Loot Distribution Systems in Massively Multiplayer Online Role-Playing Games: A study in the context of World of Warcraft

Nikolaos Kanellis

A dissertation submitted in partial fulfillment of the requirements for the degree of Master of Science in Applied Economics & Data Analysis

School of Business Administration
Department of Economic Science

Master of Science in “Applied Economics and Data Analysis”

September 2018
University of Patras, Department of Economics

Kanellis Nikolaos

© 2018 - All rights reserved

World of Warcraft and Warcraft are trademarks or registered trademarks of Blizzard Entertainment, Inc., in the U.S. and/or other countries.
Three-member Dissertation Committee:

Research Supervisor: Tsagarakis Manolis Assistant Professor
Committee Member: Giannakopoulos Nicholas Assistant Professor
Committee Member: Dimara Efthalia Professor

The present dissertation entitled:

“Loot Distribution Systems in Massively Multiplayer Online Role-Playing Games: A study in the context of World of Warcraft”

was submitted by Nikolaos Kanellis, SID 1063745, in partial fulfillment of the requirements for the degree of Master of Science in «Applied Economics & Data Analysis» at the University of Patras and was approved by the Dissertation Committee Members.
This dissertation is dedicated to the many international friends I made through online platforms like MMORPGs over the years, for they cemented my belief that when people set their racial, sexual, political, religious, and socioeconomic differences aside, they are only left with a shared passion to live, learn, explore, compete, and thrive together.
Acknowledgements

I would like to thank my supervisor Manolis Tsagarakis, who encouraged me to work on an original and relatively unexplored topic, provided me with useful resources, and supported me with enthusiasm, patience and understanding throughout the research and authoring process.

I would also like to extend my thanks to the other members of the teaching staff in the Applied Economics and Data Analysis MSc program, for introducing me to a plethora of up-to-date analytical methods, techniques and tools, and for significantly expanding my economic, financial and statistical knowledge, thus laying a solid academic foundation to build my professional career upon.
Abstract

Modern online games feature pre-designed virtual worlds that players navigate to pursue their goals. In World of Warcraft, one of the most popular Massively Multiplayer Online Role-Playing Games, players from different geographic regions navigate the same virtual world and interact with each other, forming large groups called guilds to overcome the hardest challenges the game has to offer. The question of how to distribute the rewards of these challenges (loot in game parlance) is one of the most interesting issues in that context, and players have developed several loot distribution systems to resolve it in a mutually acceptable and effective way.

In this dissertation we examine some of these systems from the perspective of virtual economics theory, and we attempt to evaluate and compare their impact on the guilds’ performance, using a simulation process to expand on the available literature.

Keywords: virtual economies, online gaming, MMORPGs, simulation
Περίληψη

Τα σύγχρονα διαδικτυακά παιχνίδια προσφέρουν προσχεδιασμένους εικονικούς κόσμους, μέσα στους οποίους οι παίκτες πλοηγούνται και προσπαθούν να επιτύχουν τους στόχους τους. Στο World of Warcraft, ένα από τα δημοφιλέστερα Μαζικά Διαδικτυακά Παιχνίδια Ρόλων Πολλαπλών Παικτών, παίκτες από διαφορετικές γεωγραφικές περιοχές συνυπάρχουν και αλληλεπιδρούν μέσα στον ίδιο εικονικό κόσμο και σχηματίζουν μεγάλες ομάδες που αποκαλούνται guilds, με σκοπό να υπερνικήσουν τις δυσκολότερες προκλήσεις που προσφέρει το παιχνίδι.

Ο τρόπος με τον οποίο τα guilds μοιράζουν τις ανταμοιβές (λάφυρα) που αποκτούν από αυτές τις προκλήσεις στα μέλη τους αποτελεί ένα από τα πιο ενδιαφέροντα θέματα στο πλαίσιο αυτών των παιχνιδιών, και οι παίκτες έχουν διαμορφώσει διάφορα συστήματα κατανομής λαφύρων για να το αντιμετωπίσουν με αποδεκτό και αποτελεσματικό τρόπο.

Στην παρούσα διπλωματική εργασία εξετάζουμε κάποια από αυτά τα συστήματα από τη σκοπιά της θεωρίας των εικονικών οικονομικών, και προσπαθούμε να αξιολογήσουμε και να συγκρίνουμε την επιδρασή τους στην απόδοση των guilds, χρησιμοποιώντας μια διαδικασία προσομοίωσης σε συνδυασμό με την ήδη υπάρχουσα βιβλιογραφία.

Λέξεις κλειδιά: εικονικές οικονομίες, διαδικτυακά παιχνίδια, MMORPGs, προσομοίωση
Contents

Acknowledgements 5
Abstract 6
Περίληψη 7
Contents 8
List of Figures 10
List of Tables 11

1. Introduction 12
   1.1. Virtual worlds and economic research 18
   1.2. Introduction to MMORPGs 24
      World of Warcraft 26
      Basic concepts and how they mirror the real world 30
   1.3. Research question: the issue of loot distribution 37

2. Theoretical Background 40
   2.1. Virtual capital, goods and economic systems 40
      In-game items as virtual goods 42
      Guilds as virtual institutions 48
      Loot distribution systems as virtual economies 50
   2.2. Literature review 51
      Player Archetypes: Richard Bartle - University of Essex 51
      Virtual Economies: Edward Castronova - Indiana University 52
      Virtual Capital: Vili Lehdonvirta - University of Oxford 54
      Sociology: Nicolas Ducheneaut - Palo Alto Research Center 54
      Loot Distribution: Dario Maggiorini - University of Milano 55
      Player Roles: Dmitri Williams - University of Illinois 55
      Motivations for play: Nick Yee - University of Stanford 56

3. Loot Distribution Systems in practice 57
   3.1. Arbitrary systems 59
      Loot council 60
   3.2. Priority based systems 62
      Suicide kings 63
   3.3. RNG based systems 64
      Simple roll 65
      Karma roll 66
   3.4. Point based systems 67
      Simple fixed-price DKP 68
      Spend-all DKP 72
      Spend-enough DKP 73
Zero-sum DKP 74
Relational DKP (EPGP) 78
Auction Bidding DKP systems 80
3.5. Personal Loot 82

4. **Empirical Methodology: Simulation** 84

4.1. Assumptions, constraints and available data 84
   - The guild 85
   - The players 90
   - The items 92
   - The loot systems 93
   - The raid progression 93

4.2. Description of the simulation process 94

4.3. Performance metrics 96

4.4. Analysis and presentation of results 97
   - Raid Strength Gain 100
   - Core player strength gain 104
   - Regular and casual player strength gain 104
   - Standard Deviation of power levels 105

5. **Conclusions and future work** 106

**References** 109

**Appendix** 116

- Simulation: Code in Python 116
- Result Analysis: Code in Stata 125
List of Figures

Fig. 1: The “Obama for President” HQ inside the Second Life virtual world 14
Fig. 2: The original World of Warcraft logo 26
Fig. 3: A gameplay still from WoW 28
Fig. 4: A female Troll hunter wielding a gun, an example of a player avatar 29
Fig. 5: A guild recruitment message 36
Fig. 6: A WoW character's full equipment, comprising of in-game items 43
Fig. 7: A WoW guild roster interface 49
Fig. 8: The pooled OLS model 98
Fig. 9: Raid strength gain over time, per system chosen. 103
List of Tables

Table 1: Roles by attendance level. 88
Table 2: Classes by attendance level. 89
Table 3: Coefficients for LDS choice per metric (pooled OLS model) 100
1. Introduction

Some of the greatest scientific advances in history were achieved through experiments and observations in controlled artificial environments. Ever since the Large Hadron Collider was first set in motion, physicians have been unlocking the mysteries of the Standard Model of physics by uncovering the elusive Higgs Boson. Biologists all over the world are painstakingly working every day in laboratories, making breakthroughs as a result of *in vitro* research. The benefits of such controlled artificial environments are obvious: insulation from outside forces that could interfere with the quality of the observations, and the uninhibited ability to control and measure every aspect of the experiment or the phenomenon under observation.

When it comes to social sciences like economics, however, any such attempt to observe human behaviour in a constrained and controlled environment is admittedly a much more complicated affair. Economists sometimes attempt to examine economic phenomena in relatively small and constrained, lab-like domains, like the premises of a small village or a geographically remote area, but outside influence can still be hard to avoid entirely. As for their measurements, they usually rely on the quality and trustworthiness of the data collection agents, which can be prone to all kinds of problems, from simple human error and bias, to intentional misreporting. The real, physical world is hard to constrain and measure...
The good news is that, in recent years, the real world is not the only one where people spend time with each other! With the advent of powerful personal computers and widely available fast internet connection, *virtual worlds* have become a reality. In a nutshell, virtual worlds are computer created environments that people can access through a computer connected to a network. In these worlds, the real people sitting behind the computer are represented by a virtual entity which might or might not bear their likeness. Through that entity, which is commonly called an *avatar*, they interact with the environment and with other avatars in real time. The first virtual worlds were created for gaming purposes (Downey, 2014), but nowadays companies like Dell, Cisco, Xerox and Nissan have virtual storefronts within virtual worlds like *Second Life* (Bray and Konsynski, 2006), or use them as virtual workspaces (like Sococo - [https://www.sococo.com/](https://www.sococo.com/)), and even well-known political figures like Barack Obama have actually campaigned for a virtual audience (see fig. 1) in order to be elected in the real world! (Wheaton, 2007).

The more sophisticated among these worlds also feature computer generated items that can be interacted with, owned, traded and consumed by the avatars. By definition, being pieces of code, these computer-generated items could practically be created once and then replicated indefinitely by the developers of the virtual worlds,
Fig. 1: The “Obama for President” headquarters inside the Second Life virtual world. Notice the realistic elements of the environment and the anthropomorphous avatars interacting. Photo by Dan Sklarew. (Wheaton, 2007)

but either unintentionally or by design, some of these items end up being scarce, as in their supply ending up less than their demand by the avatars inside the virtual worlds. As V. Lehdonvirta and E. Castronova point out in their major work in this field, *Virtual Economies: Design and Analysis* (2014), which will be a main starting point of discussion throughout this dissertation, a set of scarce resources and a group of people interacting with them by means of producing, storing, trading and consuming them are the two necessary ingredients of what we call an economy. The notion of choice under scarcity can actually be recognised on an even more
abstract level than resources or objects: as Castronova notes in his earlier work *Synthetic worlds: The business and culture of online games* (2008), since time itself is the quintessential scarce resource for any human being, “choice under scarcity happens whenever a human decides what to do”. Hence, he argues that an economy is not something that has to be created and inserted in a virtual world so that it resembles the real one more, but it rather exists by default, since people will have to constantly make essentially economic decisions on how to spend their available time inside said world. Under this light, other scarce resources like valuable objects or virtual currency can be seen as a mere convenience that allows us to quantify investments in time spent.

Going back to our earlier observations about research in a controlled environment, we begin to acknowledge that virtual worlds could potentially be the laboratory environment that economic scientists have longed for: they are neatly separated from the outside world, since the only things that can exist in them are whatever their developers allowed to be able to exist in the first place, and any external influence can be tracked and moderated, while they also lend themselves to readily accessible and accurate measurement and assessment, as everything that happens in these worlds leaves a digital trace, also known as a log in programming parlance. At any moment, the creators of these worlds can ostensibly change the available quantity of any resource in these worlds by adjusting its scarcity, allowing an economic researcher to experiment and to
observe changes in the economic behavior of the agents within that economy (the human-controlled avatars) and evaluate the success or failure of his policies at a glance (Bray and Konsynski, 2006). The more prevalent these worlds become, the more economic activity they are bound to attract, both virtual and conventional.

In this dissertation, we focus on a specific kind of virtual worlds called Massively Multiplayer Online Role-Playing Games (MMORPGs). These worlds feature avatars (which in that context are more commonly referred to as characters or adventurers), that interact with each other and the environment, and they collaborate within large groups (called guilds) in order to overcome challenges and defeat A.I.-controlled enemies created by the games’ developers. We demonstrate that the rewards (loot) from these encounters display every characteristic of a scarce resource in the context of the game’s economy. Therefore, we argue that the act of distributing these rewards in a way that is accepted by the members of these groups is an economic act akin to the enforcement of fiscal policy, and that the sets of rules that the players developed over time to facilitate this distribution of rewards, referred to from now on as loot distribution systems, are an example of an economic system forming by sheer necessity, in a manner similar to the way laws, societal norms and economic systems developed and gradually became more sophisticated in primitive and archaic human communities. As Bray and Konsynski (2006) excitedly point out, researchers rarely have this opportunity to watch such systems emerge endogenously with the potential to succeed or fail.
Before the end of this first chapter we will attempt to elaborate more on the topics of virtual economics and MMORPGs, we will provide definitions for common terms in these fields, and we will introduce the reader to World of Warcraft, the MMORPG that we will use as a reference point for our study. At the end of the chapter we will try to explain what makes loot distribution in MMORPGs an interesting issue from an economic researcher’s point of view.

In the second chapter we examine the theoretical foundation of this dissertation, by first introducing the concepts of virtual economies, virtual capital, virtual goods and virtual institutions, and then by associating them with aspects of MMORPGs like in-game items, guilds and loot distribution systems.

In the third chapter we closely examine the most common loot distribution systems in World of Warcraft practice. We describe their mechanisms and rules and we review their pros and cons, as they have surfaced from the systems’ use in practice.

In the fourth chapter we introduce a computer-generated simulation that represents a sample virtual guild going through a fixed set of challenges, using a different loot distribution system each time. We conduct this simulation in order to observe whether the strengths and weaknesses of each loot distribution system, as they appear both in available literature and through practical experience, can be reproduced and demonstrated in a way that resembles a controlled experiment. To represent these strengths and weaknesses, we employ
a set of metrics that are calculated at every iteration of the simulation and then put under scrutiny.

Finally, in the fifth chapter, we single out useful conclusions from the simulation and we discuss any impact they might have in the field of economic research. We also explore potential improvements to our method, as well as other fields of research that could lend themselves to a more overarching study of this issue.

1.1. Virtual worlds and economic research

In the introduction we gave a very brief description of virtual worlds, but in order to properly discuss them from an academic point of view, we need to also provide a formal definition. The most widely accepted definition of a virtual world is the following, by Mark W. Bell of the Indiana University (2008):

“A synchronous, persistent network of people, represented as avatars, facilitated by networked computers”

This definition underlines the following defining aspects of virtual worlds (Bell, 2008):

- Virtual worlds are *synchronous*: Unlike the case of an online message board or a turn-based game, in a virtual world interactions happen “in real time”. They also offer a sense of
space and geography. People who are “near” within a virtual world can see what each other is doing exactly when it happens, which allows for coordinated group activities.

- Virtual worlds are **persistent**: Virtual worlds cannot be “paused”. They exist and develop regardless of whether any particular user is online or not.

- Virtual worlds are **networks of people**: Interpersonal communication and interaction is a core feature of virtual worlds. Even if a user decides to interact with the environment only, and not the other users, the results of his actions will still influence the other users’ experience of the world.

- In virtual worlds, people are **represented as avatars**: Any representation of the user that has **agency** (the ability to perform actions) and is controlled by the user is called the user’s avatar. The user controls the actions, but the avatar performs them.

- Virtual worlds are **facilitated by networked computers**: This distinction is important to differentiate virtual worlds from any other kind of fantasy worlds (like the imaginary worlds players develop in traditional pencil-and-paper role playing games). It is also the main characteristic that allows them to be so complex and detailed, as computers facilitate the storage of data and the graphical representation of every avatar and environmental feature within the virtual world.
Another word that is commonly used as a synonym for virtual worlds is *synthetic worlds*, so as to take into account that nowadays, the boundaries between virtual worlds and the real world are blurring, like in the cases we mentioned in the introduction.

We have already mentioned that in sophisticated virtual worlds, like MMORPGs, users can interact not only with other users but also with objects within the world. Some of these objects can be of unlimited supply, but others can be *scarce*: demand for them may exceed their supply. To point out the obvious economic interest in how users end up interacting with these scarce objects, Lehdonvirta and Castronova begin their aforementioned book (2014) by citing Lionel Robbins, a former head of the Economics department at the LSE:

“*Economics is the science which studies human behaviour as a relationship between ends and scarce means which have alternative uses*”

In another of his papers on the subject, Vili Lehdonvirta expands on this by mentioning that such computer games often involve activities that bear a resemblance to what in the real world economists would call production, trade, consumption or labor (Lehdonvirta, 2005). Players own property, trade using currency, manipulate prices, bank their valuables, and obey governing rules (Bilir, 2009).
Since the economy seems to be such a central aspect of virtual worlds, it is no surprise that companies that develop MMORPGs have turned to distinguished economists to help them understand and shape their in-game economies in a way that makes them more attractive to users. The first famous such case was in 2007, when Eyjólfur Guðmundsson was appointed as a resident economist by the company behind *EVE Online*, a popular MMORPG with an emphasis on gathering and trading materials. In an interview (Seiler, 2008), Guðmundsson says that when players specialise in economic activities like mining, transporting and trading (virtual) goods, they need information to communicate about the economy, just like any community needs to know how interest and inflation affect its wealth. That’s why the company found it important to have a visible economist to analyze events and participate in discussion. Another case of a well-known economist joining a gaming company to study a virtual economy was Yanis Varoufakis, who, before his brief stint as the greek Minister of Finance, was appointed as an economist-in-residence by Valve Software. He mentions that the president of the company offered him the job when he realised that their issue of linking economies in two virtual environments by creating a shared currency, and wrestling with some of the subsequent problems of balancing payments, was very similar to the real world issue of Germany and Greece having to share the same currency, the euro, despite their vast differences in economic output and fiscal policy, an
issue that Varoufakis had been outspoken about in his blog at the time (Varoufakis, 2012).

Both these economists cited academic interest as part of the reason why they decided to pursue that uncommon career choice. Guðmundsson collected player data before and after every intervention he made in EVE Online’s economy, in order to study macroeconomic indicators in virtual societies (Seiler, 2008), while Varoufakis also mentions that beyond his regular duties at Valve, he intended to “forge narratives and empirical knowledge that transcend the border separating the ‘real’ from the digital economies, and bring together lessons from the political economy of our gamers’ economies” (Varoufakis, 2012). Among some of the early findings of Guðmundsson was that the same biases that have historically favoured men in the real world also exist in virtual economies. Both groups of women players and players with female avatars showed a slightly less chance of success in competition with their male counterparts, which might suggest that thorny issues like the gender gap can penetrate even novel environments, without decades of sociological and economic history (Casey, 2010).

Apart from economists spending their time figuring out policies in virtual worlds, a sizeable amount of academic literature on virtual world economic research has built up over the past few decades. Castronova can be seen as the pioneer of this body of work, as his 2001 paper “Virtual worlds: A first-hand account of market and society
“on the cyberian frontier” made a great impression to economists all around the globe and sparked an interest in this field of research. After conducting a survey among thousands of Everquest players inhabiting the virtual world of Norrath, he had the idea to calculate some macroeconomic indicators that would befit an analysis of a real-world nation’s economy. Among other things, he calculated the exchange rate between the game’s unit of currency and the US dollar, arriving at a price of US$0.0133 in May 2001 prices, which would imply, at that time, that the in-game currency was actually stronger than real world ones like the japanese yen. He also calculated that the equivalent of US$ 15000 were being created per hour in Norrath. Extrapolating, this would imply a GNP of US$135 million at 2001 prices, or a GNP per capita of US$2,266, which would rival countries like Russia or Bulgaria at that time (Castronova, 2001). The exposure of that paper stimulated researchers to take virtual worlds as a serious subject of study and showed that the academic community can only benefit if they conduct such experiments in the same manner as they would do for real world ones (Jones, 2009). Some of the authors that capitalised on that idea will be discussed in the literature review. Suffice to say, with workplaces shifting to cloud computing solutions, speculators dabbling in cryptocurrencies and virtual money, and VR (virtual reality) technology poised to revolutionize the gaming scene (and unavoidably, virtual worlds), researchers are only expected to keep flocking to virtual worlds for studies that could, one
day, describe a new paradigm of a world devoid of any boundaries between the physical and the virtual.

1.2. Introduction to MMORPGs

Massively Multiplayer Online Role-Playing Games (MMORPGs) are prime examples of a virtual world, being among the first of the kind that were ever created and also still being among the most accessible. They feature all characteristics of virtual worlds that have been mentioned already (synchronous, persistent, facilitated by networked computers), but expand on them by introducing elements commonly found in role-playing games, like a fantasy or a futuristic setting, an ongoing fictional central storyline, and the presence of challenges, puzzles, and other objectives that showcase their gaming aspect. The avatars in these virtual worlds are not explicitly made to resemble their real-life controllers, but they are rather made to blend into these fantasy worlds and become part of this ongoing story by assuming roles in it. The aim of the fantasy setting, the story and the roles that the players assume is to immerse players into a world that feels meaningful, interesting and realistic, and therefore worth spending time and money on for recreation.

Another defining characteristic of MMORPGs is the element of character progression. Following the archetype of tabletop role-playing games, as they spend time, explore the world, and overcome
challenges, characters gain *levels of experience* which reflect their increased power and arsenal of abilities over time. Combat also features heavily in most MMORPGs, as an element of play that feels in place within a fantasy world, retro or futuristic, and a means to provide players with a sense of challenge and urgency. An always important distinction is between combat initiated against computer-controlled opponents created by the game’s developers (also called *non-player characters* - NPCs) and combat initiated against other players. In RPG literature, the first case is called *Player versus Environment* - *PvE*, and the second case is called *Player versus Player* - *PvP*. While it is not unusual for one of the two styles of virtual combat to be absent from a given MMORPG, the most sophisticated ones strive to enable both kinds of combat settings in order to please all kinds of players. The issue that we examine in this dissertation is generally encountered in PvE combat scenarios.

MMORPGs are among the most lucrative genres in the videogame industry. For example, *World of Warcraft*, the most popular subscription-based MMORPG, while far from its subscriber peak, still reported over a billion dollars in revenues in 2014 (Tassi, 2014).
World of Warcraft

World of Warcraft is an MMORPG that was released by *Blizzard Entertainment* in 2004. The setting of this virtual world was based on the acclaimed *Warcraft* series of real-time strategy (RTS) games that had been released by the same company in previous years, which was also a massive success for the company at the time. Among other accolades, WoW was praised for being one of the first MMORPGs that allowed for a more casual gameplay than its intensively grindy predecessors. It was also praised for its crisp graphics and seamless world rendering, with reviewers mentioning that it was the first MMORPG where one could walk from one edge of the map to the other without encountering a single loading screen. It went on to become the best selling computer game in 2005 and in 2006. WoW follows a subscription business model, with players paying a monthly fee in order to be able to access the world. Blizzard reported a peak of 12 million subscriptions in October 2010, while various sources still
make an estimate of about 5 million active accounts as of 2018 (Blizzard stopped providing official headcounts in 2015). In January 2014, Blizzard announced that more than 100 million accounts had been created over the game’s lifetime (Sarkar, 2014). Overall, the game has grossed about $9.23 billion in revenue, making it one of the highest-grossing video game franchises of all time (Leack, 2017).

The game sends the players on a quest to discover a world that combines Tolkienesque fantasy with diverse mythological elements and even steampunk and science fiction themes. Player avatars collaborate and go on missions, gradually becoming more powerful by advancing their in-game level of experience and acquiring equipment that improves their physical and mental capabilities. At the end of this ever-expanding path, the strongest among these adventurers form large groups to tackle menacing dragons, monsters, and even vengeful gods that threaten to destroy the world, a staple trope that can be found all over fantasy videogames, literature and films.

The initial game world is constantly getting larger and richer in content by means of expansion packs released by Blizzard approximately every three years. The latest of these expansion pack, Battle for Azeroth, was released in August 2018.
Fig. 3: A gameplay still from WoW. The player avatar, a female Human mage can be seen in the middle, while in the background a snake-like enemy non-player character is also visible. At the edges of the screen you can see features of the game’s user interface like the game menu, the ability buttons, a chat channel window, health bars, a minimap, and a list of objectives.

Academic interest in World of Warcraft has been surprisingly high for a videogame. As a virtual world, it has mainly attracted sociologists and economists, and we intend to showcase some important studies conducted through WoW by researchers in these fields in the literature review section of this dissertation. However, it has also attracted researchers from other disciplines, and we should really mention the most famous case: In 2005, a glitch in the game allowed players to contract a virtual disease from a high level area of the game and then spread it in low level areas and
populated hubs. The disease quickly took pandemic characteristics, which had been unforeseen by the game’s developers, and a software patch was required to finally rid the world from the plague and to make sure it could not happen again. Nonetheless, this incident piqued the interest of Ran Balicer, an epidemiologist, who studied the way this plague spread and the reasons why it ravaged the virtual world for days until the developers took extreme measures, and published his findings in a respected epidemiology medical journal (Balicer, 2007). The idea that studying the spread of virtual diseases could aid in the way we confront real ones quickly made the paper an overnight hit in the news and in academic circles, and helped establish virtual worlds research in other areas than social sciences.

Fig. 4: A female Troll hunter wielding a gun, an example of a player avatar in WoW.
Basic concepts and how they mirror the real world

Player avatars in MMORPGs are usually referred to as characters, and they display features that differentiate them reflecting their place in the world and the game's ongoing storyline. Some of these features are:

- **External or visual characteristics:** Firstly, it is common for MMORPGs to feature more than one playable race that players can choose from. These races differ from the ones we encounter in the real world, and they are meant to introduce diversity in the population of the fantasy world, as well as add to the immersive element of the storyline. World of Warcraft, like many other role-playing games, draws heavily on traditional J.R.R. Tolkien fantasy influences, featuring elves, dwarves, and trolls among several other playable character races. A character's race mainly affects his appearance, but could also influence other factors related to his gaming experience, like his fictional homeland and nationality, physical and mental traits, and more. Players can also choose a gender for their character, and they can edit other aspects of their appearance like skin, eye and hair colour, hairstyle, height, and even jewellery or tattoos.

- **Attributes:** An essential element of RPGs, also dating back to their tabletop predecessors. Attributes (also called statistics or stats in game parlance) are a means of conveying physical and
mental traits of the in-game characters, by assigning a numerical value (sometimes on a Likert-style scale) to represent their aptitude in each particular area. Akin to the real world, aptitude in specific physical or mental traits tends to influence the character’s role in the game’s community. For example, if we assume that a game assigns attributes on an 1 to 20 scale, a character with 5 in Intelligence and 18 in Strength is bound to excel in physical skills like combat or manual labor, whereas if he had these attributes in reverse he would be more suited for tasks that reward mental aptitude like art, politics, or as it is common in a fantasy setting, magic. Most people in the real world excel in one area or try to manage several areas at a lesser depth. Likewise, MMORPGs strive to put a cap on the amount of attribute points player characters can have, so as to avoid ending up with characters that are really good at everything and to facilitate specialisation and commitment to diverse roles.

- **Equipment:** In MMORPGs, players can improve their character’s attributes and enhance their abilities by equipping in-game items. These can be weapons, clothes, armor, and they have both a visual effect (all players can see them on the respective character), as well as a practical one (weapons can be used in combat). Mainly though, equipment (most commonly called gear) is the usual means of improving attributes. In this sense, equipment is usually specialised to fit specific roles. For
example, a fighter would always seek new weapons to improve his fighting capabilities, whereas a magician would possibly look for a magic wand or a spellbook. The utility of equipment for player avatars is one of the main reasons that we have to consider these in-game items as virtual capital.

- **Specialisation or class:** As we said, different characters with different attributes and different equipment tend to assume different roles in the MMORPG setting. This role is called specialisation or class, and it is to a character what a job is to a person in the real world. Choice of class usually indicates what kind of abilities a player character has, or, in other words, how he can overcome the game’s challenges or provide support to other player characters. Examples of a player class can be Warriors, Hunters and Priests, all of which already sound close enough to being actual real-life jobs!

- **Role:** In the greater sense of the word, we have already spoken about characters’ role in a storyline. However, in the context of characters grouping up to overcome powerful enemies most fantasy RPGs, including WoW, follow the tank - healer - damage dealer trifecta. These three kinds of player responsibility in a group are usually called player roles, and they designate how each individual character contributes to the group’s success.
  
  ○ **Tanks** are characters with a focus on being strong and sturdy, able to take a lot of punishment from enemies and equipped to be able to draw their attention away from
their fellow players. They are usually equipped with heavy armor and invest on physical traits like Stamina and Strength.

- **Healers** are characters tasked with tending to other players’ wounds and keeping them alive and healthy throughout encounters with strong opponents. They are usually equipped with light armor that improves their mental traits, like Intelligence or Healing Power.

- While tanks sustain the enemies’ blows and healers keep everyone alive, **Damage Dealers** have a simple responsibility: to topple the enemy resistance, by inflicting damage to opponents, through might or magic.

Since MMORPGs put an emphasis on being *massively multiplayer*, while not shying away from some solo content, they focus heavily of providing players with *group content*. Group content can refer to challenges, or objectives within the game that players are not powerful enough to overcome on their own. This is what encourages players to form groups and assume *class roles* like the ones we mentioned above.

For the hardest challenges available in the game, players have to form bigger and stronger groups. To facilitate these large-scale efforts, players end up forming tightly knit communities called **guilds**.

A *guild* is a large group of players, formed as a means to socialise and to overcome multiplayer challenges within the game. Guilds are the
most common kind of an organised community formed by like-minded individuals in MMORPGs. They exhibit features such as:

- *Long-term commitment to the group:* even though players may always assemble one-time large groups to overcome a specific challenge, they tend to create guilds with a goal of establishing a group that will keep cooperating to overcome challenges in the long-term. This has obvious advantages, like the players getting to know each other, becoming more effective as a team over time, as well as giving them the ability to schedule their events in a way that fits everyone’s playing hours, long in advance. A disadvantage that has been noted in literature (Yee, 2006c) is that sometime this sort of long-term commitment to a guild (and to the game by extension) can blur the boundaries between play and work, with people sometimes ending up feeling that they play the game out of obligation instead of enjoyment. This situation is called *burnout* among players, and it can speed up a common phenomenon in MMORPGs called *player churn*, or character abandonment, which, put simply, is nothing less than players quitting the game for good (Ducheneaut et al., 2006a).

- *Operational structure and hierarchy:* like any community, guilds require people that make an effort to keep it together and lead it towards their goals. Every guild has a form of leadership going, and not unlike real-world countries, companies or communities, this leadership can range from very authoritarian to very democratic! The more disciplined guilds assign structural roles
to their most dedicated members, and these players (usually called officers) have an increased level of responsibility within the guild, which can be anything from leading them in combat, to managing the guild’s resources, organising guild events and so on (Andrews, 2010; Ducheneaut, 2009). Aside from dedication to the guild, guild leaders and officers are also expected to possess above par game knowledge, to be able to lead their group to battle by forming and explaining strategies and tactics, and also to be able to manage the social aspect of the guild by encouraging camaraderie and diffusing tensions among members (Williams, 2014).

- **Formal practices:** Not unlike real world organizations, guilds use mission statements to codify their purpose, recruitment and expulsion practices to maintain and expand their playerbase, and external (to the game) tools like a guild website, discussion forums and voice chat modules as tools to facilitate communication among the players, and to relay information from the leadership to the members (Andrews, 2010; Williams et al., 2006)
Fig. 5: A guild recruitment message relayed to an in-game chat channel in WoW. Notice the similarities it has with a recruitment announcement from a real world company: locality (NA - North America, mentioned to signal the timezone in relation to playing hours), guild name, raid progression status (1/1 Ony, 10/10 MC means that they have bested all 11 challenges in these raids), mission statement (casual community with a core of geared raiders), expectations from the recruits (immediate raid spots - we recruit regular members) and info about their raiding schedule.

- **Camaraderie** among the members of the guild and **rivalry** with members of other guilds. Guilds are the closest thing to a family or tightly-knit community players can have in an MMORPG setting, and as such they instill their members with a sense of belonging together with their guildmates, with all the kinds of social commitment this can encourage, like helping and supporting each other towards their in-game goals. On the other side of this spectrum, players tend to develop a competitive attitude towards other guilds, since being in one of the most successful guilds in a virtual world can be seen as a symbol of status and power, and therefore players are encouraged to sabotage the efforts of other guilds as much as promoting their own.

The endgame for MMORPG players who get organised in guilds is to overcome multiplayer challenges called **raids**. Raids usually involve defeating a very strong enemy, like a dragon, or a monster, or a god of the in-game lore, and are designed by the developers of MMORPGs to
require coordination and demonstration of skill from a large group of players. Players who successfully defeat a raid encounter become eligible for some of the greatest rewards the game can provide, which can be pieces of equipment, in-game currency or other symbols of status and dominance (Andrews, 2010). Guilds that specialise in defeating this kind of content consistently and effectively are usually called **hardcore guilds**, and players who join these guilds, willing to put a lot of effort in order to experience the MMORPG endgame in all its glory, are called **power players** (Silverman, 2006)

### 1.3. Research question: the issue of loot distribution

Having mentioned the difficulty of raids and the value of the rewards bestowed to the players who brave them, we arrive at the issue that concerns this dissertation. Due to said difficulty, and also due to a set off artificial constraints set by game developers, the rewards from defeating raid challenges (referred to as *loot* from now on) are *scarce*. We will detail this in the next chapter when we talk about virtual goods, but in order to give a brief demonstration, let’s just provide an example from WoW, for now. Raids in the original version of WoW (which will be the one we will focus on in this dissertation) required a group of 40 players to defeat. Each raid could only be completed once per week, had a fixed number of encounters (called *bosses* in WoW), and each boss dropped two to
three items on average. The rewards could not be split or sold for gold: they were equipment items that had to be received by one member each, and they could not be traded afterwards. It quickly becomes obvious that not every player in the guild would be certain to receive loot every week.

Therefore, the issue of **loot distribution** arises:

> “How can players distribute loot among themselves, in a way that leaves every member of the team satisfied in the long term?”

Traditionally, there was no in-game functionality to resolve this issue, and players would have to leave it up to luck (like a dice roll), or depend on the raid leader’s judgement in order to reach a decision every week. In the course of many years of MMORPG experience, players eventually devised sets of rules, not enforced by the game itself but by the players as “gentleman agreements” (Maggiorini, 2012b), called **Loot Distribution Systems**, which facilitated the process of loot distribution, and allowed guilds to satisfy their members, strengthen their raiding force, and avoid **drama**.

Drama is a passe-partout word that refers to all kinds of tension and conflict amongst raid members. If left unattended to and unresolved, drama can often lead to players leaving their guilds in protest, or even worse, the guild itself disbanding as relationships between large groups of people within it have been irrevocably damaged. Conflicts related to loot distribution have been observed to be the most common cause of drama in guilds, by far (Andrews, 2010).
By employing Loot Distribution Systems, guild leaders try to shift responsibility away from them in terms of loot decisions, in order to reduce drama and provide players with a transparent solution to the loot issue, free from interpersonal allegations of bias and favouritism. Every guild can decide upon its own loot system, but through years of MMORPG practice, some standard, widely accepted systems have prevailed over others. LDS can take many forms, and they can range from very simple to quite complex.

In this dissertation, we argue that the act of a guild enforcing an LDS to distribute loot among its members is akin to the act of an economic institution developing a system to allocate a scarce resource in the real world. We will describe some of the most prevalent LDS, and we will attempt to compare their pros and cons, both in guild practice as well as in a simulated raiding environment.
2. Theoretical Background

The foundation of this study lies in the field of Virtual Economics, and specifically in the theory of virtual goods and virtual capital. Since this is a relatively new field in terms of development of theory, we shall fall back on the 2014 Lehdonvirta and Castronova book “Virtual Economies: Design and Analysis” as the main source of theoretical context, being the most comprehensive and widely accepted work on that domain so far, while taking elements from recent sociological, game design and virtual worlds publications when it is appropriate.

2.1. Virtual capital, goods and economic systems

Castronova and Lehdonvirta use the term *virtual economy* to refer to an economy that is built upon scarce digital resources, and the term *virtual goods* to refer to the scarce digital resources themselves. Lehdonvirta in particular, mentions these three typical characteristics of a virtual economy (Lehdonvirta and Ernkvist, 2011), in contrast to what he calls *digital economy*, referring to e-commerce and online services regarding real-world goods and resources:

- It centers around commodities that are digital yet scarce
- Demand arises from the increasing use of digital services in business and leisure
Supply is created through the expenditure of human effort, and doing so requires relatively few specialized skills or resources

Castronova and Lehdonvirta then go on to define the notion of virtual goods. They describe them as digital goods with a major difference to the typical digital information goods we are familiar with, like a DVD or a software package: while information goods derive their value only from the piece of information they relay, and they can be reproduced easily without loss of value, virtual goods derive their value from function, either tangible within the virtual environment, or as a social status indicator that makes the owner stand out. Then, they single out some defining virtues that bestow value on goods:

- **Goods are social markers:** Humans are predisposed to seek recognition and to improve their status within their society. This social status can sometimes be implied by the possession of status goods, highly expensive or hard to get objects whose value mainly lies in their exclusivity.

- **Goods express identity and membership:** groups of people can express affiliation to a group by possessing similar things with other members of the group. This can be seen in the real world in the cases of fashionable clothes, or sports jerseys, for example.

- **Flows of goods create bonds and fulfil obligations:** the ability to offer something as a gift to someone else also bestows additional
value to it above its practical value, as well as the ability to purchase something just to satisfy the person who sold it.

- **Goods provide personal meaning and pleasure:** they can simply fulfill needs that only apply inside the owner’s mind, like the need to collect old memorabilia or the need to look at beautiful things.

- **Goods fulfil needs and solve problems:** the instrumental utility of an item is ultimately measured by the extent to which it can be useful for the task it was created for.

Malaby (2006), argues that all of virtual goods fall into one of three categories of capital: material capital, social capital, and cultural capital, depending on the nature of the function that gives them their value.

**In-game items as virtual goods**

Having said all that, can the items that *drop* from WoW bosses (also called *raid drops* or *raiding items* or *raiding gear* or *boss loot*) be considered virtual goods? To reply to this question, we must establish whether they exhibit the characteristic traits of a virtual good described in the previous section. However, we must first provide some additional context to them.

The vast majority of WoW *boss loot* is *equipment* (hence *gear*), as we described it in the introduction to the MMORPGs section. The main,
material function of equipment is to improve the attributes of an in-game player character, making him better at his chosen role.

Fig. 6: A WoW character’s full equipment, comprising of in-game items. Each item goes to its corresponding item slot: the character can only wear one pair of boots, one pair of gloves, one helmet, one chestpiece, one cloak, two rings etc. Mousing over the items gives you information about the kind of attributes they improve (see top right). At the bottom left of the character tab one can see a list of the character’s total attribute values. Notice that as this particular character is a Warrior, a class that specializes in melee combat, her choice of items favours those that improve attributes like Strength or Attack Power, eschewing ones that improve attributes less relevant to her class like Intellect and Spirit. The notion of fine-tuning a character’s gear to play to the class’ strengths is called min-maxing in game parlance, and it is a very important consideration when it comes to loot distribution.
Developers of the game have introduced elements of artificial scarcity to these items, in an effort to keep players interested in the game for longer. Some of these are (Malone, 2009; Fairfield and Castronova, 2006):

- Each specific raid can only be completed once every week. This is called a raid lockout, and it is set in place by the game’s developers so that players can’t just do the same raid several times in a row to get every item they want in one sitting, which would mean that they would not have a reason to come back to that raid next week, negatively affecting the game’s longevity.

- Bosses don’t drop the same loot every time. The loot is selected randomly from a list of potential rewards called a loot table. The probability that an item with specific qualities will drop among those in the loot table is called the drop rate of the item. Some highly coveted items can have drop rates as low as 5% or less.

- The amount of loot that drops per boss is disproportionately low compared to the amount of players raiding for it. In the classic (also called vanilla by players) version of WoW, the hardest raids in the game required 40 players to have a chance of completing them, but every boss dropped only about 3 items on average.

- The perceived value of items that drop from raid bosses is generally much higher than the value of items players can get from easier group content or they can buy using in-game currency. This is obviously done to encourage players to
participate in these high-end missions and to compensate for the increased difficulty of raiding.

- Once a player receives an item from a raid in WoW, the item is said to be *soulbound* to him, which means that only that particular player can use it from now on, and he may not trade it or sell it away to other players. Soulbinding is a practice introduced in order for all players to have to spend the same effort to get good loot from raids. If it was not in place, long-standing raiders could trivialise the game for newer ones, by giving them strong items without them having to raid for said items like their previous owners (Fairfield and Castronova, 2006).

- Harder raids, ones that are in later stages (*tiers*) of raiding progression, offer better loot in terms of functionality, since they are improving the player’s attributes by a greater amount. This makes raid items a prime example of *positional goods*: items that gain value based on their ranking in relation to similar items that can be considered substitutes (Lehdonvirta and Castronova, 2014). The notion that raid items are positional goods also explains why players feel the need to always progress to even harder raiding content in the game: once better equipment becomes available, older items lose value by comparison to it, and once a lot of other players can manage to get a similar level of equipment, its value that stems from comparison and social status fades away. This phenomenon,
which closely resembles *inflation* in the real world caused by the influx of more and better goods for the same price is called *MUDflation*, from inflation and M.U.D. - multi user dungeons, one of the first kinds of MMORPGs (Lehdonvirta and Castronova, 2014).

Having said the above, it is now easier to demonstrate that items which can be acquired through raiding fit Castronova and Lehdonvirta’s description of what describes a virtual good:

- **Raiding items fulfil needs and solve problems:** The functional value of raiding items is that they increase the players’ stats, enabling them to tackle even harder challenges and progress in the game, fulfilling their need for achievement and solving the issue of being *gear-checked* by bosses. A boss is called a *gear check* when it is specifically tuned as to not be killable if the players don’t have the required level of equipment, even if their preparation and coordination is on point. Bosses in later tiers of progression are tuned by default in a way to require the players to have at least a few items from the previous tier of progression, in order for the endgame to feel like an ongoing process of incremental improvement, and to avoid new players skipping almost all the game’s content and going straight for the absolute final bosses that offer the absolute best gear.

- **Raiding items provide personal meaning and pleasure:** Apart from higher stats, raiding equipment also usually comes with a unique appearance. Adventurers wearing several raiding items
are instantly recognisable, and by matching items that look good together they can customise the visual aspect of their characters in a way that pleases them and allows them to express their personality and creativity.

- **Raiding items create social bonds and fulfil obligations:** The act of getting loot is a cooperative effort, and many players are motivated not only by getting the items they personally desire, but also from being able to get such items for their friends in the virtual world. Once a player receives loot, the bond he has with other guild members gains in strength, not only because he can expect more items to come towards his way by staying in that guild, but also because he feels obliged to help the other members get the items they need as well, just as they helped him do so.

- **Raiding gear is a social status marker:** For all the reasons mentioned above, raiding gear in MMORPGs is particularly exclusive, as only skilled players who team up with their peers can obtain them. Other players seeing them in the world can immediately assume that they are good at the game, just by inspecting their gear, which is visual proof that this avatar has managed to overcome some of the hardest challenges in the game.

- **Raiding gear expresses identity and membership:** An avatar fully-clad in raiding loot is a clear sign that the player behind is a *power gamer*, skilled enough to overcome hard challenges. It
is also a clear sign that this avatar is a member of one of the top raiding guilds in the game's community, as he could only have obtained all these items by collaborating with similarly skilled and achievement-oriented players in an organized guild.

Consequently, raiding items can be undoubtedly classified as scarce, non-pecuniary, positional virtual goods.

**Guilds as virtual institutions**

Institutions are persistent social patterns that are emergent and self-enforcing. They are a manifestation of a social equilibrium, an outcome to which society naturally drifted (Lehdonvirta and Castronova, 2014). Guilds emerged from the players need to facilitate communication and cooperation with similarly minded peers, in order to overcome challenges they could not manage by themselves.

In the real world, institutions can be organisations that regulate the allocation of resources. For example, national healthcare organisations regulate the allocation of medical support to their insured members. In many societies, their role is to offer a decent level of healthcare to less privileged people, one that they would not be able to provide for themselves in a world that would follow a market-based healthcare allocation paradigm. This is a social equilibrium that these societies drifted towards: they decided that there is more value to keeping every citizen healthy, even by utilizing resources in a sub-
optimal way to do so, rather than leaving this issue to the *invisible hand* of the markets.

Similarly, guilds act as *virtual institutions* by regulating the way loot is distributed among their members according to their own conventions. For one guild rewarding the most loyal members might be the accepted norm, while for another it might be rewarding the most skilled ones. These regulatory norms are enforced by guilds through *loot distribution systems*. In order for guilds to be successful institutions, they have to inspire *trust* to their members that their community is functioning in the way they all want (Lehdonvirta and Castronova, 2014).

![Fig. 7: An example of the guild roster interface in WoW. Notice that next to the avatar names, the in-guild ranks are listed, signifying the player's status within the guild. The player at the bottom is the Guild Master, a character with power over distributing these ranks.](image-url)
On a final note in this section, we discuss how LDS display features of a *virtual economy*. Of course, a fully-fledged economic system is more than a set of rules on a single page, but in the small premises of a guild, where the only scarce resource that needs to be allocated is raiding loot, the LDS alone can be all the guild needs in terms of policy.

Lehdonvirta and Castronova (2014) indicate that any virtual economy related feature in a multiplayer game should aim to contribute to at least one of these three objectives:

- Creating content
- Attracting and retaining users
- Monetizing

Loot distribution systems fall into the second category. A successful loot distribution system is the glue that binds guild members together, by allocating raiding gear in an efficient and accepted way, and by incentivizing guild members to attend raids and contribute time and resources to the guild. More details on what distinguishes a successful LDS will be discussed in the next chapter.
2.2. Literature review

This study was based on more than 60 different sources of material and information. However, most of this material was authored by a small group of specialists in the field, and in this section we will focus on demonstrating their area of research, and how it helped us in our own project.

**Player Archetypes: Richard Bartle - University of Essex**

Richard Bartle is a pioneer in the field of game design, and his seminal work “Designing Virtual Worlds” has been acknowledged by every other researcher mentioned in this section as a very important foundation that kickstarted the boom of virtual world projects, and was among the first to point out the vital importance of managing the economic aspects of virtual worlds (Bartle, 2004).

One of his most famous contributions to the field was the idea to split players into four main archetypes (Bartle, 1996):

- **Achievers:** Players whose main motivation is to improve their avatar’s power level and status by amassing game levels, points and currency. Raiders, the focus of this dissertation, are a prime example of achievers, aiming to maximise their character's power level by obtaining the hardest to get and most powerful items in existence.
• *Explorers:* Players who are motivated by uncovering every secret the game holds and exposing its internal machinations. Visiting every place in the world, creating maps and guides and discovering glitches in the game are among the favourite things of an explorer.

• *Socialisers:* For socialisers, the game worlds is merely just another place where they can hang out with other people, express their world views and listen to others. They are motivated by establishing long-lasting relationships with other players and becoming acquainted with a large crowd.

• *Killers:* Killers are players whose main motivation in the game is imposing their will and power onto other players. In games where PvP combat can be initiated, this translates simply to killing (hence the name) other players’ characters and forcing them to go through the consequences of character death, which may range from item and experience loss, to social shame and the stigma of being “inferior” to the player who killed you.

**Virtual Economies: Edward Castronova - Indiana University**

We already mentioned the pioneering work of Edward Castronova in the field of virtual economics as well as the field-defining book he co-wrote with Vili Lehdonvirta that we used as our main launchpad in our search for virtual capital elements in WoW equipment.
A significant predecessor of that book was *Synthetic worlds: The business and culture of online games* (Castronova, 2008), in which he elaborated on all economic aspects of virtual worlds that he had discussed in several of his early papers (Castronova, 2002; 2006). This book is commonly named alongside Bartle’s book as essential items in a modern game designer’s library.

In the authors’ opinion, Castronova’s main contribution to the field has to be the very idea to study virtual worlds in the same way one would study the real worlds, by conducting field research and calculating microeconomic and macroeconomic indicators that were thought to be inapplicable to virtual worlds, like the GDP, wages, employment and many more. He also sought to explore solutions to real world problems by observing how they manifested in virtual worlds. A very interesting example is his work on the social question: what should be done about those who receive relatively fewer material benefits from the current set of economic institutions in society. Castronova finds that a generation raised both in the real and in synthetic worlds would have significantly different expectations from economic policies, and different factors would affect issues like income inequality, with a shift from physical to mental indicators (Castronova, 2006). On a relevant note to this dissertation, Castronova is among the first to suggest the notion of guilds as economic institutions and LDS as economic systems of scarce resource allocation.
Virtual Capital: Vili Lehdonvirta - University of Oxford

The coauthor of *Virtual Economies: Design and Analysis* is a very active researcher in the field of virtual economy, and has made great efforts in shaping it as a concise field of research (Lehdonvirta, 2005; Lehdonvirta and Ernkvist, 2011). Some of his other material that we studied in preparation for this document included important works on material culture and consumerism in virtual worlds (Lehdonvirta, 2010a; Lehdonvirta et al., 2009).

A main focus of his research has been the effort to blur the boundaries between virtual and “real” economics, by demonstrating the interplay between them in seemingly unrelated areas (Lehdonvirta, 2010b; 2013).

Sociology: Nicolas Ducheneaut - Palo Alto Research Center

Ducheneaut has written a lot on the social aspect of MMORPGs, with a particular interest in WoW. For example, he made the surprising observation that most MMORPG players actually spend a lot of time alone in virtual worlds, with other avatars being spectators to their progress instead of collaborators (Ducheneaut et al., 2006b), and together with other researchers like Yee he elaborated on the gameplay aspects that make players want to invest time in MMORPGs (Ducheneaut et al, 2006a).
We found some of his material on the social structure and the life cycle of guilds very useful in our attempt to simulate a guild for the experimental part of this study (Ducheneaut et al., 2007).

**Loot Distribution: Dario Maggiorini - University of Milano**

Maggiorini’s work is probably the most influential and the most relevant to what we did in this study, as he also focused on Loot Distribution Systems in WoW and used a simulation as a means of gathering data (Maggiorini et al., 2012a; 2012b). However, his work had a slightly different scope, which was to see which LDS fits different kinds on guilds, based on the typology of players introduced by Bartle (Achievers - Explorers - Socializers - Killers). Our study tries to compare these systems mainly on their own perceived strengths and weaknesses, and to see if they have any individual effect when they apply to the same guild, *ceteris paribus*. Regardless, we agree on many of his points and we use similar arguments in describing LDS. His work also provides testimony on the popularity of the systems we explore in our simulation, as they are also systems that Maggiorini and his colleagues study in their work.

**Player Roles: Dmitri Williams - University of Illinois**

Dmitri Williams’ work was instrumental in our analysis of player roles within guilds. He finds WoW to be as social as a team sport, with its own rules, literal boundaries and social norms (Williams et al., 2006).
Williams also examined the demographics and social characteristics of gamers, the people behind avatars (Williams et al., 2009). Through this work, Williams managed to debunk several long-standing stereotypes about gamers, (Williams et al, 2008) about their health, political and religious beliefs, among others.

**Motivations for play: Nick Yee - University of Stanford**

Finally, Nick Yee, a frequent collaborator of Ducheneaut, provided us with comprehensive material regarding *motivations* for people to play online games, which branch out to our observation about LDS being tools that facilitate player commitment to the guild and reduce *guild churn* (Yee, 2006a; 2006b; Yee et al., 2012).

We also already mentioned him when discussing the similarities that long-term commitment to a guild has to an actual job in real life (Yee, 2006c).
3. Loot Distribution Systems in practice

In this section we will discuss the most common LDS in practice, as they appear in guild websites, community hubs like WoWWiki, the authors’ own experience of the game, and academic literature (Andrews, 2010; Fairfield and Castronova, 2006; Lehdonvirta and Castronova, 2014; Maggiorini et al., 2012a; Malaby, 2006; Malone, 2009; Nardi and Harris, 2006).

We already discussed the theoretical aspect of LDS as economic policies enforced by institutions (guilds). Here, we begin talking about the functional aspect: what do players want to achieve through these systems?

In the Loot Systems article of the well-established collaborative online encyclopedia about WoW, WoWWiki, we read that loot distribution systems strive to achieve as many as they can among the following:

- **Avoid drama:** We mentioned earlier that drama is the main reason for the death of guilds, by corroding the social bonds between their building blocks, the members. An LDS is a gentlemen’s agreement that acts as a means to resolve conflicts involving loot distribution in a way that has been predetermined and agreed upon by the guild members.

- **Sustain raid progress:** An LDS has to be efficient enough to distribute loot in a way that steadily improves a guild’s raiding
force over time. It also has to provide players with incentives to stay in the guild and attend raids, otherwise the guild might end up weakened by poor attendance or player churn.

- **Items should go to those who benefit most:** An LDS has to make sure that loot is distributed in a logical way that prioritises classes that benefit the most from the attributes each item improves. If cloth equipment goes to a warrior, and plate equipment goes to a priest, then there is something inherently wrong in the way that guild distributes loot.

- **Upgrades (even minor ones) for any raid member are not going to waste:** A really thorny issue, as players can sometimes avoid upgrades in lesser tiers, in expectation of getting priority on higher tier gear. Of course, if this attitude prevails among players, in the short term the guild can’t make progress as its characters are not improving. Some elements of LDS systems like *point decay*, which will be analyzed in the context of the DKP system, were introduced to tackle this very issue.

- **Elegant, easy to understand and consistent system:** In practice these characteristics are of vital importance. If a system is not consistent, it will quickly cause drama among players, while if a system is not easy to understand and work out, it tends to create misunderstandings and confusion that delays raids and demoralises players.

- **A fair balance exists between effort spent and reward gained:** This last objective can be controversial to some people, as
quantifying things like effort and loyalty is never an easy task. However, rewarding the most consistent raiders makes a lot of sense from a progression point of view, as it increases the chance that rewards will be put to immediate use in subsequent missions. Players in MMORPGs have been observed to value meritocracy highly, and when people who put minimal effort are being rewarded for reasons like pure luck or personal relations with the officers, it can often cause drama and corrode the social bonds between the officers and the core members of the guild, who might feel betrayed by such a turn of events (Verhagen and Johansson, 2009).

In the following sections we examine the most popular loot distribution systems in detail, and we determine just how well they adhere to the principles laid out in this introduction. As a disclaimer, we will avoid talking about trivial, never-used loot systems like free for all (whoever gets to the boss faster wins the loot!), systems involving currency not created for the purposes of the loot system (like WoW gold DKP or real money DKP), or marginal systems that were put in place by specific guilds but never managed to attract a much wider audience (like Shroud DKP, or Ni Karma, among others).

3.1. Arbitrary systems

Arbitrary systems can be viewed as a manifestation of autocracy, or to put it more lightly, of benevolent despotism in WoW. The central idea
is that guild leaders and officers, as experienced and responsible players who value the guild’s prowess and longevity above everything else, should make every decision about loot distribution themselves, without any intervention of luck or rule systems. Even though this power can sometimes rest in the hands of a single person (the guild master), the most common form of such arbitrary system is a collaborative effort among a group of officers known as the *loot council*.

**Loot council**

A group of designated players (usually the guild’s officers) decide who gets every item that drops, based not only on factors like attendance, performance, effort, progression requirements, but also largely on the officers’ informed opinion on what is good for whom, and where the guild needs to invest in upgrades. Advocates of such system claim that it:

+ benefits from the superior game knowledge of the officers, which sometimes can be better informed on whether an item is an upgrade for a player, than the player himself.
+ values current player performance much more than other loot systems.
+ values size of upgrade much more than other loot systems, since the council can direct items to players who will get the most out of the upgrade maximising the benefit for the whole raid instead of catering to individual’s desires.
+ can better distribute loot for specific raid needs. If the guild needs players of a certain role, such as tanks or healers, to get prepared for a gear check, it's easy to allocate loot to them.

However, just like every autocratic system in the real world, it draws stern critics who readily dismiss it by pointing out that:

— a Loot Council is only as fair as the people on the council. A certain amount of trust to the guild's leadership has to be built before players are ready to accept a loot council system, and any signs of favouritism can shatter that trust.

— even councils that try to be scrupulously fair will encounter drama over their decisions, as fairness is in the eye of the beholder.

— it is hard to determine if loot council members have the level of game knowledge required to determine which item is suitable for which class/role

— It requires more work on the part of council members to pay attention to and keep track of that which determines loot distribution.

— the process of awarding loot can take more time as council members debate whom it should go to, delaying the whole raid.

For the reasons above, this system is usually employed by guilds that have a homogeneous and long-standing playerbase, and also by guilds doing the very high-end content of the game where officers already have a very strong rule and prefer to min-max the upgrades for the
purposes of the content they are progressing through. It can be surprising to an outsider to see a group of players agreeing to this sort of authoritative decision making, but in small homogenous groups, where trust upon the leadership has been built and cemented over years of fair and informed decisions, it might very well be the best system. The majority of players, however, frown upon this imbalance in administrative power, and that’s essentially why *loot distribution systems* became a thing in the first place: unwilling to trust other people on the internet this much, while still not wanting to rely upon pure luck in the sensitive matter of loot distribution, players resorted to developing the kind of rule-based systems that we will discuss in the following subsections.

### 3.2. Priority based systems

A first step in the establishment of LDS rules was to decide on *priorities*. Some simple priority rules are so embedded in players that it feels almost unnatural not to follow them: a warrior class should get priority in blunt weapons, while a spellcaster should get priority on spell scrolls. In the context of guilds, however, priority can be given for several other reasons, like consistent attendance to raids, loyalty and continued effort to the guild. An example of a simple priority LDS would be to prioritize loot to people who have attended the most raids overall. This never caught on, however, as it would make new players
extremely averse to joining the guild. A system drastically tackling this new player issue is the *suicide kings* system

**Suicide kings**

Players are initially put in an ordered list, usually based on a random roll. When a new player needs to be added to the list, it is possible to let him "roll in," or simply insert him at the bottom of the list.

When loot is dropped, the person who wants it and is nearest the top of the list wins the loot and goes to the bottom of the list. That’s the basic principle of the suicide kings (SK) system, and it has been a favourite especially among casually raiding guild for:

- being very transparent, and simple to maintain
- loot distribution takes place at a glance (minimum raid delay)
- veteran players cannot build a large lead over other players like in some point or priority systems, making inflation a non-issue
- casual gamers who do not attend raids very often can still work their way up the priority list and have an opportunity at loot
- works well in guilds with very motivated players, who don’t need to use DKP bonuses as incentives
- encourages people to pass on minor upgrades so others who need them more can have priority

However, while tackling some issues of LDS in a very effective way, SK fails to address one of the most important, meritocracy:
— it does not reward players for desirable behaviour (like punctuality, potion grinding, joining stressful and potentially unrewarding progression runs)
— it does not take into account or track if one player performs better within raids or attends more times than another.
— allowing players to go up the list without being in the raid by default might be desirable in some cases, but could also definitely lead some players to care less about attending when they are near the bottom of the list, decentivising attendance.

For reasons like the above, while SK has traditionally been popular among casual guilds, it never caught on to the top-end, hardcore raiding guilds. Variations of the SK system that attempt to fix some of its shortcomings include using a different list for each tier of raid progression, as well as fixing the position of absent players to reduce intentional absence.

3.3. RNG based systems

RNG is short for Random Number Generator, the mathematical device behind every aspect of the game that operates on probability, like dodging an enemy attack, or resisting an enemy’s magic spells, or having a particularly desirable raid loot drop from a boss. In game parlance, RNG essentially means luck. A player who finds a ridiculously rare item, or who survives by luck against very unfavourable odds, will be said to have “good RNG” by other players.
**Simple roll**

The default system for distributing loot in WoW, built in-game, is a simple dice roll. When an item drops, players are asked through a pop-out window whether they want to roll on it or not, and the game generates a random number from a uniform distribution between 1 and 100 for them. The player who lands the highest number, gets the item. In order for every other system we discuss in this dissertation to work, raid leaders have to manually suppress this default system and enable another loot mode called “master loot”, which allows the leadership to distribute loot in accordance to their own system.

Being already integral to the game user interface, and also very easy to understand, are the two main advantages of his system. Statistically minded players might also say that according to the *law of large numbers*, in the long-term distribution will end up being fair among the practitioners of the system. However, virtually no raiding guild actually uses that system, because:

- it doesn’t account for variance in player effort, as everyone gets the same chance at getting loot
- can be abused by greedy players who roll on everything, even on items they don’t really need.
- from a guild standpoint, it can’t be ensured that loot goes to the most suitable recipients
— outliers can break raid morale, like one person winning every item he rolls for in a raid, or another person not getting items in several raids in a row

Due to the disadvantages above, very few organised guilds use a simple rolling method. However, we must note that it is very popular in pick-up groups (PUGs). Pick up groups are one-time collaborations between guildless players or members of different guilds in order to tackle a raid challenge. Since the members of such groups have no previous history between them, or common leadership, they are essentially forced to use this system, as players from different guilds are not expected to trust each other with any system involving a *loot master*. Even in PUGs, refinements to this system crop up once in a while, like a cap on the maximum times a player can win a roll (called a *+1 roll system*), or a *karma system* like the one described below:

**Karma roll**

Karma is a twist on the simple rolling system, where after every roll happens, the rolls are modified for each player by a positive or negative number called *karma*, before a winner is declared. Karma can be accumulated in many ways, like attending raids or gathering resources for the guild, and it can be reduced or dropped below zero by gaining items, or by unwanted actions like leaving in the middle of raids, causing drama, or sabotaging the raid performance through bad play (Maggiorini, 2012b). Like SK, this has also been a favourite of
casual guilds, but it inherits many of the limitations of simple rolling, making it a quite unpopular choice in hardcore raiding guilds.

### 3.4. Point based systems

Just like most archaic economies in the real world, loot distribution systems eventually evolved to the point of employing currency. Point-based systems were made on the basis of quantifying elements like performance and attendance in a way that would facilitate comparison, in the same way currency in the real world quantifies the value of goods to facilitate trade. The first point-based system to emerge in MMORPGs, and probably the most famous among them, while also being the one that appears most frequently in academic literature on the subject, is the **DKP system**.

DKP stands for *Dragon Kill Points*. In the early days of *Everquest*, one of the first MMORPGs that stood out and became massively popular, the only raid encounters were two huge dragons. Hence, the word *dragon* would be interchangeable with *raid boss* at that time. As MMORPGs evolved, challenges other than dragons featured in raids, but the system became so popular that the name stuck (Fairfield and Castronova, 2006). In the following subsections we will discuss the many manifestations of the DKP system in MMORPG practice, as they also appear in literature in the work of Krista-Lee Malone (2009), Maggiorini (2012a), Fairfield and Castronova (2006).
Simple fixed-price DKP

In its fundamental implementation, DKP is described by this process:

- When the leadership of a guild decides to use fixed-price DKP, they must first assign a *DKP price* to every possible item that can drop. This is facilitated by readily available loot tables for the bosses the guild is planning to encounter. Prices have to be assigned in a way that reflects an item’s power and desirability.

- Every time players attend a raid they receive a fixed amount of DKP. These points have to be tracked using a spreadsheet or an external application, as the game itself does not offer this functionality. DKP can be awarded at the start, at the end, or in discrete time periods during the raid, like every hour, depending on the specific act the guild wants to reward: attendance, punctuality, successful completion of the raid, or consistent performance throughout. These points add up to what the player had amassed in previous raids. DKP can also be awarded outside raids, to incentivise effort towards the guild like gathering of required materials and resources.

- Every time an item drops, the player who stands to receive it is the player with the highest current amount of DKP among the ones who declare their interest in it.

- After the winner is announced and the item is given to him, the DKP price of the item is subtracted from the total DKP that player has.
In this sense, DKP is the currency within the DKP system economy. Like a currency, players are able to use it immediately or to hoard it and wait for the right moment to spend it. The value of virtual goods (items) is also expressed in terms of this currency, allowing players to compare them, and make economic decisions on how to spend their available resources in order to get these goods when they become available. The reasons why this kind of system became so popular are apparent:

+ Quantification of item values allows players to compare then and plan ahead the way in which to spend their DKP in order to end up with the items they desire the most.
+ The point system acts as an incentive for players to attend raids, in order not to miss the DKP payoff.
+ DKP facilitates meritocracy: people who attend more raids, amass more DKP and thus they get more items.
+ DKP allows guild leaders to also incentivise player effort outside raids. Tasks like preparing for raids and gathering resources for the guild are usually much less exciting than participating in the raids themselves, so players tend to neglect them if they don’t have some extra incentive for them.
+ By comparing their position in the DKP table with other players, they can know in advance when they would be able to get an item they want with a degree of certainty, which is not true in the case of other systems like simple rolling.
Decisions on loot distribution in raids are made more quickly: they are as simple as checking a spreadsheet to see who has the most DKP out of the players who want the item.

The way in which the desire of guilds to tackle the issues mentioned above led them to an economic system with its own currency that exists outside the virtual world, reminds us of the economic equilibrium situation that led to the birth of guilds in the first place. For any economic researcher, to see this kind of economic thinking coming to life in such an unexpected area can only confirm the validity of what they were taught in school about how economies formed in human societies: out of the necessity to distribute scarce resources in an efficient way. It is also interesting to see how DKP systems evolved over time, like the economic systems in human societies, in order to fix their initial inherent flaws. Prolonged use of simple DKP systems like the one described above uncovered some of these flaws:

— While the amount of loot any player wanted from a specific raid tier was always finite (every character has about 16 gear slots in his inventory, so even at the most extreme case he would end up needing nothing after filling every one of these slots with the best item he could), DKP kept accumulating with every raid that came to pass. At this point, any economist can already imagine the word that describes this situation: inflation! When the item prices are fixed and the currency itself accumulates indefinitely, the most consistent raiders among players in a guild would end
up in a situation where they would have so much DKP that the fixed price of any item would be trivial and would not threaten their position in the DKP list. At that point, DKP doesn’t function much differently than a simple attendance list, and it makes the guild very unattractive to new players, who simply can’t compete for gear with veterans of the guild with vast amounts of DKP in their virtual pockets.

— Unlike the systems discussed earlier, DKP systems require significant effort by officers outside the game to be established and maintained. Deciding the initial item prices is tedious work, and the prices themselves might become a source of controversy. During the raids, someone has to keep track of points and how they change in the course of the raid as items are awarded. Even when software that facilitates this activity is available, it still requires effort from the player responsible for keeping the point system updated, and he also has to bear the blame from other players if he makes any mistake. This kind of responsibility is not something many players want to take up, especially within the context of a game they play for fun! Again, we can see the boundaries between play and work blurring in a potentially undesirable way (Malone, 2009; Yee, 2006)

In order to combat DKP inflation, players ended making modifications to the original DKP system that resulted in the systems we will be discussing in the next subsections.
**Spend-all DKP**

_Spend-all DKP_ is one of these modifications that attempted to tackle the inflation issue in an absolutely radical way. That way was to get rid of fixed prices entirely: instead of fixed prices, the player with the most points still wins the item, but he has to spend all his available DKP to get it. This system never really caught up because this change, while it indeed gets rid of the inflation issue, it also nullifies some of the positive aspects of DKP discussed above. Players become averse to spend their points as it might take ages for them to get back to the point where they can win an item, resulting in a situation where no one wants minor upgrades, while there is fierce competition over the most coveted items. In WoW, when nobody wants an item, it can be _vendored_ (sold to non-player-character vendors for a small amount of _gold_ - WoW currency) or _disenchanted_ (broken apart for raw magical materials). This is a natural occurrence as players become stronger and they need fewer items, but if real upgrades end up discarded, the guild stagnates, as players develop in power more slowly, which affects the guild’s progression pace in a negative way. If a guild decides on a strict upgrade rule (as in forcing players to spend their DKP if an item would be an upgrade for them), they not only end up irritating players who would rather spend their DKP on something else, but the system itself ends up being no different than a glorified ladder/reel system like _suicide kings_.

72
Spend-enough DKP

An improvement on the radical modification described above, spend-enough DKP is another variable price DKP system, with a simple difference from spend-all DKP: players who win an item have to pay a DKP price equal to the total amount of DKP the next player who needs the item has. Things get interesting here, as it seems like an invisible hand might come in the works to give items their true value: players with lots of DKP will compete for the most valuable items, while players with fewer DKP will compete for the less valuable ones, and the prices they will pay will end up being balanced accordingly.

While this sounds very efficient, spend-enough DKP is another of those DKP modifications that only ended up being used by a handful of guilds. The reason is an issue that creeps up in every variable price system: collusion between players. Just like real world companies form trusts to alter market prices to their favor, apparently so do players when they operate in a variable-price system!

Simply put, players in guilds using variable price DKP systems like this one or like the bidding systems described later in this section, would end up forming cliques with the purpose of driving item prices down for themselves, at the expense of the other players in the guild. This worked in a simple fashion: when players within a clique knew that they would be competing against each other for an item drop, players who knew they did not stand to win the item would simply not express their interest, allowing the winner to pay minimum price for
it. On the other hand, when those same players knew that the winner is expected to be a player outside their clique, they would all express interest in order to maximise the price that player would have to pay for the item he would get. As one can imagine, the eventual drama that ensued when such a scheme was uncovered was of guild-breaking proportions.

**Zero-sum DKP**

Zero-sum DKP is a return to the original *fixed price* DKP system, but with an ingenious twist towards the same purpose of avoiding inflation: this time, instead of a fixed DKP income and variable prices, the prices are fixed but the income is variable, in a very specific way. First of all, at the beginning of the system’s adoption, every player’s DKP is set to zero, and a player’s DKP supply is allowed to go into the negatives, which means that even if his total DKP is less than the item’s fixed price, or less than zero outright, he can still express interest for it and even potentially win the item. This will make more sense once the reader understands the DKP allocating mechanism described in the following paragraph:

Players do not receive a fixed amount per raid attended, or per boss killed, or per hour spent raiding like in the simple DKP system. Instead, whenever an item drops, the player with the most DKP still gets it and pays the fixed DKP price for it, but at the same time every other player in the raid gets an amount of DKP equal to the price of
the item divided by the number of players in the raid minus one (the winner). This process instills the system with the quality to which it owes its name: at any given point, if we add up the DKP amounts that every player has in the guild, the sum will always be zero, since every point that is expended by a player to get loot, returns to the system split among the rest of the people in the raid as income, and no other source of DKP income exists. The advantages of this system are the following:

+ It deals with inflation in an emphatic way. According to the quantity theory of money, the general price level of goods and services is directly proportional to the amount of money in circulation. Since both DKP prices and the total amount of DKP are fixed, those prices will always express the same amount of value that they would do initially, at the adoption of the system. Keynes and Friedman would be happy to discover that MMORPG players eventually became “quantity theorists” in a virtual world to solve their macroeconomic problems!

+ It still rewards attendance and effort, as players who do not attend raids cannot improve their standing.

+ It is very attractive for new players joining the guild, unlike every other dkp system we talked about so far. A new player starts from zero, which would usually be about halfway through the list of guild members in relation to their DKP amount, making them more likely to start getting items soon after
joining. The DKP of players who quit the guild is also not lost but spread among the remaining members.

+ It allows for modification of item prices without affecting the total DKP in circulation. When the developers of the game release new, harder content with better rewards, the *positional value* of current items decreases sharply in comparison to the newer ones, which is a phenomenon we described earlier called *MUDflation.* Such an occasion might call for a readjustment of DKP prices so that the items reflect their up-to-date value.

+ It reduces the amount of loot that goes to waste, as players are less averse to express their interest in smaller upgrades, knowing that their points would go back up when other players eventually do the same thing.

All these qualities have made zero-sum DKP one of the most popular loot distribution systems historically, and one that features heavily in academic discourse as well. Krista-Lee Malone, author of one of the most comprehensive papers on loot distribution and DKP systems, became member of a WoW raiding guild that used this system for her research purposes, and praised its merits highly by virtue of her experience with it (Malone, 2009).

Again, just like the real world, it seems that there is no perfect system for scarce resource allocation. The unique problem zero-sum DKP faces is lies behind its apparent strength: it only rewards points when items are given to players. If no player wins an item, no player gets points and the system remains in the same state, potentially
discouraging players who feel that their DKP supply is stagnating. This is not ridiculous, as it can actually happen in two very common situations:

- when a raid is on farm status by the guild, which means they have been clearing it quickly and effortlessly for several weeks, a situation might arise when most players already have what they needed to get from said raid, but some players still need one or two items, and the guild has to oblige them so as not to risk losing them over this issue, and in order to capitalise even on these few upgrades. In this situation, most items end up vended or disenchanted, and only a few items are acquired by players, which means that players who joined that raid but got no loot stand to gain only a minimal amount of DKP, if not zero.

- when a guild is progressing on a new raid, the players are still learning how to deal with the encounters, and the raid might not already have the gear level required to defeat these bosses. During those raid sessions, it is not uncommon for a guild to spend many hours only to manage defeating just a couple of bosses, or even no bosses at all. While this can be a frustrating experience, it is also a very important one in order to learn the fights and be able to progress as a guild to harder content. Not getting DKP because of the way the system works can add up on that frustration.

To address this issue, some guilds using zero-sum DKP have resorted to introducing a player dummy, which is a made-up player profile in
the system that gets charged with an arbitrary amount of points in raid sessions such as the ones described above, in order for that amount points to be distributed among the players who attended that raid, despite the difficulties. Of course, even if the DKP sum of the guild still remains zero, in practice this introduces a small amount of inflation when it is done, as this “player” is in reality an arbitrary outside source of player income that skews the amount of points in circulation. Still, guilds might be willing to accept this level of inflation in order to incentivise their players in situations like the ones we described.

Relational DKP (EPGP)

Relational DKP, also called EPGP after the quotient that defines it, is another modification of the traditional fixed-price DKP system, with a unique feature: each player’s DKP supply is not an actual amount of points, but a quotient between two distinct amounts of points that represent different things. Let’s explain it further:

- In a similar way to any other fixed-price DKP system, a fixed price is set for every item in the bosses’ loot tables at the initial adoption of the system.

- Every week, players earn an amount of points called effort points - $EP$, mainly by participating in raids, but also by contributing to the guild in other ways like gathering materials and helping new players prepare their characters for raiding.
The amount of these points depends on the amount of effort shown by each player: people who only come to raids will get less EP than people who also contribute in other ways, but still more than people who do not attend raids that week.

- For each player, the system also keeps track of another metric called *gear points* - GP, which starts at an arbitrary amount above zero, and increases every time that player gets a gear upgrade, in the way described as follows:

- Each time an item drops in a raid, the player who gets it among interested players is the one with the *highest EP/GP ratio*, as in the quotient that we get if we divide each player’s effort points with his gear points. Once the winner gets the item, his gear points increase by an amount equal to the item’s DKP price.

- In order to combat inflation, since both EP and GP can only increase over time, every week both effort points and gear points of every player *decay* by a fixed percentage (15% is a common number), which means they are reduced by said amount. Specifically for gear points, the initial amount does not decay, which means that the initial amount is the lowest point it can get back to. We want this to stay above zero to avoid any divisions by zero in the calculation of the EP/GP ratio.

This is surely a bit more complicated than any other system we examined before, which is this system’s main downside: it requires significant effort from the officers to be put into practice and to be maintained. On the other hand, it posts several upsides:
+ it rewards effort in a very transparent way: effort is the numerator of the ratio, which means that the more effort you put into the guild, the more likely you are to get loot.

+ it allows guilds incentivize literally anything they want by simply adding it to the things that reward EP.

+ It is very efficient at spreading loot around, as it makes it very hard for a single player to be greedy, since his gear score increases with every item he gets, which results to his EP/GP ratio to diminish due to GP being the denominator of the ratio.

+ It is very new player friendly, in a very customisable way: the officers can decide the initial ratio of a player by simply modifying his initial effort point or gear point ratio.

The sophistication of this system makes it a popular alternative to other DKP systems. However, the complexity and effort needed to maintain it (adjusting prices, keeping up with two different resources, having to calculate the ratio for every player all the time) make it slightly unattractive to all but the most meticulous of guild officers.

**Auction Bidding DKP systems**

The final kind of DKP systems that is prevalent in WoW guild is a category of variable-price systems called *auction/bidding systems*. As the name suggests, while players earn their DKP through a simplistic weekly income just like the case of simple DKP, the way they spend it resembles an auction: every time an item drops, interested players bid
an amount of DKP they can afford to spend on it, either in plain view or secretly. The winner is the player who submitted the highest bid, and after he gets it, an amount of DKP equal to that bid is subtracted from his DKP pool.

The obvious appeal of these systems is that they have a *laissez-faire* quality to them: player bids express the exact amount of resources they are willing to part with in order to get them, which directs item pricing right at their hands, and arguably works as a more accurate representation of the items’ value to the players than a fixed price.

However, to quote a certain Rocky Balboa, the world ain’t all sunshine and rainbows! While systems like these always had their appeal, especially in guilds comprised of people who enjoyed the gambling aspect of this approach, the problem which did not allow them to achieve the same levels of popularity like other fixed price DKP systems is one we already spoke about: *collusion*. Again, in the context of these systems, players can organise into cliques to manipulate prices. When they would be up only against other members of the clique, they would decide who gets the item among them in advance and then bid a minimum amount so that this player gets his item for a very low price. When they would be up against players outside their clique, and they knew they really wanted an item, they would engage in a bidding war in order to make that player pay the maximum price he would be willing to pay for it. Having experienced such occasions, most guilds would end up switching to other systems, immune to collusion.
3.5. Personal Loot

In very recent expansions of the game, the developers behind World of Warcraft, seeing how the issue of loot distribution can always be a source of conflict among players, as well as a confusing aspect for newcomers to the game, decided to implement a new default boss loot mode called *personal loot*.

Quoting the online source *WoWpedia*:

“Under personal loot the game chooses a number of players and awards them a random item for their spec (i.e. class and specification), while everyone else receives an amount of gold specific to them.”

Starting with the latest expansion of the game, *Battle for Azeroth*, which will be released to the public at roughly the same time as this dissertation, it was announced that this loot mode will replace traditional loot modes like *simple roll* and *master looter*. While this change is seen as a way to untangle a thorny issue and make the game simpler by developers, power gamers especially have been very vocal against this change in platforms like *Reddit*, rightfully claiming that this reduces the liberty players have on how to distribute loot in a way they see fit.

The authors do not have experience with this very recent latest version of World of Warcraft, and like the other researchers mentioned in this dissertation, we can only opine on the version of the game we experienced, where all these systems were commonplace.
Only time will tell whether the decision to force *personal loot* upon players is wise, or misguided. For our purposes, the systems we examine still hold their ground in other MMORPGs that have kept *master loot* as a player option.

The simulation process that we will describe in the next chapter is based on the original version of World of Warcraft that was released back in 2004, affectionately called by players nowadays as *Vanilla WoW*, when raids were still tuned for groups of forty people, and *personal loot* did not exist. In an interesting turn of events, this year, Blizzard Entertainment announced plans to bring *Vanilla WoW* back by introducing *Classic WoW servers*, as in game servers where the game world is exactly the same as it was back in the original game, without any changes that were introduced with later expansions. If this comes to fruition, then it is a certainty that traditional loot distribution systems like the ones we examined will come back to the spotlight.
4. **Empirical Methodology:**

**Simulation**

For the last part of this dissertation, we decided to simulate a guild going through three tiers of raid progression, using a different LDS every time but keeping every other variable intact, in order to see if we can reproduce the practical observations we mentioned in the previous chapter, and also to examine whether any of these systems is actually more efficient by design, *ceteris paribus.*

The simulation was developed by the author using the *pandas* and *numpy* libraries of the *Python* programming language, and econometric analysis of the output was conducted using the statistical package *STATA.* Of course, we did not create any kind of AI agents to play the actual game! Instead, we worked with two datasets: one that represents a group of players who form a guild, and another that represents a set of items organised in boss loot tables, based on real raid data from the original version of World of Warcraft.

4.1. **Assumptions, constraints and available data**

In order to reduce computational complexity in the model, we made some initial assumptions about the character and the composition of the guild, the expected behaviour of players, the distribution and the
power level of the raiding items, the loot systems we will experiment with, and the specifics of the raid progression that our virtual guild will attempt to go through.

The guild

In the study closest to what we attempted to do, Maggiorini and his colleagues ran a set of simulations (Maggiorini et al., 2012a; 2012b) to deduce which systems fit different kinds of players best, based on Bartle’s archetypes: achievers, socializers, explorers and killers (Bartle, 1996). In this study, what we wanted to see is whether the loot systems themselves have an observable effect on guild performance. For that reason, we thought that the best course of action would be to have the same guild go through a fixed progression process, with the only difference between sets of iterations being the loot distribution system used by the guild. This way, we would control for endogeneity that might crop up if we created different kinds of guilds, and thus we could ostensibly attribute any significant variance in the performance metrics to the loot system only.

The first question we had to address was about the size of the guild, as in the number of members. Raids in vanilla WoW were designed for groups of 40 players, and guilds would usually be larger than that number, so that the guild would be self-sufficient for raiding purposes, and so that it could afford to have a bench: a number of players available to replace regular members who would be absent on
a raid day. If the guild was too big though, like having 200+ members, it is obvious that competition for a raid spot would be too high, and chances for a cohesive group that will learn encounters and progress as a team would get slim. Browsing through available literature, we discovered that Ducheneaut had attempted to address the same issue (Ducheneaut et al., 2007) and he found some answers in a couple of articles on an online blog about the Dunbar Number (Allen, 2005a; 2005b). This number was first proposed in the 1990s by the anthropologist Robin Dunbar, who found a correlation between primate brain size and average social group size. By extrapolating these results to humans, he proposed that they can comfortably maintain only about 150 stable relationships. Allen, in his article series, used data from MMORPGs like Asheron’s Call and Ultima Online, proposed that the usual size for active group members for creative and technical groups (like a guild) hovers somewhere between 25-80, but it is optimal around 45-50. Anything more than this and the group would have to spend too much time "grooming" to keep group cohesion. Data from Ultima Online, specifically, seemed to center around guilds of 60 members as the norm. Already having in mind that, in our simulation, we would have to stick with the same players for the whole progression period, we agreed that 60 is a very convenient number as it allows for a small bench, which, with the percentages for players of different attendance levels we had in mind, seemed to converge to a number of available players for each raid slightly above 40. In a real guild situation, this would be ideal, since
both the group would fill, and not too many players would be left behind, leading to a very tightly-knit community indeed.

Next issue about the guild would be its class composition. These 60 players would have to be split into classes and roles in a way so that every class and role is represented in a realistic way. The way we did the split in this simulation was based on gaming forums and sources, as well as the authors’ experience. Another required split among members would be related to their level of attendance.

Experience in raiding guilds would point to three different kinds of players: core members who are the backbone of the raid, join almost every raid, and eventually tend to become part of the guild’s leadership as officers, regular players, average gamers who would do a sensible amount of raiding and would put up a decent amount of effort towards the guild, without usually wanting to carry extra responsibilities by taking the mantle of an officer, and casual players, who would be people who used to play other games as well or had a busy real life schedule with their jobs or families, and ended up only attending raids every once in a while, staying in the guild primarily for the social aspect of it. We were happy to discover sociological literature that confirmed our observations (Ang and Zaphiris, 2010).

The amount of players within each of these three attendance groups would usually determine the guild character: guilds with lots of core players would be classified as hardcore guilds, and usually were among the top guilds in the world in terms of raid progression, while guilds with a high amount of social players would be called casual
guilds, with their main focus being to create a nice community instead of breaking progression records. For the purposes of this simulation, since loot distribution systems only take effect in raiding situations, we chose to create a guild closer to the hardcore paradigm, with the bulk of players having an attendance percentage that would classify them as power gamers (Malone, 2009). In doing this we end up focusing only on a subgroup of the kinds of player groups that Maggiorini modelled in his work: the Achievers. The end product is described using the tables below:

<table>
<thead>
<tr>
<th>Role</th>
<th>in guild</th>
<th>core (90%)</th>
<th>regular (70%)</th>
<th>casual (50%)</th>
<th>avg. avail.</th>
</tr>
</thead>
<tbody>
<tr>
<td>tank</td>
<td>6</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>4.4</td>
</tr>
<tr>
<td>physical dps</td>
<td>24</td>
<td>8</td>
<td>12</td>
<td>4</td>
<td>17.6</td>
</tr>
<tr>
<td>magical dps</td>
<td>16</td>
<td>6</td>
<td>7</td>
<td>3</td>
<td>11.8</td>
</tr>
<tr>
<td>healer</td>
<td>14</td>
<td>4</td>
<td>8</td>
<td>2</td>
<td>10.2</td>
</tr>
<tr>
<td>total</td>
<td>60</td>
<td>20</td>
<td>30</td>
<td>10</td>
<td>44</td>
</tr>
</tbody>
</table>

*Table 1: Roles by attendance level.*

In this first table we see how the 60 members of the guild were split by role and by attendance level. The “in guild” totals reflect a realistic amount of how many of these roles a WoW guild would have in vanilla. Tanks would be the hardest role to gather the required gear for, but thankfully only a few tanks were needed per raid (about 3-4), and they would all be Warriors in terms of class. Healers needed would generally be any amount between 8 and 12 people, which would correspond to roughly two five-man healer groups in a forty-man raid. The healing classes in vanilla WoW were Druids, Paladins and Priests. The bulk of the raid would be damage dealers (dps),
slightly skewed towards physical dps because there were more physical dps classes than magical dps (usually referred to also as casters). Physical DPS classes would be two melee classes, Warriors and Rogues, and a ranged class, Hunters. There were only two classes that could deal magical damage, both ranged: Mages and Warlocks.

The class / attendance breakdown ended up being as follows:

<table>
<thead>
<tr>
<th>Class</th>
<th>in guild</th>
<th>core</th>
<th>regular</th>
<th>casual</th>
</tr>
</thead>
<tbody>
<tr>
<td>warrior</td>
<td>14</td>
<td>5</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>hunter</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>rogue</td>
<td>10</td>
<td>3</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>mage</td>
<td>8</td>
<td>3</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>warlock</td>
<td>8</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>priest</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>paladin</td>
<td>5</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>druid</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>total</td>
<td>60</td>
<td>20</td>
<td>30</td>
<td>10</td>
</tr>
</tbody>
</table>

*Table 2: Classes by attendance level*

The only things to note here would be to address the low number of priests, paladins and druids, which is explained by the lower need for healing classes we discussed above, and the high number of warriors and rogues. Warriors are that many because among them there are both tanks and damage dealers, since it was the only class able to excel in more than one role. Rogues were simply the most popular class in vanilla wow, and they were desirable in raids, so we skewed them up a bit in numbers, while bringing a few less hunters because while they were a popular class too, they were less desirable in raids as they would usually be performing worse than rogues due to game-related imbalances favouring melee classes.
We didn’t speak about the attendance split yet, even if it is apparent in both tables. We decided on a 20/30/10 split between core/regular/casual members, in order to give our team the composition characteristics of a semi-hardcore raiding guild, skewed towards more active members, but not overly much. The percentage numbers next to attendance levels were used as estimates for the amount of raids each player in their corresponding player group would be available for. Thus, hardcore players would be available for approximately 90% of the raids (about one absence in more than two months in game terms - raids were weekly), regular players would be available for approximately 70% of the raids (about one absence every month), and casual players would only show up for half the raids. In Table 1, the average availability column shows how this is expected to end up for raid attendance on the guild level. As you can see by the average at the bottom right corner, 44, we expect that most raids would be filled, and there would be a small bench available.

The end product of this process was the guild.csv file that we fed into the simulation.

**The players**

We already talked about how we model the decision for players to decide whether to attend a raid or not: a probability relative to the attendance level assigned to each one of them. What we didn’t talk about is how are the players going to decide whether they want an item or not, or in other words, when to express interest in an item.
Modelling complex behavioural models would be far from the scope of this dissertation. Instead, not wandering too far away from traditional economic theory, we decided to model players as rational greedy agents. Rational, as in wanting to improve the total value of their items, and greedy, as in making decisions only based on the information they have at the specific moment that the decision has to be taken. Our players essentially behave as if they are guided by the famous Queen lyrics: I want it all, and I want it now!

In the context of the simulation, the concept is simple: whenever an item drops, if the player is able to equip it, and it is better than what he currently has (based on a metric that we will discuss below), then the player expresses interest for it. This behaviour is realistic for many players, but the most sophisticated and knowledgeable among them, in reality, tend to weigh in their future options and actually eschew some upgrades in the present in order to get a bigger update in the future, which is quite the opposite of a greedy agent! As this would involve a complicated game-theoretical model to put in effect, we simply stuck with what we could make, at the expense of a degree of realism. A player’s power is calculated by the itemlevel of his items, using a different formula for each class as certain items mattered more for one class than the other. The concept of itemlevel will be explained below.
The items

For the purposes of the simulation we used real item data from user-managed, WoW related online sources like Wowhead. We then restricted items to be only available to the classes that would normally use them in a real in-game situation. For example, shields that would improve armor and defense would be restricted to tank warriors, while shields that would improve healing would be restricted to paladins, since druids and priests are not able to wear a shield in WoW. This painstaking process was conducted by reading up on what kinds of items each class would equip, and what attributes were desirable by different classes, in order to make distribution of those items as realistic as possible.

To simulate the value of each item, we used a property of the items that we could find on item databases called itemlevel. Items dropping from higher tiers of raid progression would have a higher itemlevel than those from lower tiers, so this was accurate and realistic enough for our purposes. In reality, game-savvy players might sometimes prefer an item with a lower itemlevel, simply because they have inferred that the specific mix of attributes it improves suits their needs better. The end product of this process was the items.csv file, the second dataset that we fed into the simulation.
The loot systems

Among the several loot systems we described, we decided to test five characteristic ones: one RNG-based (simple roll), one priority-based (suicide kings), and three point-based ones (simple DKP, Zero-Sum DKP and EPGP). This is actually consistent with relevant literature (Andrews, 2010; Fairfield and Castronova, 2006; Maggiorini, 2012a; 2012b). We avoided bidding systems like auction dkp because modelling an agent that chooses the best amount of points to bid would require a very deep dive in game theory and artificial intelligence algorithms! For each of the loot systems, a function was created within the simulation that encompasses all their rules.

The raid progression

We decided to use a three-tier progression structure, consisting of three iconic raids of Vanilla WoW: Molten Core, Blackwing Lair, and Naxxramas. These three raids were actually called tier 1, tier 2 and tier 3 respectively by players at the time of their release, since they were the first three raids that would offer, among other rewards, a full armor set for each class. Our item database is essentially comprised of every possible item that players could get as loot from these three raids. We did research on which items drop from which boss, and how each boss handles its loot tables, in order to make the system as realistic as possible. As you go from one raid to the next, the average itemlevel increases, which is what provides our simulation with its
progression character. While there were some other raiding instances in Vanilla WoW, we decided not to include them to not make the simulation overly complicated, as it would not make a huge difference in the long term anyway. The only exception was including the dragon Onyxia alongside Molten Core in the first progression tier, for item-set related reasons that add cohesion to the progression structure.

4.2. Description of the simulation process

The simulation process follows the following steps:

1. At the start of each iteration, we choose the LDS that will be used, and we modify our code accordingly.

2. At the start of every raid, players declare their availability, and the raid roster is formed by picking the best available player from each role. This process continues until there are no more available players, or the raid roster is full (40 players). To avoid saturating the guild with too many support classes (tanks and healers), we put a cap on the maximum amount of those classes that can join the raid.

3. After the raid is formed, the raid strength is calculated, as an average of the power level of every character in the raid. This is an important metric for our purposes, as it works in the way of an indicator of how much the guild gains in power with every raid. In the simulation, raid strength determines how far into the progression structure the raid can proceed. The reasoning
behind this is that in general, in order to be able to progress on further tiers, the guild members have to be fairly heavily equipped with raiding gear from the previous ones. For the sake of putting some numbers out to make this easier to understand, here is a list of the progression breakpoints that we used:

a. In order to begin the first tier of progression, Molten Core, our raid has to have a strength of more than 50. The initial item level average is 55, so only a very small turnout to the raid will drop this average below 50.
b. In order to progress to the last stage of Molten Core, the raid has to reach a strength of 60.
c. In order to begin the second tier of progression, Blackwing Lair, the raid has to reach a strength of 62.5.
d. In order to reach the final stage of Blackwing Lair, the raid has to reach a strength of 70.
e. In order to begin the third tier of progression, Naxxramas, the raid has to reach a strength of 72.5.
f. In order to reach the final stage of Naxxramas, the raid has to reach a strength of 80.
g. As a note to the above, items in Molten Core have a power level of about 67 on average, items in Blackwing Lair, 77, and items in Naxxramas, 87. Therefore, every player in the raid only has to get about half of his gear up-to-date with the current content in order for the raid to progress
to next step. Every time the raid reaches one of these breakpoints and it cannot go past it, the raid ends, and the algorithm moves on to the next week, and the next raid.

4. The raid goes through every boss’ loot tables, and awards items as dictated by the loot system in each case. This continues until the raid reaches a breakpoint that it can’t go past. Raid strength is updated after every item that drops in order to allow the guild to progress if the breakpoint is reached during a raid.

5. This process is repeated until we reach a number of raids specified by the researcher. In our case we decided on 104 raids, which represent 104 weeks in real time (two years), which corresponds to the bigger part of an expansion cycle in WoW terms.

For our purposes we performed 10 iterations for each loot system, and then averaged them out elementwise to control for outliers.

### 4.3. Performance metrics

The main performance metric that we use, and one that really matters a lot to players and guilds, is how fast they can progress through content, or in other words, how soon they can manage to be able to defeat every boss in the game, in order to have access to every item that all these bosses can offer for their players. At any given week, the content that the guild can access is determined by raid strength.
Therefore, raid strength is the metric we examine, as a function of time and loot system used. We also calculated some other metrics like the standard deviation among player power levels within guild members (as an indicator of how evenly loot is spread out throughout the raid), and also the average power level among groups of players with similar attendance, to gauge how *meritocratic* was each LDS.

All these metrics, for each player made loot system, were compared to the default loot system which is the simple roll, to see their merit of adoption, in the following way: We subtracted the value for the simple roll system from the (average) metric for each week in each other system (Suicide Kings, Simple DKP, Zero-sum DKP, EPGP). Thus, the numbers that we use to perform our econometric analysis are expressing the *raid strength gain* over the Simple Roll system.

### 4.4. Analysis and presentation of results

After the simulation and the data preparation processes described above, we are presented with five panels of guild metrics for each LDS used, over 104 time periods (weeks). More specifically, the metrics we calculated are the following:

- *Raid strength* gain over the simple rolling system. Again, raid strength is defined as the average power level among raid participants, not all guild members.
- Average power level gain over the simple rolling system, among *core raiders* in the guild.
• Average power level gain over the simple rolling system, among regular raiders in the guild.

• Average power level gain over the simple rolling system, among casual raiders in the guild.

• Standard deviation of power level among all players in the guild.

In order to analyse those panels and attempt to estimate the effect of LDS choice over each of these metrics, we ran a pooled Ordinary Least Squares estimator over the panel data, with the metric as the dependent variable and the LDS used as the only independent variable, split into dummy variables for each LDS. The reason we chose the pooled OLS model over other models suitable for panel analysis like fixed-effects or random-effects, was that we already knew that there is no endogeneity among the regressors, as we used the exact same guild that we created for our simulation processes for every iteration, and there are no universal effects across time since nothing else influences our simulation other than loot table RNG, and the only thing that we changed every time was the loot system used.

The pooled OLS can be written as follows, with \( y \) being the dependent variable (strength gain), \( x \) is the independent variable (loot system), \( \alpha \) and \( \beta \) are coefficients, \( i \) and \( t \) are indices for individuals and time, and \( u \) is the error term (Cameron and Trivedi, 2010).

\[
y_{it} = \alpha + x'_{it}\beta + u_{it}
\]

Fig. 8: The pooled OLS model
What matters for our purposes is the value of the $\beta$ coefficient, which expresses the effect of the LDS used on strength gain, in terms of power level points. Considering that the difference between tiers of progression, as it is defined in our simulation, is about 10 gear strength points, we can give the following example to make our results more coherent: if the coefficient of one LDS takes a value of 1, it would mean that a guild adopting this LDS would have essentially covered 10% of the way towards the third raid tier, at the time when a guild using the simple rolling system would have only just arrived at the second one.

We calculated the $\beta$ coefficients for each system per each metric through the pooled OLS method, and we organised all the results on the table below, for easier reference and comparison. The columns of the table are the metrics in the order that we explained them earlier in this chapter, each representing a different panel data set, and the rows of the table correspond to the LDS used each time: “sk” for Suicide Kings, “sdkp” for Simple fixed-price DKP, “zsdkp” for Zero-sum DKP, and “epgp” for Relational DKP (EPGP).
As one can already see from the table above, our analysis brought out some interesting insights, most of them expected, but also some surprising ones. We will try to elaborate on these results for each one of the metrics we examined in the subsection below.

**Raid Strength Gain**

In the performance metric which matters most to the guilds, average power level among raiders (raid strength), the results where the most surprising. Only one system appears to improve raid strength over the default one, zero-sum DKP, end even for that system, the severity of the effect is minimal: a gain of about 0.3 in average power level, which would translate to an advantage of less than 3-4% on the tier
progression race over a guild using the default system, according to the logic we described earlier regarding power level points. Two other systems fail to demonstrate a statistically significant result, while the last one, EPGP, actually seems to slow down the raid compared to the default system!

Regarding the minimal impact of the systems, we believe that the explanation lies at our simulation parameters. Simply put, the “ideal guild” we created proved to be too well structured to be significantly affected by the choice of loot system! No new players, no players who quit, and a tightly knit community that manages to stay as a unit for two years of raiding might have been a bit unrealistic, in hindsight, but since we wanted to see if LDS have an inherent effect on raid performance, our results actually give us a good answer: they do not! An ideal guild can use any loot system without noticing much difference in terms of performance, even the simple rolling one, if the players are willing to go with it. However, in practice, guilds always have their flaws. Our advice to a guild leader based on the results of our simulation would then be to just choose whichever system better caters to their guild’s needs and flaws according to accepted practice, since our analysis shows that they can all be efficient over time, and they do not have inherent systemic flaws. Still, guilds on the very high end of raid progression might still be willing to maximise every positive influence they can get towards their performance. To those guilds, we could propose the zero-sum DKP system, based on our results. Apparently, the neat way in which it deals with DKP inflation
while still rewarding attendance can be beneficial even in the most well-structured and tightly knit guilds.

The statistically significant negative influence of the EPGP system was a surprise to the authors, and a real head-scratcher. Our best guess would be that the penalty inflicted on the most geared players by the GP on the numerator eventually ends up being too harsh on them, as they might be surpassed in EPGP by less committed people before a tier of progression ends, leading them to miss out on being the first to get stronger upgrades at the start of the next tier.

As this is the most important metric, we would also like to provide a graph of how raid strength gain progresses over time with each LDS. This will not be necessary in the next few metrics, as their main purpose was to confirm practical observations about the systems regarding specific player groups.
Fig. 9: Raid strength gain over time, per system chosen.

The graph above shines a better light of how different loot systems affect raid performance over time. The drop below zero on the EPGP chart possibly confirms our suspicions about harsh punishment on people who get good gear first. Simple DKP looks like it’s doing very well during the first year of raid progress, but it takes a great dive once the vast difference in gear among players of different attendance levels starts to strongly affect power level averages. Suicide Kings expectedly performs almost similarly to the default system, while Zero-sum DKP is the only one that consistently scores slightly above zero, only dropping right at the end of the progression cycle when upgrades don’t matter that much anymore.
Core player strength gain

Core players demand meritocracy above everything else, and they despise RNG-based systems like simple rolling. Therefore, it should have been expected that every system which enables meritocracy by rewarding effort, like the three point-based systems in our simulation, significantly improve average power level across their ranks. Equally expected would be the fact that Simple fixed-price DKP is the most beneficial for core players, as they are able to consistently amass more points than players who attend less, essentially getting first priority on every upgrade over the other player groups. If core players have the most influence in their guild, they would act in their best interest by vouching for such a simple DKP system, especially if players who attend less would not be willing to object to a system like that.

Regular and casual player strength gain

As the concept of meritocracy favours players who join more raids, it naturally affects regular and casual players in a negative way, which from an ethical standpoint might actually be acceptable, even by these player groups. The only system, apart from simple rolling, which does not affect them negatively in a statistically significant way is the Suicide System, as expected for a system with a main purpose of spreading gear around as evenly as possible. If the choice of LDS in the guild is decided by a majority vote, and these groups combined
form the majority, it would be to their best interest to vote for the default simple roll system, or at least the Suicide Kings one.

**Standard Deviation of power levels**

We only included this metric to confirm the following practical observations about LDS:

- The simple rolling system manages to spread gear evenly because of the *law of large numbers* dictating that everyone will get lucky roughly the same amount of times, in the long term.
- Suicide Kings was created as a system that spreads gear around guildmates as evenly as possible, and this is also confirmed by standard deviation in power levels being close to zero.
- Point-based systems introduce *bias* towards players who put more effort and attend more raids, skewing the power level balance in the guild towards core members. This is generally considered more than acceptable by most guilds, and that’s why systems like Suicide Kings, while sounding very fair on paper, never caught on heavily in practice.
5. Conclusions and future work

Despite the relatively low impact of loot systems in an “ideal” guild per our results, it is interesting to see that zero-sum DKP, the only loot system that inherently looks like an improvement over simple rolling, is the one that featured a concept which also applies in the real world economy: the idea that controlling the total supply of currency in order to keep inflation to an acceptable level is very important for the health of an economic system (the quantity theory of money). We were also happy to showcase that practical observations regarding specific systems being biased towards benefiting specific player categories could be reproduced and confirmed experimentally. In terms of practical applications, we believe that the most important conclusion guild leaders can take from this study is that in an ideal world, most systems perform relatively similarly, and so their decision for a loot system should mainly depend on the specific needs of the guild and the specific problems they would like to solve through it, without any prejudice towards one LDS or another. It remains to be seen if our conclusions could also affect decision-making processes in the real world, since the unique nature of goods that Loot Distribution Systems were made to manage makes it hard to find equivalents, considering that almost every good or resource in the real world is pecuniary. Still, as we mentioned earlier, there is a noticeable trend of economic activity moving into virtual environments, and in such a future, it would not be hard to imagine non-pecuniary scarce virtual
goods and resources becoming important to groups of people, who would seek optimal ways to resolve the issue of distributing them among themselves.

Regardless of our experimental outcomes, the idea that gamers, faced with the task of allocating scarce resources in a virtual world, resorted to creating their own economic systems, which in time evolved and became more sophisticated in order to tackle economic issues like inflation and market distortion, is a clear indicator that virtual worlds are a ripe field of study for economists. With every new technological advancement bringing us closer to a future where the boundaries between the physical world and virtual worlds will be very hard to discern, the value of studies related to artificially scarce virtual goods increases. From the perspective of Applied Economics, especially, the opportunity to conduct true experiments and analyse their outcomes with a high level of data collection accuracy and in real time, is reason enough to think twice before doubting the worth of virtual economics as a legitimate field of research.

This particular work was experienced by the authors as an excellent starting point for exploring ways to model and simulate economic behaviour. In future attempts to improve the method followed in this study, we consider taking a page from fields like game theory and incentive theory in order to be able to model human agents in a more realistic way. Another direction we would like to maneuver our efforts towards would be to attempt to create a new loot distribution system, potentially tapping on the power of machine learning methods like
artificial neural networks. It would be very interesting to see what would come up as the optimal LDS by such methods, and whether that LDS would be codifiable in a way as to be useable by gamers in MMORPGs without excessive requirements in technical knowledge. In any case, we feel that this study has only scratched the surface of a very interesting, and relatively unexplored subject of economic theory.
References


• **Bilir, T.** (2009). Real economics in virtual worlds: A massively multiplayer online game case study: Runescape.


• **Cameron, A. C., and Trivedi, P. K.** (2010). *Microeconometrics using stata* (Vol. 2). College Station, TX: Stata press.


• **Castronova, E.** (2001). Virtual worlds: A first-hand account of market and society on the cyberian frontier.


• **Castronova, E.** (2008). *Synthetic worlds: The business and culture of online games.* University of Chicago press.


conference on Human Factors in computing systems (pp. 407-416). ACM.


- Lehdonvirta, V. (2010). Virtual worlds don’t exist: Questioning the dichotomous approach in MMO studies. *Game Studies, 10*(1).


(Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering).


- **Seiler, J.** (2008). What Can Virtual-World Economists Tell Us about Real-Worlds Economies. in *Scientific American, March 17th issue,* available online at:


import pandas as pd
import numpy as np
guild = pd.read_csv("guild.csv", header=0, sep="", engine=’python’)
items = pd.read_csv("items.csv", header=0, sep="", engine=’python’)

raidmetrics = pd.DataFrame()
# this may be used for logging purposes
raidcounter = 0

# This is just for initialising power levels. inraid will revert back to the default 0 after
# the updatepower function skips people out of raid to reduce runtime, as they are not getting upgrades anyway
# I could have initialised at the csv level but this was useful for testing the function code
guild.loc[\:, "inraid"] = 1

# The updatepower() function updates player power level after every item is assigned. It should be run after every drop
# Each class has each own formula as the weight of each item slot differs for each class. formulas can be found in the google doc
# returns an estimate of the average item level per raider
def updatepower():
    raidpower = 0
    for i in range(0, 60):
        if guild.loc[i, "inraid"] == 1:
            if guild.loc[i, "class"] == "tankwarrior":
                guild.loc[i, "gearLevel"] = (((guild.loc[i, "oneHandLVL"] + guild.loc[i, "trinketbLVL"] + guild.loc[i, "trinketaLVL"] * 1.2) +
                (guild.loc[i, "offhandLVL"] * 1.4) + (guild.loc[i, "neckLVL"] + guild.loc[i, "cloakLVL"] + guild.loc[i, "wristLVL"] +
                guild.loc[i, "ringaVL"] + guild.loc[i, "ringbVL"]) * 0.8) + guild.loc[i, "rangedVL"] + guild.loc[i, "headVL"] +
                guild.loc[i, "shouldersVL"] + guild.loc[i, "chestVL"] + guild.loc[i, "legstVL"] + guild.loc[i, "feetVL"] + guild.loc[i,
                "waistVL"] / 16
            elif guild.loc[i, "class"] == "dpswarrior":
                guild.loc[i, "gearLevel"] = (max((guild.loc[i, "twoHandLVL"] * 2.6), ((guild.loc[i, "oneHandLVL"] + guild.loc[i,
                "offhandLVL"] * 1.3)) *
                (guild.loc[i, "trinketbLVL"] + guild.loc[i, "trinketaLVL"] * 1.2) + ((guild.loc[i, "neckLVL"] + guild.loc[i, "cloakLVL"] +
                guild.loc[i, "wristLVL"] +
                guild.loc[i, "ringaVL"] + guild.loc[i, "ringbVL"] * 0.8) + guild.loc[i, "rangedVL"] + guild.loc[i, "headVL"] +
                guild.loc[i, "shouldersVL"] + guild.loc[i, "chestVL"] + guild.loc[i, "legstVL"] + guild.loc[i, "feetVL"] + guild.loc[i,
                "waistVL"] / 16
            elif guild.loc[i, "class"] == "hunter":
                guild.loc[i, "gearLevel"] = (max((guild.loc[i, "twoHandLVL"] * 2), (guild.loc[i, "oneHandLVL"] + guild.loc[i,
                "offhandLVL"])) + (guild.loc[i, "trinketbLVL"] * 1.2) + ((guild.loc[i, "neckLVL"] + guild.loc[i, "cloakLVL"] +
                guild.loc[i, "wristLVL"] +
                guild.loc[i, "ringaVL"] + guild.loc[i, "ringbVL"] * 0.8) + guild.loc[i, "rangedVL"] + guild.loc[i, "headVL"] +
                guild.loc[i, "shouldersVL"] + guild.loc[i, "chestVL"] + guild.loc[i, "legstVL"] + guild.loc[i, "feetVL"] + guild.loc[i,
                "waistVL"] +
                (guild.loc[i, "rangedVL"] * 1.6) / 16
            elif guild.loc[i, "class"] == "rogue":
                guild.loc[i, "gearLevel"] = (((guild.loc[i, "oneHandLVL"] + guild.loc[i, "offhandLVL"]) * 1.3) + ((guild.loc[i, "trinketbLVL"] +
                guild.loc[i, "trinketaLVL"] * 1.2) + ((guild.loc[i, "neckLVL"] + guild.loc[i, "cloakLVL"] +
                guild.loc[i, "wristLVL"] +
                guild.loc[i, "ringaVL"] + guild.loc[i, "ringbVL"]) * 0.8) + guild.loc[i, "rangedVL"] + guild.loc[i, "headVL"] +
                guild.loc[i, "shouldersVL"] + guild.loc[i, "chestVL"] + guild.loc[i, "legstVL"] + guild.loc[i, "feetVL"] + guild.loc[i,
                "waistVL"] / 16
            elif guild.loc[i, "class"] == "mage":
                guild.loc[i, "gearLevel"] = (max((guild.loc[i, "twoHandLVL"] * 2.6), ((guild.loc[i, "oneHandLVL"] + guild.loc[i,
                "offhandLVL"])) * 1.3) + ((guild.loc[i, "trinketbLVL"] * 1.2) +
                (guild.loc[i, "neckLVL"] + guild.loc[i, "cloakLVL"] + guild.loc[i, "wristVL"] +
                guild.loc[i, "ringaVL"] +
                guild.loc[i, "rangedVL"] + guild.loc[i, "headVL"] +
                guild.loc[i, "shouldersVL"] + guild.loc[i, "chestVL"] + guild.loc[i, "legstVL"] + guild.loc[i, "feetVL"] +
                (guild.loc[i, "waistVL"] / 16
            elif guild.loc[i, "class"] == "warlock":
                guild.loc[i, "gearLevel"] = (max((guild.loc[i, "twoHandLVL"] * 2.6), ((guild.loc[i, "oneHandLVL"] + guild.loc[i,
                "offhandLVL"])) * 1.6) + (guild.loc[i, "trinketbLVL"] * 1.2) +
                (guild.loc[i, "neckLVL"] + guild.loc[i, "cloakLVL"] +
                guild.loc[i, "wristVL"] +
                guild.loc[i, "ringaVL"] +
                guild.loc[i, "rangedVL"] + guild.loc[i, "headVL"] +
                guild.loc[i, "shouldersVL"] + guild.loc[i, "chestVL"] + guild.loc[i, "legstVL"] + guild.loc[i, "feetVL"] +
                (guild.loc[i, "waistVL"] / 16
            elif guild.loc[i, "class"] == "warlock":
                guild.loc[i, "gearLevel"] = (max((guild.loc[i, "twoHandLVL"] * 2.6), ((guild.loc[i, "oneHandLVL"] + guild.loc[i,
                "offhandLVL"])) * 1.6) + (guild.loc[i, "trinketbLVL"] * 1.2) +
                (guild.loc[i, "neckLVL"] + guild.loc[i, "cloakLVL"] +
                guild.loc[i, "wristVL"] +
                guild.loc[i, "ringaVL"] +
                guild.loc[i, "rangedVL"] + guild.loc[i, "headVL"] +
                guild.loc[i, "shouldersVL"] + guild.loc[i, "chestVL"] +
                guild.loc[i, "legstVL"] + guild.loc[i, "feetVL"] +
                (guild.loc[i, "waistVL"] / 16
        else:
            guild.loc[i, "gearLevel"] = 0
    return raidpower

116
guild.loc[i, "gearLevel"] = (max((guild.loc[i, "twoHandLVL"] * 2.6), ((guild.loc[i, "oneHandLVL"] * 1.6) + guild.loc[i, "offhandLVL"])) +
    (guild.loc[i, "trinketALVL"] + guild.loc[i, "trinketBLVL"] * 1.2) + ((guild.loc[i, "neckLVL"] + guild.loc[i, "cloakLVL"] +
    guild.loc[i, "wristLVL"] + guild.loc[i, "ringALVL"] + guild.loc[i, "ringBLVL"] * 0.8) +
    (guild.loc[i, "rangedLVL"] + guild.loc[i, "headLVL"] +
    guild.loc[i, "shoudlersLVL"] + guild.loc[i, "chestLVL"] +
    guild.loc[i, "legstLVL"] + guild.loc[i, "feetLVL"] +
    guild.loc[i, "waistLVL"])) / 16
elif guild.loc[i, "class"] == "priest":
guild.loc[i, "gearLevel"] = (max((guild.loc[i, "twoHandLVL"] * 2.6), ((guild.loc[i, "oneHandLVL"] * 1.6) + guild.loc[i, 
    "offhandLVL"])) +
    (guild.loc[i, "trinketALVL"] + guild.loc[i, "trinketBLVL"] * 1.2) +
    (guild.loc[i, "neckLVL"] + guild.loc[i, "cloakLVL"] +
    guild.loc[i, "wristLVL"] +
    guild.loc[i, "ringALVL"] + guild.loc[i, "ringBLVL"] * 0.8) +
    (guild.loc[i, "rangedLVL"] +
    guild.loc[i, "headLVL"] +
    guild.loc[i, "shoudlersLVL"] +
    guild.loc[i, "chestLVL"] +
    guild.loc[i, "legstLVL"] +
    guild.loc[i, "feetLVL"] +
    guild.loc[i, 
    "waistLVL"])) / 16
elif guild.loc[i, "class"] == "paladin":
guild.loc[i, "gearLevel"] = ((guild.loc[i, "oneHandLVL"] * 1.6) +
    guild.loc[i, "offhandLVL"] +
    (guild.loc[i, "trinketALVL"] +
    guild.loc[i, "trinketBLVL"] * 1.2) +
    (guild.loc[i, "neckLVL"] +
    guild.loc[i, "cloakLVL"] +
    guild.loc[i, "wristLVL"] +
    guild.loc[i, "ringALVL"] +
    guild.loc[i, "ringBLVL"] * 0.8) +
    (guild.loc[i, "rangedLVL"] +
    guild.loc[i, "headLVL"] +
    guild.loc[i, "shoudlersLVL"] +
    guild.loc[i, "chestLVL"] +
    guild.loc[i, "legstLVL"] +
    guild.loc[i, 
    "feetLVL"] +
    guild.loc[i, "waistLVL"])) / 16
elif guild.loc[i, "class"] == "druid":
guild.loc[i, "gearLevel"] = (max((guild.loc[i, "twoHandLVL"] * 2.6), ((guild.loc[i, "oneHandLVL"] * 1.6) + guild.loc[i, 
    "offhandLVL"])) +
    (guild.loc[i, "trinketALVL"] + guild.loc[i, "trinketBLVL"] * 1.2) +
    (guild.loc[i, "neckLVL"] +
    guild.loc[i, "cloakLVL"] +
    guild.loc[i, "wristLVL"] +
    guild.loc[i, "ringALVL"] +
    guild.loc[i, "ringBLVL"] * 0.8) +
    (guild.loc[i, "rangedLVL"] +
    guild.loc[i, "headLVL"] +
    guild.loc[i, "shoudlersLVL"] +
    guild.loc[i, "chestLVL"] +
    guild.loc[i, "legstLVL"] +
    guild.loc[i, "feetLVL"] +
    guild.loc[i, "waistLVL"])) / 16
# power is calculated as an average with a base of 40 regardless of actual participation to reflect
# difficulty arising from absences
raidpower = raidpower / 40
return raidpower

def initialqueue():
    for i in range(0, 60):
        guild.loc[i, "roll"] = np.random.uniform(1, 100)
    for i in range(60, 0, -1):
        j = guild["roll"].idxmax()
        guild.loc[j, "pos"] = i
        guild.loc[j, "roll"] = 0
initialqueue()  # only run for the suicide kings loot system
raidmetrics.loc["raidstr", raidcounter] = raidstr
raidmetrics.loc["guildmean", raidcounter] = np.mean(guild.loc[:, "gearLevel")
raidmetrics.loc["guildstd", raidcounter] = np.std(guild.loc[:, "gearLevel")

for i in range (0, 60):
    if guild.loc[i, "attendance"] == "core":
        corelv = guild.loc[i,"gearLevel"]
    elif guild.loc[i, "attendance"] == "regular":
        regulvl = guild.loc[i,"gearLevel"]
    else:
        casulvl = guild.loc[i,"gearLevel"]

raidmetrics.loc["coremean", raidcounter] = (corelv / 20)
raidmetrics.loc["regumean", raidcounter] = (regulvl / 30)
raidmetrics.loc["casumean", raidcounter] = (casulvl / 10)

gauge()

# The availability() function is run at the start of every raiding session, always before the player setup step
# Every player is marked as available for that particular raid, with a chance related to his attendance classification
# We assume core raiders participate in about 90%, regular raiders in about 70% and casual raiders in about 50% of all raids
def availability():
    for i in range(0, 60):
        j = np.random.uniform(0, 1)
        if guild.loc[i, "attendance"] == "core":
            if j < 0.9:
                guild.loc[i, "available"] = 1
            else:
                guild.loc[i, "available"] = 0
        elif guild.loc[i, "attendance"] == "regular":
            if j < 0.7:
                guild.loc[i, "available"] = 1
            else:
                guild.loc[i, "available"] = 0
        elif guild.loc[i, "attendance"] == "casual":
            if j < 0.5:
                guild.loc[i, "available"] = 1
            else:
                guild.loc[i, "available"] = 0

def raidsetup():
    # best available tank -> healer -> magical -> physical till 40 in raid or no more available players. Always perform availability before!
    # limit on tanks and healers due to gameplay reasons. limit on casters to allow for more physical as it is standard.
    guild.loc[:, "inraid"] = 0
    bench = guild.loc[:, "available").values
    raid = guild.loc[:, "inraid").values
    tanks = 0
    healers = 0
    casters = 0
    while sum(bench) > 0:
        startbench = sum(bench)
        lvl = 0
        if tanks < 4:
            for i in range(0, 60):
                if guild.loc[i, "available"] == 1 and guild.loc[i, "inraid"] == 0 and guild.loc[i, "role"] == "tank" and guild.loc[i, "gearLevel"] > lvl:
                    maxi = i
                    lvl = guild.loc[i,"gearLevel"]
        if lvl > 0:
            guild.loc[maxi, "inraid"] = 1
            guild.loc[maxi,"available"] = 0
            tanks += 1
            if sum(raid) == 40:
                return
        lvl = 0
        if healers < 10:
            for i in range(0, 60):
                if guild.loc[i, "available"] == 1 and guild.loc[i, "inraid"] == 0 and guild.loc[i, "role"] == "healer" and guild.loc[i, "gearLevel"] > lvl:
                    maxi = i
                    lvl = guild.loc[i,"gearLevel"]
        if lvl > 0:
            guild.loc[maxi, "inraid"] = 1
```python
guild.loc[maxi, "available"] = 0
healers += 1
if sum(raid) == 40:
    return
lvl = 0
for i in range(0, 60):
    if guild.loc[i, "available"] == 1 and guild.loc[i, "inraid"] == 0 and guild.loc[i, "role"] == "magical" and casters < 12 and
    guild.loc[i, "gearLevel"] > lvl:
        maxi = i
        lvl = guild.loc[i, "gearLevel"]
if lvl != 0:
    guild.loc[maxi, "inraid"] = 1
    guild.loc[maxi, "available"] = 0
casters = casters + 1
if sum(raid) == 40:
    return
lvl = 0
for i in range(0, 60):
    if guild.loc[i, "available"] == 1 and guild.loc[i, "inraid"] == 0 and guild.loc[i, "role"] == "physical" and guild.loc[i, "gearLevel"] > lvl:
        maxi = i
        lvl = guild.loc[i, "gearLevel"]
if lvl != 0:
    guild.loc[maxi, "inraid"] = 1
    guild.loc[maxi, "available"] = 0
if sum(raid) == 40:
    return
endbench = sum(bench)
if startbench == endbench:
    break

# the drop(boss, table) takes a boss ID and the respective loot table of that boss to produce the index of the item that drops on
# the item table
# this will be called manually by the simulation so that we can adapt to the different loot tables and rules of each boss.
# the way it works is owed to the way the items.csv is sorted by boss and by table, and also allows to use the intuitive way the
# droprates are shown.
def drop(boss, table):
    rng = np.random.uniform(0, 100)
    bracket = 0
    i = -1
    while bracket <= rng:
        i += 1
        if items.loc[i, "RaidBossID"] == boss and items.loc[i, "BossTable"] == table:
            bracket += items.loc[i, "DropRate"]
    return i

# def needitem(loot) takes the index location of the item that dropped from the drop(boss, table) function
# and assigns a value of 1 to the need column on the players who are in raid and can equip the item, if it would be an upgrade
# power level considerations have to be resolved here as well (like not needing a 2h when your 1h combo is better)
def needitem(loot):
    guild.loc[:, "need"] = 0
    lootlvl = items.loc[loot, "ItemLVL"]
    lootslot = items.loc[loot, "ItemSlot"]
    for i in range(0, 60):
        if guild.loc[i, "inraid"] == 1:  # ignore players out of raid
            classtag = guild.loc[i, "class"]
            if items.loc[loot, classtag] == 1:  # ignore players who can't equip
                # time to deal with exceptions, which arise mainly for 2h and 1h weapons, as well as double items like rings and trinkets
                if lootslot == "twoHand":
                    if guild.loc[i, "class"] == "dpswarrior":
                        lvlgain = (lootlvl * 2.6) - max((guild.loc[i, "twoHandLVL"] * 2.6), ((guild.loc[i, "oneHandLVL"] + guild.loc[i, "offhandLVL"])* 1.3))
                    if lvlgain > 0:
                        guild.loc[i, "need"] = 1
                    elif guild.loc[i, "class"] == "hunter":
                        lvlgain = (lootlvl * 2) - max((guild.loc[i, "twoHandLVL"] * 2), (guild.loc[i, "oneHandLVL"] + guild.loc[i, "offhandLVL"]))
                    if lvlgain > 0:
                        guild.loc[i, "need"] = 1
                    else:
                        # if the item csv is correct only mages, warlocks, priests and druids will be rolling here and they have the same
```
\[ lvlgain = (\text{lootlvl} \times 2.6) - \max((\text{guild.loc[i, "twoHandLVL"]} \times 2.6), (\text{guild.loc[i, "oneHandLVL"]} \times 1.6) + \text{guild.loc[i, "offhandLVL"]}) \]

if \( lvlgain > 0 \):
    \text{guild.loc[i, "need"]} = 1
elif lootslot == "oneHand":
    potential = \max((\text{guild.loc[i, "oneHandLVL"]} + \text{lootlvl}) * 1.3), ((\text{lootlvl} + \text{guild.loc[i, "offhandLVL"]}) * 1.3))
    lvlgain = potential - \max((\text{guild.loc[i, "twoHandLVL"]} \times 2), (\text{guild.loc[i, "oneHandLVL"]} + \text{guild.loc[i, "offhandLVL"]}))

    if \( lvlgain > 0 \):
        \text{guild.loc[i, "need"]} = 1
    elif \text{guild.loc[i, "class"]} == "dpswarrior":
        potential = \max(((\text{guild.loc[i, "oneHandLVL"]} + \text{lootlvl}) * 1.3), ((\text{lootlvl} + \text{guild.loc[i, "offhandLVL"]}) * 1.3))
        lvlgain = potential - \max((\text{guild.loc[i, "twoHandLVL"]} \times 2), (\text{guild.loc[i, "oneHandLVL"]} + \text{guild.loc[i, "offhandLVL"]}))

    if \( lvlgain > 0 \):
        \text{guild.loc[i, "need"]} = 1
    elif \text{guild.loc[i, "class"]} == "hunter":
        potential = \max((\text{guild.loc[i, "oneHandLVL"]} + \text{lootlvl}), (\text{lootlvl} + \text{guild.loc[i, "offhandLVL"]}))
        lvlgain = potential - \max((\text{guild.loc[i, "twoHandLVL"]} \times 2), (\text{guild.loc[i, "oneHandLVL"]} + \text{guild.loc[i, "offhandLVL"]}))

    if \( lvlgain > 0 \):
        \text{guild.loc[i, "need"]} = 1
    elif \text{guild.loc[i, "class"]} == "hunter":
        potential = \max((\text{guild.loc[i, "oneHandLVL"]} + \text{lootlvl}), (\text{lootlvl} + \text{guild.loc[i, "offhandLVL"]}))
        lvlgain = potential - \max((\text{guild.loc[i, "twoHandLVL"]} \times 2), (\text{guild.loc[i, "oneHandLVL"]} + \text{guild.loc[i, "offhandLVL"]}))

    if \( lvlgain > 0 \):
        \text{guild.loc[i, "need"]} = 1
    elif \text{guild.loc[i, "class"]} = "rogue":
        potential = \max((\text{guild.loc[i, "oneHandLVL"]} + \text{lootlvl}), (\text{lootlvl} + \text{guild.loc[i, "offhandLVL"]}))
        lvlgain = potential - \max((\text{guild.loc[i, "twoHandLVL"]} \times 2), (\text{guild.loc[i, "oneHandLVL"]} + \text{guild.loc[i, "offhandLVL"]}))

    if \( lvlgain > 0 \):
        \text{guild.loc[i, "need"]} = 1
    else:
        # the rest of the classes are not dualwielding so we only compare with the previous 1h
        \text{guild.loc[i, "need"]} = 1
elif lootslot == "ring":
    if (\text{lootlvl} > \text{guild.loc[i, "ringaLVL"]}) or (\text{lootlvl} > \text{guild.loc[i, "ringbLVL"]})
        \text{guild.loc[i, "need"]} = 1
elif lootslot == "trinket":
    if (\text{lootlvl} > \text{guild.loc[i, "trinketaLVL"]}) or (\text{lootlvl} > \text{guild.loc[i, "trinketbLVL"]})
        \text{guild.loc[i, "need"]} = 1
elif lootslot in ["head", "neck", "shoulders", "chest", "cloak", "wrist", "hands", "waist", "legs", "feet", "offhand", "ranged"]:
    
    \text{lootslotlvltag} = \text{lootslot} + "\_LVL"
    if \( \text{lootlvl} > \text{guild.loc[i, \text{lootslotlvltag}] }\)
        \text{guild.loc[i, "need"]} = 1
    else:
        # the equip(loot, winner) function is called after the winner of an item is determined through any lds
        # all it does is to replace the old item in his inventory with the new one
        # the function receives its loot input from the drop(boss,table) function, which is the items dataframe index for the drop
        # the function receives its winner input from the lds function used
        # there are some cases where an item can go to more than one slot (1h weapons for some classes, trinkets and rings)
        # the function makes sure the player gains the most out of the upgrade (replaces the worst item of the two)
        def equip(loot, winner):
            lootslot = \text{items.loc[loot, "ItemSlot"]}
            if lootslot == "trinket":
                if \text{guild.loc[winner, "trinketaLVL"] <= guild.loc[winner, “trinketbLVL”]}
                    \text{guild.loc[winner, "trinketaID"]} = \text{items.loc[loot, "ItemID"]}
                    \text{guild.loc[winner, "trinketaName"]} = \text{items.loc[loot, "ItemName"]}
                    \text{guild.loc[winner, "trinketaLVL"]} = \text{items.loc[loot, "ItemLVL"]}
                    else:
                        \text{guild.loc[winner, "trinketbID"]} = \text{items.loc[loot, "ItemID"]}
                        \text{guild.loc[winner, "trinketbName"]} = \text{items.loc[loot, "ItemName"]}
                        \text{guild.loc[winner, "trinketbLVL"]} = \text{items.loc[loot, "ItemLVL"]}
            elif lootslot == "ring":
                if \text{guild.loc[winner, "ringaLVL"] <= guild.loc[winner, “ringbLVL”]}
                    \text{guild.loc[winner, "ringaID"]} = \text{items.loc[loot, "ItemID"]}
                    \text{guild.loc[winner, "ringaName"]} = \text{items.loc[loot, "ItemName"]}
                    \text{guild.loc[winner, "ringaLVL"]} = \text{items.loc[loot, "ItemLVL"]}
                    else:
                        \text{guild.loc[winner, "ringbID"]} = \text{items.loc[loot, "ItemID"]}
                        \text{guild.loc[winner, "ringbName"]} = \text{items.loc[loot, "ItemName"]}
                        \text{guild.loc[winner, "ringbLVL"]} = \text{items.loc[loot, "ItemLVL"]}
            elif (lootslot == "oneHand") and (\text{guild.loc[winner, "class"]} in ["dpswarrior", "hunter", "rogue"]):
                if \text{guild.loc[winner, "oneHandLVL"] <= guild.loc[winner, “offhandLVL”]}
                    \text{guild.loc[winner, "oneHandID"]} = \text{items.loc[loot, "ItemID"]}
                    \text{guild.loc[winner, "oneHandName"]} = \text{items.loc[loot, "ItemName"]}
                    \text{guild.loc[winner, "oneHandLVL"]} = \text{items.loc[loot, "ItemLVL"]}
                    else:
                        \text{guild.loc[winner, "offhandID"]} = \text{items.loc[loot, "ItemID"]}
                        \text{guild.loc[winner, "offhandName"]} = \text{items.loc[loot, "ItemName"]}
                        \text{guild.loc[winner, "offhandLVL"]} = \text{items.loc[loot, "ItemLVL"]}
            else:
                # onehand for other classes, or any other slot for all classes
                \text{lootslotidtag} = \text{lootslot} + "ID"
                \text{lootslotnametag} = \text{lootslot} + "Name"
                \text{lootslotlvltag} = \text{lootslot} + "LVL"
                \text{guild.loc[winner, lootslotidtag]} = \text{items.loc[loot, "ItemID"]}
                \text{guild.loc[winner, lootslotnametag]} = \text{items.loc[loot, "ItemName"]}
                \text{guild.loc[winner, lootslotlvltag]} = \text{items.loc[loot, "ItemLVL"]}
guild.loc[winner, lootslotnametag] = items.loc[loot, "ItemName"]
guild.loc[winner, lootslotlvltag] = items.loc[loot, "ItemLVL"]

# This function gathers all actions that are repeated to produce and log a raid drop
def bosskill(boss, loot):
    loot = drop(boss, loot)
    needitem(loot)
    needers = guild.loc[:, "need"].values
    if sum(needers) > 0:
        winner = suicidekings()  # CHANGE THIS LINE TO TEST NEW SYSTEMS
    equip(loot, winner)
    txtlog.write(guild.loc[winner, "playerName"] + " got " + items.loc[loot, "ItemName"] + "n")
    else:
        txtlog.write(items.loc[loot, "ItemName"] + " was disenchanted.n")

# this function simulates the simple roll loot system
# it returns the guild index value of the person to be assigned the item
# in the extremely rare case of two people rolling the exact same maximum roll,
# the idxmax() function chooses the first occurrence, which is enough for our purposes
def lds_simpleroll():
    guild.loc[:, "roll"] = 0
    for i in range(0, 60):
        if guild.loc[i, "need"] == 1:
            guild.loc[i, "roll"] = np.random.uniform(0, 100)
    winner = guild["roll"][0].idxmax()
    return winner

#this function awards dkp to participants at start time
#run after raidsetup
def DKPaward():
    for i in range(0,60):
        if guild.loc[i, "inraid"] == 1:
            # guild.loc[i, "DKP"] = 20  # for simple dkp, use a small value to avoid abnormally huge numbers
            guild.loc[i, "DKP"] = 100  # for epgp, use a relatively large value to have meaningful ratios
            winnder = guild["DKP"][0].idxmax()
            guild[winnder, "DKP"] = guild[winnder, "DKP"]
            return winner

def simpleDKP(loot):
    winnerDKP = 0
    guild.loc[:, "roll"] = 0
    for i in range(0, 60):
        if guild.loc[i, "need"] == 1:
            if guild.loc[i, "DKP"] > winnerDKP:
                guild.loc[i, "roll"] = 0
                guild.loc[i, "roll"] = np.random.uniform(0, 100)
                winnerDKP = guild.loc[i, "DKP"]
            elif guild.loc[i, "DKP"] == winnerDKP:
                guild.loc[i, "roll"] = np.random.uniform(0, 100)
        winner = guild["roll"][0].idxmax()
        guild[winnder, "DKP"] = guild[winnder, "DKP"]
        return winner

def zerosumDKP(att, loot):
    winnerDKP = -100000  #random large negative to allow for negative dkp people to win items, even if rarely
    att = att - 1
    guild.loc[:, "roll"] = 0
    for i in range(0, 60):
        if guild.loc[i, "need"] == 1:
            if guild.loc[i, "DKP"] > winnerDKP:
                guild.loc[i, "roll"] = 0
                guild.loc[i, "roll"] = np.random.uniform(0, 100)
                winnerDKP = guild.loc[i, "DKP"]
            elif guild.loc[i, "DKP"] == winnerDKP:
                guild.loc[i, "roll"] = np.random.uniform(0, 100)
        winner = guild["roll"][0].idxmax()
        spread = items.loc[loot, "price"]/att
        for i in range(0, 60):
            if guild.loc[i, "inraid"] == 1:
                guild.loc[i, "DKP"] -= spread
                guild[winnder, "DKP"] = guild[winnder, "DKP"]
                return winner
# the decay function removes 15% of the player's gear points and effort points at the start of every week,
# to discourage hoarding and make it easier for new players
# For epgp, the base GP is not decayed (300 in our case)
def decay():
    for i in range(0, 60):
        guild.loc[i, "DKP"] = guild.loc[i, "DKP"] * 0.85
        guild.loc[i, "GP"] = ((guild.loc[i, "GP"] - 300) * 0.85) + 300

def epgp(loot):
    for i in range(0, 60):  # epgp has to be updated before every new drop. we update only for needers to reduce computing time
        if guild.loc[i, "need"] == 1:
            guild.loc[i, "EPGP"] = guild.loc[i, "DKP"] / guild.loc[i, "GP"]
            winnerEPGP = 0
            guild.loc[:, "roll"] = 0
            for i in range(0, 60):
                if guild.loc[i, "need"] == 1:
                    guild.loc[i, "roll"] = np.random.uniform(0, 100)
                    winnerEPGP = guild.loc[i, "DKP"]
                elif guild.loc[i, "EPGP"] == winnerEPGP:
                    guild.loc[i, "roll"] = np.random.uniform(0, 100)
            winner = guild["roll"].idxmax()
            guild.loc[winner, "GP"] += items.loc[loot, "price"]  #update GP. EP(DKP) are not lost in this system
            return winner

def suicidekings():
    guild.loc[:, "needpos"] = 0
    for i in range(0, 60):
        if guild.loc[i, "need"] == 1:
            guild.loc[i, "needpos"] = guild.loc[i, "pos"]
    winner = guild["needpos"].idxmax
# this bit sends the winner to the bottom and pushes everyone who was below him up one rank
    winpos = guild.loc[winner, "pos"].copy()
    guild.loc[winner, "pos"] = 0
    for i in range(0, 60):
        if guild.loc[i, "pos"] < winpos:
            guild.loc[i, "pos"] += 1
    return winner

# simulation structure
raidstr = 55
with open("txtlog.txt", 'a') as txtlog:
    # the target average item level goal or the target number of raids
    while raidcounter < 104:
        if raidcounter <= 82.5:
            raidcounter += 1
            # only for EPGP
            txtlog.write("Raid #{}\n".format(raidcounter))
            availability()
            DKPaward()  # for simpleDKP and EPGP
            raidsquad = guild.loc[:, "inraid"]["inraid"]
            # att = sum(raidsquad) #for zero sum only
            raidstr = updatepower()
            print(raidstr)
            txtlog.write("Initial raid strength: {}\n".format(raidstr))
            if raidstr < 50:
                txtlog.write("Raid not strong enough to begin Molten Core.\n")
                powerlevels = leveltrack(powerlevels)
                gauge()
                continue
            # Molten Core + Onyxia starts
            # Tables that are being repeated are according to the specific boss’ loot rules
            # (some tables are supposed to be run twice.)
            bosskill(101, 1)
            bosskill(101, 2)
            bosskill(102, 1)
            bosskill(102, 1)
raidstr = updatepower()
if raidstr < 60:
    txtlog.write("Raid not strong enough to finish Molten Core.
")
    powerlevels = leveltrack(powerlevels)
    gauge()
    continue

# Molten Core + Onyxia Ends
raretable = np.random.uniform(0, 1)
if raretable <= 0.25:
    bosskill(110, 1)
bosskill(110, 2)
bosskill(110, 2)
bosskill(110, 3)
bosskill(110, 3)
bosskill(111, 1)
bosskill(111, 1)
bosskill(111, 1)
raretable = np.random.uniform(0, 1)
if raretable <= 0.25:
    bosskill(111, 3)
bosskill(111, 4)
raidstr = updatepower()
    txtlog.write("Molten Core and Onyxia completed.
")
    if raidstr < 62.5:
        txtlog.write("Raid not strong enough to begin Blackwing Lair.
")
        powerlevels = leveltrack(powerlevels)
        gauge()
        continue

# Blackwing Lair starts
bosskill(201, 1)
bosskill(201, 1)
bosskill(201, 2)
bosskill(202, 1)
bosskill(202, 1)
bosskill(202, 2)
bosskill(203, 1)
bosskill(203, 1)
bosskill(203, 2)
raretable = np.random.uniform(0, 1)
if raretable <= 0.65:
    bosskill(204, 1)
bosskill(204, 2)
raretable = np.random.uniform(0, 1)
if raretable <= 0.65:
    bosskill(205, 1)
bosskill(205, 2)
raretable = np.random.uniform(0, 1)
if raretable <= 0.65:
    bosskill(206, 1)
bosskill(206, 2)
bosskill(207, 1)
bosskill(207, 1)
bosskill(207, 2)
bosskill(207, 2)
raidstr = updatepower()
if raidstr < 70:
    txtlog.write("Raid not strong enough to finish Blackwing Lair.
")
powerlevels = leveltrack(powerlevels)
gauge()
continue

# Blackwing Lair ends
bosskill(208, 1)
bosskill(208, 2)
bosskill(208, 3)

raidstr = updatepower()
txtlog.write("Blackwing Lair completed.\n")
if raidstr < 72.5:
    txtlog.write("Raid not strong enough to begin Naxxramas.\n")
    powerlevels = leveltrack(powerlevels)
gauge()
continue

# Naxxramas starts
bosskill(301, 1)
bosskill(301, 2)
bosskill(302, 1)
bosskill(302, 2)
bosskill(303, 1)
bosskill(303, 2)
bosskill(304, 1)
bosskill(304, 2)
bosskill(305, 1)
bosskill(305, 2)
bosskill(306, 1)
bosskill(306, 2)
bosskill(307, 1)
bosskill(307, 2)
bosskill(308, 1)
bosskill(308, 2)
bosskill(309, 1)
bosskill(309, 2)
bosskill(310, 1)
bosskill(310, 2)
bosskill(311, 1)
bosskill(311, 2)
bosskill(312, 1)
bosskill(312, 2)
bosskill(313, 1)
bosskill(313, 2)
bosskill(313, 3)

raidstr = updatepower()
if raidstr < 80:
    txtlog.write("Raid not strong enough to finish Naxxramas.\n")
    powerlevels = leveltrack(powerlevels)
gauge()
continue

# Naxxramas ends
bosskill(314, 1)
bosskill(315, 1)
bosskill(315, 2)
bosskill(315, 3)
bosskill(315, 3)

raidstr = updatepower()
txtlog.write("Naxxramas completed.\n")
txtlog.write("Final raid strength: " + str(raidstr) + "\n")
powerlevels = leveltrack(powerlevels)
gauge()

# export metrics
powerlevels.to_csv("powerlevels.csv")

# fixing the first for output reasons
raidmetrics.loc["raidstr", 0] = 55
raidmetrics.to_csv("raidmetrics.csv")

# write guild to csv for testing
guild.to_csv("finalguild.csv")
Result Analysis: Code in Stata

clear all
import delimited C:\Users\Nick\Desktop\lds\METRICS\del_raidstr.csv
reshape long w, i(system) j(week)
rename w strength
encode system, generate(system_)
xtset system_ week
label variable strength "strength gain"
*xtline strength
estpost tabstat strength, by(system) statistics(mean sd) columns(statistics) listwise
regress strength sk sdkp zsdkp epgp
est sto m1
*esttab m1, replace se r2 obslast mtitle("Core Str.")
drop system week sr sk sdkp zsdkp epgp strength system_ _est_m1

import delimited C:\Users\Nick\Desktop\lds\METRICS\del_corestr.csv
reshape long w, i(system) j(week)
rename w strength
encode system, generate(system_)
xtset system_ week
label variable strength "strength gain"
*xtline strength
estpost tabstat strength, by(system) statistics(mean sd) columns(statistics) listwise
regress strength sk sdkp zsdkp epgp
est sto m2
drop system week sr sk sdkp zsdkp epgp strength system_ _est_m2

import delimited C:\Users\Nick\Desktop\lds\METRICS\del_regustr.csv
reshape long w, i(system) j(week)
rename w strength
encode system, generate(system_)
xtset system_ week
label variable strength "strength gain"
*xtline strength
estpost tabstat strength, by(system) statistics(mean sd) columns(statistics) listwise
regress strength sk sdkp zsdkp epgp
est sto m3
drop system week sr sk sdkp zsdkp epgp strength system_ _est_m3

import delimited C:\Users\Nick\Desktop\lds\METRICS\del_casustr.csv
reshape long w, i(system) j(week)
rename w strength
encode system, generate(system_)
xtset system_ week
label variable strength "strength gain"
*xtline strength
estpost tabstat strength, by(system) statistics(mean sd) columns(statistics) listwise
regress strength sk sdkp zsdkp epgp
est sto m4
drop system week sr sk sdkp zsdkp epgp strength system_ _est_m4

import delimited C:\Users\Nick\Desktop\lds\METRICS\del_stdev.csv
reshape long w, i(system) j(week)
rename w strength
encode system, generate(system_)
xtset system_ week
label variable strength "strength gain"
*xtline strength
estpost tabstat strength, by(system) statistics(mean sd) columns(statistics) listwise
regress strength sk sdkp zsdkp epgp
est sto m5
esttab m1 m2 m3 m4 m5, replace se r2 nonumbers obslast mtitle("Raid Str." "Core Str." "Regu. Str." "Casu Str." "Std. Dev.")