can be resold at any time. I also consider it to be a safe investment, as the pieces do not amortise and the only way economic agents could lose them would be with their untimely demise at the hand of the demons. However, players automatically keep their three most valuable items upon death and they have ample time to get back to their gravestone and pick up the rest. Ample time means 5–15 minutes depending on the type of the gravestone. For only 50,000 gold coins one can get a gravestone that lasts ten minutes. Getting to Tormented Demons takes less than three minutes.

6.3.2. A Safe Investment

The banks of RuneScape have a misleading name. They do not pay interest on the deposits or extend credit to economic agents. They are more like free deposit boxes. Bonds and treasury bills are also missing from the game. However, there is an item in game whose price is guaranteed by shopkeepers: the spirit shard. They can be sold to pet shop owners for 25 gold pieces each. Spirit shards are used to craft summoning pouches. These pouches can be traded with an ogre who returns 70% of the shards needed to create them, provided the economic agent has the necessary summoning levels. As a result, each pouch

has a guaranteed price of the number of shards received for it multiplied by 25. All players need to do is find a pouch whose Grand Exchange price is lower than its guaranteed price and they earn risk-free money. One might assume that finding a seller is impossible. However, empirical research proves the contrary; pouches are indeed traded under their shard value. The main reason for this is that creating a pouch requires a lower summoning level than swapping them for shards. Of course, there is a catch. The Grand Exchange has certain trading restrictions to prevent price manipulation. One of these is limiting the quantity of items traded. In the case of pouches, this means that out of each type one can buy a maximum of 5000 every four hours. The limited amount of Grand Exchange offer slots also needs to be taken into account. Members can place up to six offers at a time.

I modelled the pouch market with the help of my own RuneScape character. I created a portfolio out of pouches that I consider a good investment based on my years of pouch-trading experience. I assumed that economic agents update their portfolio every 24 hours. This is not too far-fetched, considering that adults leave for work and kids go to school in the morning and most likely have no time to turn on their computers. However, they can doubtless do this in the evening. To keep my chosen portfolio running for a day, one needs 506 million gold pieces. Naturally one can invest with less money. This way the offers will be completed sooner than 24 hours.

I have observed 117 periods and concluded that with 506 million invested one can earn an average of 41512 coins an hour. This equals an hourly return of 0.0082%. However, since one cannot invest more than 506 million, this only constitutes an opportunity cost if the economic agent has less money. If a billionaire decides to take on Tormented Demons then he can have both the 506 million invested and the expensive armour. In this paper I assume that demon slayers do not have free capital. If we multiply the return rate with the millions invested, we can see that the opportunity cost of capital is always between 2000 and 4000 coins an hour. I added this to the variable costs.

6.3.3. Opportunity Cost

In this subchapter I am going to analyse the opportunity costs of demon slaying, which is the money that could have been earned by choosing another vocation. This cost varies based on the levels of the character. There are 25 skills in game, each of which has 99 levels (with the exceptions of constitution and dungeoneering). This research focuses on elite level characters. However, even this definition leaves too many possibilities open for all of them to be included. Instead, I am going to calculate with the opportunity costs of my

nearly maxed character since she has all opportunities available. I am only going to include repetitive activities in the opportunity cost, as tedium premium requires comparison between these and challenging tasks. Contrasting the profitability of different bosses in the game would give no information on tedium premium.

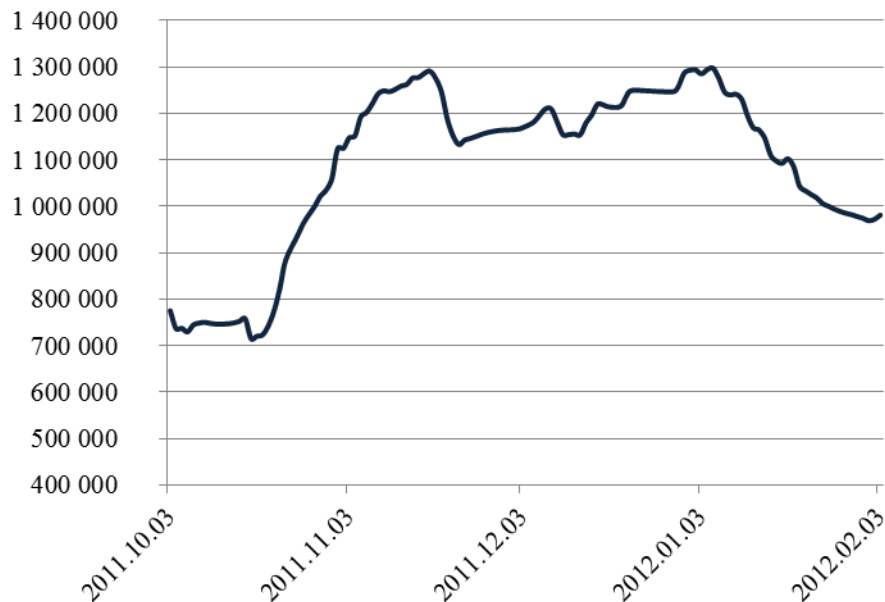


Figure 5. Implicit cost

Source: drawn by the author

I have examined the profit turned by eight methods of accumulating wealth, all of which are claimed to be “the best money-making method in game”. The maximum of these gave me the opportunity cost of demon slaying. Figure 5 illustrates the magnitude of the opportunity cost. It is noteworthy that the implicit costs are always considerably higher than the explicit costs. On average they are twice as high. This suggests that there will be a significant difference between accounting and economic profit.

7. PROFIT

In the previous chapters we have learned how the revenue and the costs of demon slaying have changed due to the elimination of bots. In possession of that information we can now look at the profit. Figure 6 illustrates how accounting profit changed over the observed time interval. This is the profit type most RuneScape players are familiar with, what they reveal in their money-making guides. We can see that even though it has decreased significantly as expected, it has never gone under 1.2 million. But is this good or bad? Unfortunately this number does not reveal that information. To learn something about tedium premium, we have to look at economic profit. Figure 7 illustrates the shifts in economic profit: although it has decreased, it is still significantly higher than zero.

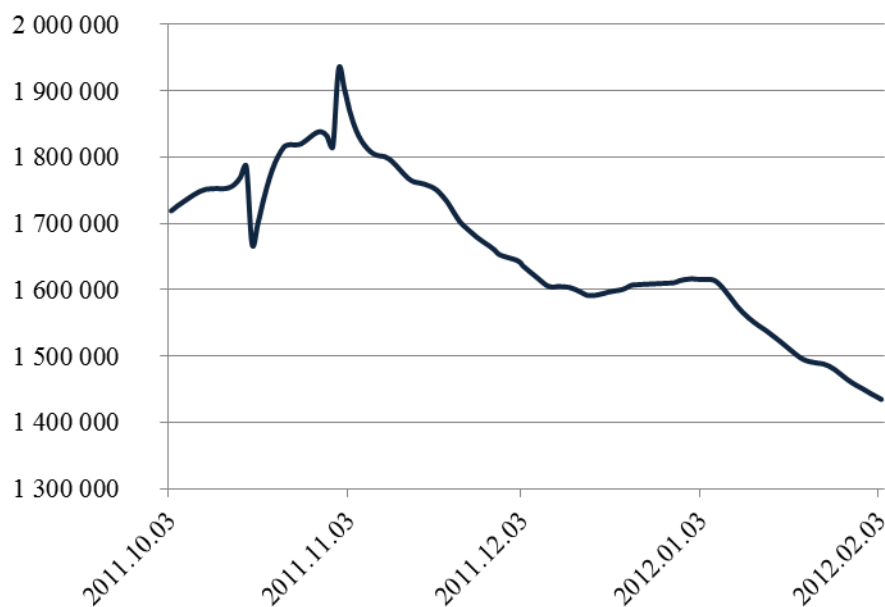


Figure 6. Accounting profit

Source: drawn by the author

As I promised in the “Calculating Revenue” subchapter, I will analyse how the drop rate of the Dragon claws and the number of demons slain affects the profit. If the drop rate of the Dragon claws were on the lower end of the confidence interval, or 0.25%, then the average of economic profit turned in the observed period would be little less than 0, assuming 30 kills. However, it would be significantly positive with 31 kills. Now let’s go back to calculating with the sample proportion, which is 0.37%, and have a look at the influence of the number of demons slain. So far we operated under the assumption that the gamer is capable of slaying 30 demons. But what happens if the person behind the computer is not that skilled? My calculations show that the mean of profit turned in the ob-



Figure 7. Economic profit

Source: drawn by the author

served time period is around zero if one kills 22 demons, whereas it becomes significantly positive with 23 killed and significantly negative if 21 are slain each hour. Getting 22 kills is not that hard to achieve. Therefore even clumsier hunters can achieve a significantly positive economic profit. The implications of this will be discussed in the next chapter.

8. EXPLAINING POSITIVE ECONOMIC PROFIT

I have mentioned that in perfect competition, it is impossible to earn economic profit in the long run. So what causes this profit? Are we looking at an oligopolistic situation or have the economic agents had too little time to enter the market? I dedicate Chapter 8 to answering these questions.

8.1. BARRIERS TO ENTRY

To kill Tormented Demons hunters not only need to have high combat skills, but they are also required to complete the grandmaster quest While Guthix Sleeps. This quest requires high skill levels, 76 other quests and 270 quest points. These constitute high barriers to entry. I will examine just how high they are in the coming few subchapters and I will also explain why they can be considered barriers.

8.1.1. Quest Requirements

Quests can be categorised according to the time it takes to complete them. The Runescape Wiki has the following length categories: very short, short, short-medium, medium, medium-long, long, long-very long and very long, which I valorise as 5, 10, 15, 20, 40, 60, 180 and 300 minutes respectively. Based on these categories, I estimated the time it takes to do all the quests required for Tormented Demons. Altogether they take about 56.58 hours to complete.

The quests specifically required for While Guthix Sleeps only reward the adventurer with 138 quests points whereas 270 are mandatory. Consequently players need to complete an additional 138 points worth of quests. The quests that are not prerequisites require an average of 14.7 minutes of work per quest point. As a result, one needs 32.34 hours of adventuring for 138 quest points. Adding this to the hours spent with the specific requirement quests, we can conclude that Tormented Demons have a precondition of 88.92 hours spent on quests.

8.1.2. Skill Requirements

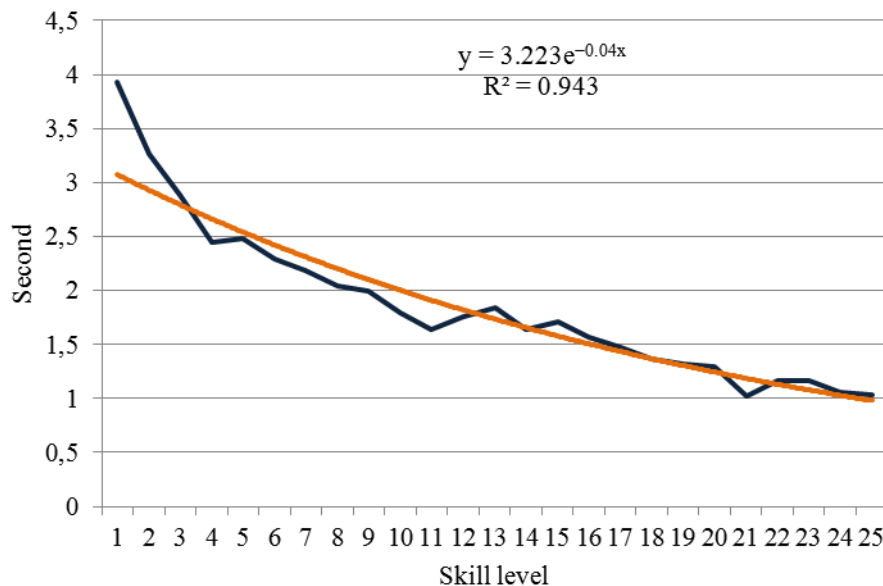
The skill requirements and my estimations of the time and money needed to achieve them are shown in Table 2. In most skills, these can be calculated without going beyond the four basic mathematical operations. One needs to find a training method available at the given skill level, look up the experience requirements, measure the speed and find the prices of the input and the output. I calculated costs using Bot Nuke Day prices.

Table 2. Skill requirements

Skill	Level required	Time (hour)	Money made
Agility	56	11.36	0
Construction	40	1.25	-240 009
Cooking	70	3.92	55 925
Crafting	61	3.41	-281 936
Farming	65	14.01	5 956 957
Firemaking	50	1.17	-25 188
Fishing	62	13.71	0
Fletching	30	2.87	31 705
Herblore	65	3.61	-3 792 486
Hunter	55	10.29	188 847
Magic	75	10.99	248 054
Mining	60	8.25	0
Prayer	55	4.09	-1 041 400
Ranged	90	42.99	0
Runecrafting	35	1.28	-58 052
Slayer	56	0.00	0
Smithing	54	3.87	-448 578
Summoning	23	0.40	122 643
Thieving	60	5.30	0
Woodcutting	55	10.88	41 017
Melee skills	90	128.98	0
Sum		282.63	757 499

Source: edited by the author

The only skills that were a bit trickier to calculate were the combat skills. Their speed changes with every level and I had no time or desire to level a character from level 1 to 90 in the skills of attack, strength, defence and ranged. What I did instead was to create

**Figure 8. The trend of seconds it takes to earn an experience point**

Source: drawn by the author

a new character, then I measured the time it took to gain each of the first 26 levels, calculated the seconds it takes to get an experience point and put an exponential trend on it. This is illustrated in Figure 8. Using the trend, I could estimate the time it takes to advance further levels. The results were consistent with what I experienced when I trained my nearly-maxed character.

8.2. DISCUSSION

In the previous subchapters I calculated that getting all the quest requirements takes 88.92 hours, while gaining the skill levels takes 282.63 hours. These constitute an overall requirement of 371.55 hours of gameplay. Tormented Demons have been part of the game since November 26th 2008. Assuming players spend an average of one hour a day online they still had enough time to gain all the requirements and enter the market. Consequently, we can say that we are talking about positive economic profit in the long run. This can only mean one thing: the market is not perfect.

Michael Parkin lists five things that define perfect competition: “There are many firms, each selling an identical product. There are many buyers. There are no restrictions on entry into the industry. Firms in the industry have no advantage over potential new entrants. Firms and buyers are completely informed about the process of the products of each firm in the industry” (Parkin 1994. p. 280.). A number of these conditions are indeed true in the case of the RuneScape economy. Sellers and buyers are present in large numbers, the products are homogeneous. However, there is no perfect information. Economic agents know the previous equilibrium prices of goods from the Grand Exchange database, but they have no information on the current conditions. Furthermore, the requirements for killing Tormented Demons constitute high barriers to entry. Last year, the average of the examined opportunity costs was around a million coins per hour. Even though a new character’s opportunity costs are lower, she still has to forgo millions if she decides to become a demon hunter. What is more, she has to do this in the beginning of her gaming life. But why would this prevent further potential hunters from entering the market? There is positive economic profit waiting to be earned, surely one more hunter would not cause it to disappear completely. Are economic agents of a virtual world not trying to maximise their profit?

8.2.1. Fisher Separation Theorem

Basic microeconomics tells us that consumers maximise their utility and firms maximise their profit. But what happens when the consumer and the “firm” is the same person? In

theory, the consumer's utility and the firm's profit can be separated from each other, as posited by the Fisher separation theorem. This theorem tells us that if the interest rate paid for credit is the same as the interest rate received on deposit, then the firm's investment and financing decisions are separate from each other and the owner's preferences. I would like to draw attention to the conditions needed for this to apply. Banks need to extend credit and take deposits on the same interest rate. In the world of RuneScape none of these exist.

Due to the fact that banks do not extend credit, the Fisher separation theorem does not apply. In a world where no interest rate exists, the owner's preferences greatly influence the firm's decisions. In the case of demon slaying, both the "owner" and the "firm" is the game player who performs this activity. Should this player value present consumption more than she does future consumption, she will not enter a market that requires immediate investment and offers zero economic profit when she has other alternatives. This is the reason why the requirements for demon slaying can indeed be considered barriers to entry. Players have to spend hundreds of hours developing their characters during which they do not earn enough to buy highly desired items. If an economic agent is impatient (values present consumption really high) then she will refuse to do this. Even if all players were indifferent to the time when they buy items, the time when they could not consume would still have to be compensated for. Demon slaying has to reimburse economic agents for the utility loss its requirements cause.

I assume that all players have their unique preferences. Some are more impatient than others. There are ones who value present consumption so high that even in a bot-infested world they chose to do repetitive tasks. Assuming they did not participate in real-money trading, they are definitely better off with macros being banned from the game. There are gamers who are somewhat more patient and have already started training to become a boss hunter, but will never finish because of the increased opportunity costs. In their case, the requirements they already earned are sunk costs. They cannot get them back, no matter what they do, therefore it does not influence their decision. The players who are indifferent to consuming now or later will still become demon slayers to enjoy the positive economic profit it offers. The players who earned all the requirements before Bot Nuking Day will stay in the market regardless of their preferences. Their previous training is also a sunk cost; the decision is solely influenced by the positive economic profit.

8.2.2. Another Possible Explanation

Another thing that has to be considered is how risky these activities are. Risk tells us how the amount of money earned varies, and it is defined as the standard deviation of the return. Based on their relationship to risk, economic agents can be risk-averse, risk-neutral or they can even be risk-lovers. In finance models it is generally assumed that investors are risk-averse and they get risk premium for taking on the risk.

I would not go as far to state that the average RuneScape player is risk-averse. The game has so widespread gambling problems that creators were forced to remove the frequently abused dice-bag from the game. Instead, they added a strange version of the wheel of fortune that every member gets to spin twice a day free of charge. However, certain clans still make enormous amounts of money by hosting games and playing the role of the house that always wins.

It seems reasonable to assume that players are not that sensitive about losing items when they are only virtual. In real life, people would not risk all their money on a round of heads or tails, but game characters cannot become homeless or go hungry just because their banks show a smaller amount of yellow pixels. Determining the community's relationship towards risk requires further investigation. Its results would tell us whether demon hunters require a risk premium for their choice of vocation.

9. CONCLUSION

In this paper I compared different ways an economic agent can make game gold. I categorised them into repetitive and challenging and I set out on a mission to see if monotonous tasks compensate boredom-averse economic agents for the utility loss they cause. My main hypothesis was that in a macro-infested world tedium premium cannot exist, but it can in a bot-free state of the economy. I decided to examine this in the case of elite level players. I did this by picking out one of the most challenging activities in RuneScape, Tormented Demon hunting, and comparing it to other money-making methods.

As expected, I found that before Bot Nuke Day slaying Tormented Demons was incredibly lucrative, with a significantly positive economic profit. Even though this profit decreased after macros disappeared from the game, it still remained significantly positive. Even zero profit would have been enough to disprove the existence of tedium premium in the case of elite level players, but this result also suggests that it is the demon slaying that gets some sort of premium.

I considered two possibilities that could cause this: the high standard deviation of return on demons, known as risk, and the effect of the players' personal preferences on their virtual career choice. As the first explanation is only a theory, it requires more research and could be the topic of a separate paper. However, there is no further investigation needed to prove that banks do not extend credit in the game which effectively means that the Fisher separation theorem does not apply.

Even though this paper showed that elite level gamers do not get a premium for choosing to do repetitive tasks over challenging ones, this does not disprove tedium premium's existence completely. One could examine the profitability of activities available to low and medium level players. In their case barriers to entry are not that high. Therefore, if the high requirements are the only thing that influence tedium premium in a bot-free state then analysing the choices of a medium level player could reveal this.

Since I chose to examine a small section of the player base I cannot draw conclusions regarding previous hypotheses that refer to the gamer society as a whole. The scope of my research is simply not wide enough to be commensurable with them. All I can disprove is Huhh's statement of real money trading being a Pareto improvement of MMORPGs. I found that impatient players who are net sellers of items produced by bots are better off in a macro-free world, consequently real world trading cannot be Pareto-improving.

I would like to sum up by directly answering all my research questions. I could not prove or disprove the existence of tedium premium for the whole of the player base, but it definitely does not exist in the case of elite level players. However, I was able to show that new players' decision to enter the market depends on their preferences regarding the time of consumption. Players who were indifferent to entering the market in the time of macros would not enter now, as economic profit, which is the compensation for their initial utility loss, has decreased. Nevertheless, more patient gamers still have the incentive to start getting all the requirements. Hunters who have already entered the market should stay regardless of preferences as in their case the initial utility loss is a sunken cost, it cannot be recovered. Now if you'll excuse me, I have some demons to torment.

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APPENDIX

1. APPENDIX: DATA SMOOTHED OUT WITH A CENTRED MOVING AVERAGE

Date	Revenue	Explicit Cost	Implicit Cost	Accounting Profit	Economic profit
2011.09.26	2 060 822	415 411	1 592 304	1 645 411	53 107
2011.09.27	2 061 145	415 274	1 143 125	1 645 871	502 745
2011.09.28	2 061 809	417 819	873 728	1 643 990	770 261
2011.09.29	2 062 383	419 319	627 822	1 643 064	1 015 242
2011.09.30	2 089 036	422 033	627 185	1 667 003	1 039 818
2011.10.01	2 130 830	422 080	639 773	1 708 750	1 068 977
2011.10.02	2 165 330	418 610	649 608	1 746 720	1 097 112
2011.10.03	2 178 291	412 966	653 734	1 765 325	1 111 591
2011.10.04	2 181 181	407 548	645 178	1 773 633	1 128 455
2011.10.05	2 175 855	411 743	653 188	1 764 112	1 110 924
2011.10.06	2 168 017	408 783	649 624	1 759 234	1 109 610
2011.10.07	2 165 101	407 236	648 288	1 757 865	1 109 577
2011.10.08	2 164 398	410 294	644 904	1 754 104	1 109 201
2011.10.09	2 161 993	409 374	641 335	1 752 619	1 111 284
2011.10.10	2 164 368	407 315	938 614	1 757 053	818 440
2011.10.11	2 156 973	407 372	1 014 524	1 749 601	735 078
2011.10.12	2 147 043	409 564	1 154 295	1 737 479	583 184
2011.10.13	2 143 827	411 917	754 800	1 731 910	977 110
2011.10.14	2 148 297	418 219	849 699	1 730 078	880 379
2011.10.15	2 162 682	425 046	689 697	1 737 636	1 047 939
2011.10.16	2 178 434	423 255	666 058	1 755 179	1 089 120
2011.10.17	2 181 337	420 611	611 108	1 760 726	1 149 619
2011.10.18	2 183 593	415 720	632 059	1 767 873	1 135 814
2011.10.19	2 184 238	413 800	647 661	1 770 438	1 122 777
2011.10.20	2 202 357	415 757	658 088	1 786 600	1 128 512
2011.10.21	2 263 835	426 832	680 776	1 837 003	1 156 227
2011.10.22	2 357 120	442 571	699 493	1 914 549	1 215 056
2011.10.23	2 460 366	460 033	728 441	2 000 333	1 271 892
2011.10.25	2 676 165	466 508	1 016 734	2 209 657	1 192 923
2011.10.26	2 763 626	465 297	1 059 136	2 298 329	1 239 193
2011.10.27	2 678 655	466 822	1 442 561	2 211 833	769 272
2011.10.28	2 562 365	466 080	1 248 245	2 096 285	848 041
2011.10.29	2 454 879	468 506	1 585 815	1 986 373	400 558
2011.10.30	2 352 943	477 786	1 586 253	1 875 157	288 905

Date	Revenue	Explicit Cost	Implicit Cost	Accounting Profit	Economic profit
2011.10.31	2 257 266	485 537	1 093 775	1 771 729	677 954
2011.11.01	2 248 159	492 295	953 523	1 755 864	802 340
2011.11.02	2 318 945	489 941	1 029 290	1 829 004	799 714
2011.11.03	2 361 724	488 384	939 973	1 873 340	933 367
2011.11.04	2 374 865	492 862	925 542	1 882 003	956 461
2011.11.05	2 367 577	497 922	1 012 786	1 869 655	856 870
2011.11.06	2 322 931	504 377	897 896	1 818 554	920 658
2011.11.07	2 269 413	507 439	1 094 767	1 761 974	667 207
2011.11.08	2 265 151	507 520	981 194	1 757 631	776 437
2011.11.09	2 262 066	509 577	1 021 084	1 752 489	731 405
2011.11.10	2 277 853	513 925	1 399 560	1 763 928	364 368
2011.11.11	2 343 815	523 177	1 506 402	1 820 638	314 236
2011.11.12	2 376 840	537 408	1 858 689	1 839 432	-19 257
2011.11.13	2 365 384	545 904	1 728 002	1 819 480	91 478
2011.11.14	2 314 030	550 778	1 867 135	1 763 252	-103 883
2011.11.15	2 276 956	553 237	1 412 727	1 723 719	310 992
2011.11.16	2 286 951	550 582	1 055 575	1 736 369	680 794
2011.11.17	2 304 918	554 053	1 000 385	1 750 865	750 480
2011.11.18	2 310 962	565 603	1 015 482	1 745 359	729 876
2011.11.19	2 313 738	577 632	1 033 740	1 736 106	702 366
2011.11.20	2 315 278	579 963	1 066 123	1 735 315	669 192
2011.11.21	2 318 000	580 907	1 101 825	1 737 093	635 268
2011.11.22	2 319 495	584 202	1 114 079	1 735 293	621 214
2011.11.23	2 317 631	592 786	1 111 020	1 724 845	613 825
2011.11.24	2 306 909	605 308	1 093 513	1 701 601	608 088
2011.11.25	2 298 390	611 892	1 160 668	1 686 498	525 829
2011.11.26	2 291 817	607 904	1 066 277	1 683 913	617 636
2011.11.27	2 277 343	604 562	997 629	1 672 781	675 152
2011.11.28	2 201 236	594 934	1 180 155	1 606 302	426 147
2011.11.29	2 145 163	584 345	1 582 668	1 560 818	-21 850
2011.12.02	2 183 439	587 658	1 560 733	1 595 781	35 048
2011.12.03	2 218 174	598 412	1 106 917	1 619 762	512 845
2011.12.04	2 234 145	593 528	1 067 935	1 640 617	572 682
2011.12.05	2 245 259	593 733	1 085 557	1 651 526	565 969
2011.12.06	2 245 058	596 108	1 088 171	1 648 950	560 779
2011.12.07	2 237 346	601 534	1 104 729	1 635 812	531 083
2011.12.08	2 226 603	605 227	1 131 488	1 621 376	489 888
2011.12.09	2 220 786	615 101	1 147 542	1 605 685	458 143

Date	Revenue	Explicit Cost	Implicit Cost	Accounting Profit	Economic profit
2011.12.10	2 223 507	624 549	1 158 950	1 598 958	440 009
2011.12.11	2 224 501	633 813	1 177 996	1 590 688	412 692
2011.12.12	2 226 731	644 440	1 268 441	1 582 291	313 850
2011.12.13	2 225 653	652 824	1 280 275	1 572 829	292 554
2011.12.14	2 227 649	657 949	1 203 972	1 569 700	365 728
2011.12.15	2 229 542	665 811	1 179 272	1 563 731	384 459
2011.12.16	2 242 392	664 150	1 171 367	1 578 242	406 875
2011.12.17	2 253 328	665 284	1 144 911	1 588 044	443 133
2011.12.18	2 267 937	664 343	1 102 424	1 603 594	501 171
2011.12.20	2 263 630	667 926	1 091 123	1 595 704	504 581
2011.12.21	2 256 428	670 749	1 056 906	1 585 679	528 773
2011.12.22	2 245 258	662 093	1 469 830	1 583 165	113 335
2011.12.29	2 272 484	643 217	1 362 747	1 629 267	266 521
2011.12.30	2 285 648	643 544	1 481 213	1 642 104	160 891
2011.12.31	2 282 297	646 856	1 125 603	1 635 441	509 838
2012.01.01	2 277 133	642 715	1 094 866	1 634 418	539 552
2012.01.02	2 275 304	638 799	1 191 361	1 636 505	445 145
2012.01.03	2 271 481	636 724	1 590 845	1 634 757	43 912
2012.01.04	2 264 865	637 535	1 474 961	1 627 330	152 369
2012.01.05	2 263 013	643 232	1 159 301	1 619 781	460 480
2012.01.06	2 261 601	651 453	1 343 718	1 610 148	266 430
2012.01.07	2 265 153	659 067	1 603 617	1 606 086	2 468
2012.01.08	2 261 335	659 366	1 244 115	1 601 969	357 854
2012.01.09	2 255 313	659 936	1 119 026	1 595 377	476 351
2012.01.10	2 242 145	651 391	957 837	1 590 754	632 918
2012.01.11	2 231 341	645 157	1 191 701	1 586 184	394 483
2012.01.12	2 213 984	645 764	1 522 532	1 568 220	45 688
2012.01.13	2 179 350	650 462	1 049 448	1 528 888	479 440
2012.01.14	2 149 734	659 344	1 026 346	1 490 390	464 043
2012.01.15	2 137 836	667 885	1 027 151	1 469 951	442 800
2012.01.16	2 137 874	676 684	1 117 575	1 461 190	343 615
2012.01.17	2 168 250	673 371	1 026 432	1 494 879	468 447
2012.01.18	2 177 262	663 735	1 059 693	1 513 527	453 834
2012.01.19	2 179 588	656 868	1 088 801	1 522 720	433 920
2012.01.20	2 179 007	652 968	1 084 642	1 526 039	441 396
2012.01.21	2 182 668	659 315	1 068 007	1 523 353	455 346
2012.01.22	2 176 851	670 129	1 067 408	1 506 722	439 314
2012.01.23	2 173 483	672 926	1 053 451	1 500 557	447 105

Date	Revenue	Explicit Cost	Implicit Cost	Accounting Profit	Economic profit
2012.01.24	2 165 663	675 291	1 048 427	1 490 372	441 945
2012.01.25	2 154 838	671 703	1 100 711	1 483 135	382 425
2012.01.26	2 146 615	668 131	934 809	1 478 484	543 674
2012.01.27	2 136 445	666 030	901 329	1 470 415	569 086
2012.01.28	2 131 096	667 723	898 417	1 463 373	564 956
2012.01.29	2 136 379	677 300	907 933	1 459 079	551 147
2012.01.30	2 133 402	687 324	912 057	1 446 078	534 021
2012.01.31	2 129 091	687 317	937 009	1 441 774	504 765
2012.02.01	2 121 950	678 739	940 967	1 443 211	502 243
2012.02.02	2 120 669	687 987	969 650	1 432 682	463 031
2012.02.03	2 123 390	703 628	1 010 473	1 419 762	409 290
2012.02.04	2 146 731	725 048	1 026 599	1 421 683	395 084
2012.02.05	2 176 814	744 452	1 020 914	1 432 362	411 449
2012.02.06	2 175 768	743 926	1 008 092	1 431 842	423 750
2012.02.07	2 170 812	744 037	994 398	1 426 775	432 377
2012.02.08	2 155 991	742 494	972 338	1 413 497	441 159
2012.02.09	2 141 295	730 742	1 143 784	1 410 553	266 768
2012.02.10	2 129 984	721 779	1 072 014	1 408 205	336 191