



UMEÅ UNIVERSITY

Monetary Value of a Player in GTA Online: Role of Inflation

Ivan Ivanik

Degree Project, 30 hp

Degree project in Economics for a Degree in Master of Science in Business and Economics, 30 hp
Spring term 2023

Abstract

This study investigates the monetary value of a player within the video game GTA Online, published by Rockstar in 2013. A survey was sent out to a subreddit called r/gtaonline where a sample of 171 respondents who play GTA Online were used and the results were analysed using an OLS regression. Monetary value was calculated by multiplying GTA\$ earned per hour by the indirect exchange rate between GTA\$ and the Euro €. Further data was collected on the inflation within each content update of the virtual economy of GTA Online, measured in terms of CPI. This measurement was then corresponded with when a player first started playing GTA Online to get a measure of the relative CPI they experienced when they first started playing. This study found that the most significant determinants affecting monetary value were if a person was a grinder their monetary value increased by €8.1. If a person purchased micro transactions named “Shark Cards” in GTA Online, the monetary value for purchasing one “Megalodon Shark Card” was €38.7 and one “Whale Shark Card” was -€59.1. However, sampling error and a limited time frame should be considered when interpreting the results. Despite the limitations, this study offers a perspective for future research into monetary value as others can learn from the limitations and improve future methodology.

Table of Contents

Abstract	2
Table of Contents	3
1 Introduction	1
1.1 Game Design	2
1.2 Monetary Value of a Player	3
1.3 Inflation	5
2 Literature Review	6
2.1 Game Design	7
2.2 Monetary Value	13
2.3 Inflation	14
3 Methodology	16
3.1 Measuring Monetary Value	16
3.2 Hypotheses	18
3.3 Inflation	22
4 Data	24
5 Estimation	27
5.1 Biases and Data Processing	27
5.2 Regression Results	29
6 Discussion	32
7 Conclusion	35
References	37
Appendix 1: Descriptive Statistics	41

1 Introduction

Traditional economic research examines the economies of the real world; ranging from cities to entire countries and continents. As the world developed and technology evolved so did economies as now there are virtual economies. No longer are economies bound to traditional limitations such as scarcity and transportation costs; now begins an era of economies that not only create profits but also unique experiences for those willing to participate in them. This thesis looks into the virtual economy of the videogame GTA Online and investigates the determinants of the monetary value of a player in GTA Online. Furthermore, GTA Online's economy has experienced inflation which leads to the economic question of what effect did inflation within GTA Online's economy have on the monetary value of players within GTA Online?

On the surface, GTA Online resembles an ordinary multiplayer game that places players into a satirical interpretation of an American metropolis with a deadly and chaotic criminal underworld. What many overlook in GTA Online is the intricate economy. In addition to allowing the player to navigate and participate in this virtual world, it shares various aspects of real life economies and bolsters new concepts that challenge the notion of traditional economic theory. Developers must consider designing economies that, in addition to generating profit, must also consider the fact that said economies must also deliver entertaining experiences for consumers to participate in. This creates a distinct ecosystem that poses the questions about value, productivity and inflation.

Virtual economies are becoming more common. As the age of digitalisation rises, so does its influence on various aspects of our lives, notably economies which have an important significance. Exploring virtual economies such as GTA Online enables the understanding of digital markets and how they relate to various established real-world economic theories. Furthermore, the gaming industry gains more users and popularity year after year and is a notable source of revenue in various economies all over the world. A multi-billion dollar industry only bound by human creativity, it has near infinite possibilities in terms of how to generate revenue. By identifying the determinants of a player's monetary value in GTA Online and how inflation impacts the monetary value allows this research provides a better

understanding of how virtual economies operate, in relation to traditional economic theory, as well as give developers possible aspects to consider when developing virtual economies.

1.1 Game Design

Virtual economies adhere to fundamental economic principles, distinguished primarily by their objectives. Conventional economies, such as those that exist within countries, try to be as efficient as possible. Virtual economies aim to create products that attract users, satisfy them and make the publisher of the virtual economy money. Where in real life concepts such as “scarcity of resources” and “transportation cost” hinder economies for example, virtual economies can eliminate these concepts altogether due to the fact that they are within a digital world. In theory, if an economist wants to design a virtual economy within a videogame with the tools they use to design a conventional economy, they are left with a game in which any character can travel to any place instantly and obtain any item instantaneously. Though efficient and fits the narrative of a conventional economy, this does not work for a virtual economy simply because it is not fun to be a part of. And this is what publishers of video games want to achieve. They do not care about efficiency but rather create economies that attract users, satisfies them and ultimately makes the publisher money (Lehdonvirta & Castronova, 2014).

One such example of a virtual economy is GTA Online. It is an online multiplayer game that follows a plot of a silent protagonist slowly making their way up the fictional criminal world of Los Santos (*Grand Theft Auto Online* | *GTA Wiki* | *Fandom*.). As mentioned before, the basic structure of a virtual economy should attract users, satisfy them and make the publisher money. The one of interest is how the publisher makes money as it enables the application of basic economic theories to the game.

GTA Online makes the publisher money through its market structure. There are a variety that apply to virtual economies but the one that is most descriptive of GTA Online is the monopoly structure. In it, the publisher is the only retailer of virtual goods and gets to dictate prices (Lehdonvirta & Castronova, 2014.). GTA Online has in-game markets in which players can purchase anything ranging from apartments and buildings to cars and clothing. What all these in-game stores have in common is that they use the virtual currency GTA\$ as payment

and that all these markets are “owned” by the publisher Rockstar; in the sense that Rockstar dictates the virtual goods sold and their prices.

Whenever a player wants to buy a virtual item within GTA Online, they are required to use the mandatory virtual currency GTA\$. This is connected with how GTA Online satisfies users since they earn this currency and want to spend it since that is the main point of it; players do not get any traditional rewards for simply holding the money in your virtual bank account. In addition to earning GTA\$ by completing tasks within the game, players can directly purchase GTA\$ through the publisher Rockstar. They retail virtual packages called “Shark Cards” that contain a certain amount of GTA\$, with more GTA\$ being more expensive, however buying the larger packages earns a player a greater value of GTA\$. Shark Cards can only be bought with real-life money and hence is the main source of revenue for Rockstar. This is how Rockstar makes money which is integrated within the video game through a system known as microtransactions.

Although GTA Online is a paid game, the revenue associated will not provide sufficient revenue for maintaining such a game as a user typically purchases only one copy of the game. In order to get additional and more constant revenue, Rockstar has implemented these Shark Cards which are a microtransaction. Microtransactions are good for revenue. In 2013 developers of mobile games collected 90% of total revenues from “freemium” (free to download but featuring microtransactions) games, compared to a paltry 6.1% from games that required payment to download (Lescop & Lescop, 2014). Microtransactions allow game developers to tap into the financial resources of those most invested in a game and generate revenue beyond game’s release. Through microtransactions, developers earn revenue based on the number of customers actively playing a game, as opposed to the traditional system which rewards the quantity of new games sold (Christensen, 2021). In general, it is better to design a game that retains its users compared to a game that prioritises selling physical units of itself as being able to retain players means they are more likely to become a repeat purchaser for the game which leads to more revenue.

1.2 Monetary Value of a Player

The existence of microtransactions allows players to purchase virtual currency with real life money, giving an indirect exchange rate for the virtual currency GTA\$ and any real life

currency. Since GTA\$ is a virtual good, there is nothing stopping Rockstar from handing it out to every player for free. Bits are not scarce, they are bits of information that can be duplicated infinitely. If Rockstar gave away GTA\$ for free to all players, there would be no need to be productive in the game and you can acquire whatever you want. This relates back to the basic concept of a virtual world; it is not meant to be efficient. This would not be an economy but rather a community (Lehdonvirta & Castronova, 2014.).

But Rockstar does not allow this; the players must work to earn the virtual currency. GTA Online does this by allowing players to earn the same virtual currency by completing different objectives within the game. This indicates that Rockstar made this resource scarce and in the context of a virtual economy, this is imposed scarcity of virtual goods. However they needed to do that as scarcity is a central concept in what distinguishes an economy from a community. A set of scarce resources together with processes such as production, trade and consumption that arise from people's economic interactions is called an economy. Thus, a virtual economy is an economy that is based on scarce digital resources. Rockstar creates this scarcity by having the player actively spend their time being a certain level of productivity in exchange for virtual currency. And since the amount of virtual currency is infinite (virtual good) but time is finite, and time is required to make virtual currency, it makes the virtual currency finite and scarce (Malaby, 2006).

Since a player's productivity in-game earns them a virtual currency that has an indirect exchange rate with real life currencies, it allows for obtaining a measure of the monetary value of a player's in-game productivity since their time and effort put in the game earns a virtual good, in this case a currency. This virtual currency is backed by real-life currencies which allows for measuring productivity akin to how it is measured in the real world i.e hourly wage and salary (Lehdonvirta & Castronova, 2014). That is, monetary value is defined as the rate at which a player obtains a virtual currency through in-game productivity.

An hourly wage and salary are a monetary value put on an individual's job that produces a certain level of productivity that rewards them with money at the expense of their time and skills/determinants. It can be thought of as what variables does a person have that affects the amount of money they make by being at some level of productivity at a job which earns said money. And since the productivity of a player earns them a virtual currency that has an indirect exchange rate to real life currency, it allows to place a monetary value on a player's

in-game productivity. However, productivity is a broad term and has different interpretations depending on different contexts. Understanding what productivity means in the context of GTA Online. Based on results, the determinants that statistically impact a player's monetary value are their playstyle and the purchase of microtransactions that award the player virtual currency.

1.3 Inflation

Much like how game design of GTA Online enables the application of a monetary value on a player, game design also has the concept of inflation. Since both these concepts are caused by how GTA Online is designed, an attempt can be conducted to find a link between these two concepts since they share the same common denominator, video game design. Thus, an analysis on monetary value in the sense of how inflation affects it or cause it can be conducted.

In a virtual economy, the money used to pay for subsidies can be created out of thin air. But this additional source of money flowing into the economy needs to be offset with a corresponding sink; otherwise it can cause inflation. Inflation is a subtle tax on everyone who owns money, so even virtual subsidies are not free (Lehdonvirta & Castronova, 2014).

Much like real life, macroeconomic theory can be applied to virtual worlds and analyse the management of money. The total amount of money available in an economy is called the money supply. Actions that aim to adjust the size of the money supply are called monetary policy. These concepts are key for a developer like Rockstar to understand. Within national economies, central banks are tasked with managing the money supply with two main objectives to keep in mind; price stability and managing the rate of economic growth. Subsequently, an exploration of how Rockstar has addressed these objectives will be conducted within GTA Online (Lehdonvirta & Castronova, 2014).

Measuring inflation, can be conducted by tracking changes to the general price level. One common method that Lehdonvirta & Castronova use is the consumer price index (CPI). Their method is to decide on a basket of goods that represents roughly what an average user would be buying in a week. Then you note how much it would cost to buy that basket on the market at regular intervals, say weekly (Lehdonvirta & Castronova, 2014).

Once inflation has been measured within GTA Online, the subsequent step is to link it to the monetary value of a player. One way is with the concept of wages. In a national economy, wage data is used to measure productivity and opportunity; think of it as a proxy for well-being. This is where the analysis of this thesis lies in, the relationship between wages and inflation. “Wages are a sign of health or illness in an economy because people with low wages can be presumed to be unhappy. Wage stagnation is a problem in that users are not experiencing growth in the hourly purchasing power. And as mentioned, wage inequality leads to dissatisfaction” (Lehdonvirta & Castronova, 2014). And wages in this context is the monetary value of a player.

As economies grow, they become ever more complex to the point where different indicators and concepts become more interlinked in numerous ways and as an economy evolves, the relationship between them also evolves. Understanding the mechanisms of a virtual economy however is not to maximise a certain measurement but rather to investigate and record a variety of measures and how each one can influence another. Once a new relationship or pattern has emerged from an evolving virtual economy, one must therefore update our current knowledge and understandings of said economy so one can gauge the inner workings of the system better (Lehdonvirta & Castronova, 2014). So I will investigate what the effect inflation within GTA Online had on a player’s monetary value. Did it lead to lower wages, wage stagnation or wage inequality? And based on the effects I figure out with my regression, I can analyse how this relationship between two out of the many different economic indicators in GTA Online can be used to improve GTA Online, depending on what issue I find.

2 Literature Review

A leading figure within the study of virtual economies is Edward Castronova. In 2001, he invented the concept of virtual economies and ever since, his research and outcomes managed to support his prediction of virtuality and economy merging and working together. His main outcomes are published in a book he co-wrote with Vili Lehdonvirta called “Virtual Economies: Design and Analysis” in 2014 (Edward Castronova, 2015). This is the framework of many studies concerning virtual economies and in which this paper will follow. A key concept to understand when reading any research concerning virtual economies is that they

do not operate like traditional economies in the real world. Although they are based on the same fundamental ideas as a regular economy, there is a major difference in their objectives. Conventional economies, such as those that exist within countries, try to be as efficient as possible. Virtual economies aim to create products that attract users, satisfy them and make the publisher of the virtual economy money. Where in real life there are concepts such as “scarcity of resources” and “transportation cost” for example, virtual economies can eliminate these concepts altogether due to the fact that virtual economies exist in a digital world. In theory, if an economist wants to design a virtual economy within a videogame with the tools they use to design a conventional economy, the end result a game in which any character can travel to any place instantly and obtain any item instantaneously. Though efficient and fits the narrative of a conventional economy, this does not work for a virtual economy simply because it is not fun to be a part of. And this is what publishers of video games want to achieve. They do not care about efficiency but rather create economies that attract users, satisfies them and ultimately makes the publisher money (Lehdonvirta & Castronova, 2014). With this in mind, the following section will provide a summary of what current research concerning virtual economies looks like.

2.1 Game Design

There are a wide range of topics researchers investigate within videogames and overtime new research fields have developed when researching video games. In the early stages of when videogames were a recent product released to consumers, much of the research revolved around investigating the possible negative effects playing video games had on consumers with topics such as linking psychopathy to videogames (McClure & Mears, 1986). Overtime, more research was developed to include interest in other topics such as the benefits from playing video games (Granic et al., 2014) and how to design videogames to be incorporated within schools for educational use (González-González & Blanco-Izquierdo, 2012). This was mainly due to the development of massively multiplayer games. Demanding more powerful hardware to run, massively multiplayer games allow for a large player base to interact with one another which create new and interesting social dynamics that lead to publishers to create a new business model to extract revenue for these types of games (Lehdonvirta, 2005).

Exploring further, a noticeable trend is that a majority of studies examining virtual economies do so with these massive multiplayer games, abbreviated as MMO. As Lehdonvirta (2005)

states, virtual economies can be derived from any video games that are applicable; for example Super Mario Bros by Nintendo released in 1985. Lehdonvirta (2005) states as follows: “The factors of production are Mario's labor and boxes. By expending Mario’s labor on the boxes, the player can produce goods such as mushrooms and flowers. The goods must be consumed immediately. They cannot be traded. Players generally prefer flowers over mushrooms.” Whilst it fulfils the basic requirements of an economy, such as production, trade, consumption or labour, there are no external factors influencing this economy thus there is no insightful economic analysis to be made.

Multiplayer games circumvent this issue as the added concept of multiple players able to interact and influence another's decision provide aggregate effects in conjunction with a videogame’s game mechanics (Lehdonvirta, 2005). In addition, video game publishers have developed new business models with the emergence of multiplayer games which can be grouped as real-money trade of virtual items as publishers realise that there is a market for virtual items. One of the earliest research papers by Castronova explores the idea of virtual economies. It takes the videogame Everquest and its virtual world Norrath as it contained a unique avatar-to-avatar market which allowed players to sell their own virtual items they acquired to other players. According to Everquest’s publisher, it is illegal to purchase the virtual items with real-life money as they are considered intellectual property. Players circumnavigated this by exchanging money in real life then meeting up in the virtual world of Everquest and exchanging the virtual items, hence establishing a real-money trade mechanic and putting value on virtual goods (Castronova, 2001). However, it begs the question as to why certain people place value on virtual items within a video game.

Huhh (2008) illustrates how human attention is considered to be a scarce resource within virtual economies. He puts it into perspective by stating that there is an opportunity cost to participate within a virtual economy, in this case videogames. This opportunity cost is defined as a player’s own time since humans have a limited amount of time available and thus make a decision on what activities they should spend their time on. His formula for the participation condition for a game takes into account a person’s value of time reflected in terms of wage. So as long as a person sees time spent in a game as more valuable than spending that same time engaged in another activity, the person will choose to participate in the virtual economy (Huhh, 2008). Similarly, Ondrejka (2004) shows how content generation

within video games is a key factor in capturing human attention since generating new content draws in new and casual users which achieves long-term growth (Ondrejka, 2004).

Much like regular economies, users in virtual economies generate content themselves if the game permits it. However, since it is a virtual economy, the content generated does not have the same value as it does in the real world. Malaby (2006) examines the concept of generating capital in virtual worlds as he equates virtual goods to market capital. He states that goods generated in a virtual economy as commodities and buyers convert their own market capital (in the form of currency or credit) into market capital in terms of commodities. This phenomena occurs because of the concept of imposed scarcity in which developing these virtual commodities requires some form of a scarce resource, in this case users' time (Malaby, 2006). However, Malaby (2006) states that commodities are hard to get a "real-life" value on since much of the value of virtual commodities rely on cultural importance which means they have different values on a user-to-user basis. The best comparison with a real-life phenomena is baseball cards where to some people they are just pieces of paper with no inherent value and to some they are extremely valuable memorabilia which gives them a much higher value. Thus, investigating virtual goods with no direct value is difficult to put any sort of economic analysis to since a virtual good such as an item has no unique value that is shared across all people.

Video games have expanded their virtual economies, becoming larger and more complex over time. New business models such as the free-to-play model have facilitated new ways for publishers to obtain revenue from consumers, most notably virtual gambling in the form of "loot boxes" (N. Chen et al., 2019; Christensen, 2021; Drummond & Sauer, 2018; Geng & Chen, 2019; Liu et al., 2014). Videogames have allowed the direct purchase of virtual items with real life currencies which have come to be known as "microtransactions". Some video games have instead created virtual currencies, a form of fiat currency, which a consumer exchanges real life money for virtual currency through a publisher's mandatory currency market with its own unique currency exchange between said money and virtual currency. These virtual currencies allow for players to purchase virtual items within a video game (Christensen, 2021; Gibson et al., 2022; McCaffrey, 2019). This concept is explored by Lehdonvirta and Castronova (2014) as they deem that there is no fundamental difference between virtual currency and real currency. The major difference between them lies in the size of their currency areas which is a geographical area in which a given currency is

accepted as a means of payment (Lehdonvirta & Castronova, 2014). Within GTA Online, a small currency of the virtual currency GTA\$ which comprises the area of the virtual world of GTA Online only. However, since it is accepted as a form of payment for virtual goods within GTA Online, it is hence considered a virtual currency.

The area of investigating the monetary value of a player within a videogame has very limited research published. To my knowledge, no other research paper has aimed to investigate the monetary value of a player within GTA Online specifically. Research concerning monetary value of a player within a videogame has had a publisher's perspective. Papers aimed to investigate the value a player brings towards a company in terms of revenue towards the publisher (P. P. Chen et al., 2018). Research papers investigating the monetary value of people have been written in contexts other than video games, namely for sports players. Football and basketball players, for example, had their monetary value calculated using OLS regressions and by carefully selecting variables that researchers believe had an impact on a player's monetary value (Franceschi et al., 2023; Li & Huang, 2014).

However, there have been research papers released such as Wang et al (2013) paper and Castranova (2001) who have results and methods aimed at getting an understanding of the current research within the field of the generated monetary value of players within videogames. Wang et al (2013) investigate the determinants of the monetary value of virtual goods in 24 different MMORPGs. They found that intensive social networking and flatter hierarchical structures are associated with a lower monetary value of virtual goods. A larger active user base increases the monetary value, due to increased demand, and steeper hierarchical structures further amplify the effect. Castranova (2001) used the indirect exchange rate between the virtual item of platinum pieces (PP) and real life money to obtain an exchange rate. He then regresses the value of a player's inventory by the number of hours that player has been active to obtain the amount of PP a player earns an hour. This figure was multiplied with the exchange rate to obtain the monetary value of a player's productivity, equivalent to \$3.42 an hour (Castranova, 2001).

My study follows Wang et al. (2013) as his paper aims to find the determinants of monetary value of virtual goods within massively multiplayer games. This research paper differs as it investigates the monetary value of a player instead of a virtual good and the genre of the game is a regular multiplayer game instead of a massive multiplayer game. Castranova

(2001) has investigated the monetary value of a player within a videogame academically before and my paper will build off of his outcomes and methods as well.

GTA Online is not an MMORPG, but rather a regular multiplayer online video game and this shift in genre will have an impact on how to analyse GTA Online compared to an MMORPG. A massively multiplayer online role playing game, referred to as an MMORPG, has a unique virtual economy that is one of the closest resemblances to a real life economy. This is because it closely follows the law of supply and demand the closest due to the virtual market present. This is one of the three main reasons Wang et al. (2013) chose MMORPGs as the video game genre to study. GTA Online, although a different genre, can fulfil these three criteria as well which adds support for using GTA Online as a feasible videogame for this study. First, MMORPGs follow the law of demand; that is to say that MMORPGs have virtual goods that are desirable by the players which create demand for said virtual goods (Armstrong & Hagel III, 1998). GTA Online follows this criteria as it too follows the law of demand. It has virtual goods that players spend either their time or real-life money towards acquiring those virtual goods since they are designed in a way to make players want to acquire them. Second, players have different intrinsic needs which can cause a sort of heteroskedastic effect when trying to analyse a virtual world. However, MMORPGs negate this effect due to game design since MMORPGs are designed so a player follows the game's telos and story structure ie, they do not veer off the planned play-style the developers had in mind (Mayer-Schoenberger & Crowley, 2005). Thus, if a virtual world meets this criteria, it enables a controlled experiment to be conducted at an individual level. GTA Online also fulfils this criteria as the only way to receive GTA\$ is by playing the game as Rockstar designed or by purchasing GTA\$ through the microtransaction store, again as Rockstar designed. A player's own personal opinions and intrinsic values do not cause any heteroskedastic effect since Rockstar designed GTA Online to mitigate this effect.

Wang et al (2013) third and final reason is to have an economic linkage between the virtual world and the real life world. Within an MMORPG, there exists RMT markets which are secondary markets not regulated by the publisher in which players can trade virtual goods for real currency directly, giving an exchange rate between virtual goods and real life currency hence, the linkage between the real and virtual world is fulfilled. Most MMORPGs contain markets similar to that of regular multiplayer games where you can purchase virtual items for real life money or purchase virtual currency for real life money which could also be used to

purchase virtual items. However, MMORPGs differ as they also contain auction houses and bartering systems between players in which players can exchange virtual items between themselves. This creates a system of demand and supply; demand from players to obtain certain virtual items and a supply of players who have accrued said virtual items and sell them for a certain value.

Auction houses and bartering systems are not included in most regular multiplayer games like the one used in this study, GTA Online. GTA Online has a publisher controlled market, akin to a monopoly where the publisher is the sole supplier of the virtual items, in this case the virtual currency GTA\$. Players can only purchase GTA\$ through the publisher Rockstar. Thus, investigating the monetary value of virtual items in GTA Online is a simple task that can easily be measured as it does not follow a dynamic system of supply and demand.

Instead, I will be focusing on the monetary value that a player within GTA Online creates. This idea takes inspiration from Castranova (2001) first research paper published on virtual economies. In it, players sell their virtual avatar within the videogame Everquest that have certain valuable virtual items. Since several dollar-based markets for virtual items within Everquest, Castranova (2001) finds that the avatars sell for between \$500 and \$1000. Each avatar has a shadow price, due to the valuation of their avatar, and using data to determine how much virtual items a player produces allowed Castranova (2001) to develop a measure of gross value creation per hour in terms of dollars. Although Everquest is an MMO and has the unique player-to-player markets that GTA Online lacks, this method of placing value on a player's productivity can still be applied. In GTA Online, in addition to playing the game and earning the virtual currency GTA\$, you can also purchase GTA\$ with real life currency, hence creating a microtransaction market for GTA\$. This indirectly gives us a real life exchange rate for GTA\$ since you can divide the amount of GTA\$ you purchase with a real life currency and get an exchange rate. Hence, this part of game design creates measurements of the monetary value of a player's productivity within GTA Online. However, that begs the question of what monetary value is exactly and why is it useful to measure?

My results will be relevant for the videogame GTA Online and its participants only. As the previous papers such as Wang et al. (2013) looked into a variety of MMORPGs, their results could be used to make generalisations that can be valid for a variety of games that fit the MMORPG genre since many games share the same determinants that they have observed.

However, GTA Online has determinants that not only are unique to itself but also the context matters. For example, a player who is level 10 in GTA Online will not share the same attributes as a player that is level 10 in another multiplayer game. This is an important aspect to consider when interpreting the results.

2.2 Monetary Value

According to Westermarck (2019), a researcher at Sveriges Riksbank, productivity growth can be measured as GDP per hour worked (Westermarck, 2019). Since the only good with value added within GTA Online is its virtual currency GTA\$ and all players can earn GTA\$, the measure productivity growth can be conducted according to the Riksbank definition in terms of how much GTA\$ is earned per hour. When discussing monetary value of a player, it is useful to think of it in terms of a player's wage since a player earns a certain amount of GTA\$ within an hour.

As explained before, wage data is used to measure the productivity and opportunity within an economy. But how so? According to OECD, there are many different productivity measures but they managed to categorise them to labour, capital and multifactor productivity (MFP). These then take the form of capital-labour MFP, based on a value-added concept of output or in the form of capital-labour-energy-materials MFP, based on a concept of gross output. Gross output is a measurement of sales or revenue from production without taking into account the costs of inputs and fixed costs. Value added, however, is the difference between gross output and intermediate inputs which represents the value of labour and capital used in producing gross output (Schreyer, 2001). Therefore, the concept of producing GTA\$ should be thought of as labour productivity based on gross output. Value added is not taken into account as the survey did not account for the input variables a player faces within the game to earn GTA\$. In terms of productivity, this can be interpreted as how productively labour is used to generate gross output. In terms of GTA Online, it shows how certain activities or variables of GTA Online affect the players' in-game production of GTA\$. This follows Wang et al. (2013) measurement of players' productivity function and enabling further research as the subsequent step is identifying out which variables affect a player's production of GTA\$.

2.3 Inflation

One of the most observable effects of GTA Online's economy is inflation. Whilst there are numerous virtual goods within GTA Online, they will be organised into groups. So instead of looking at every super car model or every plane in-game, they will be grouped together into super-cars or planes as although different, they all do the same purpose. A car drives a player from one location to another and is used in races whereas planes travel by air and are more used for combat etc.

Why does inflation happen? There are a variety of theories to explain this effect in the real world and the notable one is the quantity theory of money as it allows for an explanation for inflation within virtual worlds. The theory coined by Irving Fisher essentially states that the prices of goods depend on the amount of money in circulation in the economy (Fisher, 2006). With this in mind, Lehdonvirta & Castronova (2014) state that if the amount of money in everyone's pocket increases, prices will increase to the same degree. This is because the formula for the quantity theory of money is

$$M * V = P * Q$$

where M is the amount of money in circulation, V is how fast the money circulates, P is the price level and Q is the volume of transactions during the time period. We assume that V and Q stay constant and that M varies in any ratio. Based on Fisher's first theory, P must also vary in the same ratio. This is observed within GTA Online as players earn additional GTA\$ which then increases demand for various virtual items. The developer Rockstar notices this and with a subsequent content update releases new virtual items with increased prices, hence aligning with Fisher's theory and causing inflation (Lehdonvirta & Castronova, 2014).

Focusing on M within the context of GTA Online, there are a variety of factors that can influence the amount of money in circulation. These mainly stem from the developer Rockstar adding content updates. These content updates can contain new missions, businesses to own and in-game promotions that all award players with GTA\$. These new methods increase the source of revenue for players, allowing them to earn more GTA\$. This influx of GTA\$ then affects players' purchasing powers which can therefore influence the overall economic relationship of GTA Online.

This is important to note as the effects of inflation within GTA Online also draw parallels to the real world. Raising prices of certain virtual goods that are necessary within GTA Online, such as apartments and vehicles, can have an impact on newer players who do not have sufficient GTA\$ to purchase these vital items in order to play GTA Online comfortably. Inflation can change players' attitudes, GTA\$ earning strategies, player preferences and overall experiences within the game. However, virtual economies are unique in the sense that all aspects of it can be changed to suit or fix a particular issue, such as inflation.

The publisher acts like the central bank; able to control the amount of money in circulation and creating it out of thin air, due to virtuality. The publisher also needs to also design a corresponding sink so that this additional circulation of money is used within the economy in order to offset the virtual inflation (Lehdonvirta & Castronova, 2014). This corresponding sink are the virtual items within GTA Online that you can purchase with the supply of virtual currency.

There are criticisms and limitations of the quantity theory of money. The main assumption is that circulation of money V and volume of transactions Q are kept constant. Post Keynesian economists argue that velocity is a volatile and unpredictable variable making it hard to measure. Some also pose that money supply responds passively to demand for it. That is, if money is demand driven then the supply of money will not fall short of the quantity demanded. In addition, new money that is added towards peoples' balances is not guaranteed to all be spent but rather lay idle in said balances (Humphrey, 1974). However, these criticisms are in the context of a regular economy where many of these factors are not easily identifiable or measurable. Virtual economics such as GTA Online allow the publisher to control many aspects of a virtual economy so that it can fulfil assumptions such as constant values of V and Q . Rockstar can add limits on how much of a virtual item a person can purchase during a certain period to keep Q constant or limit the amount of GTA\$ a person obtains by imposing time restrictions on when a mission can be played next. In short, the quantity theory of money holds in a virtual economy due to the nature of it being easily manageable as opposed to a regular economy that deals with unexpected shocks.

3 Methodology

3.1 Measuring Monetary Value

With a better understanding of monetary value, further research can be conducted into the investigation of monetary value of a GTA Online player. To look at why GTA Online was chosen as a suitable virtual world to measure monetary value, we look at Wang et al (2013) paper. They use a different genre of game, an MMORPG, to measure monetary value and they give three reasons for doing so. GTA Online, although a different genre, fulfils these three criteria as well.

First, MMORPGs follow the law of demand; that is to say that MMORPGs have virtual goods that are desirable by the players which create demand for said virtual goods (Armstrong & Hagel III, 1998). GTA Online follows this criteria as it too follows the law of demand. It has virtual goods that players spend either their time or real-life money towards acquiring those virtual goods since they are designed in a way to make players want to acquire them.

Secondly, players have different intrinsic needs which can cause a sort of heteroskedastic effect when trying to analyse a virtual world. However, MMORPGs negate this effect due to game design since MMORPGs are designed so a player follows the game's telos and story structure ie, they do not veer off the planned play-style the developers had in mind (Mayer-Schoenberger & Crowley, 2005). Thus, if a virtual world meets this criteria, it enables a controlled experiment to be conducted at an individual level. GTA Online also fulfils this criteria as the only way to receive GTA\$ is by playing the game as Rockstar designed or by purchasing GTA\$ through the microtransaction store, again as Rockstar designed. A player's own personal opinions and intrinsic values do not cause any heteroskedastic effect since Rockstar designed GTA Online to mitigate this effect.

The third criteria is to establish an economic linkage between the virtual world and the real life world. Within an MMORPG, there exists RMT markets which are secondary markets not regulated by the publisher in which players can trade virtual goods for real currency directly. Although it is not possible to exchange virtual goods for real life money directly through the

game, the existence of a microtransaction market in which you can purchase virtual currency for real life money provides us with a real-life exchange rate for virtual currency, hence, the linkage between the real and virtual world is fulfilled.

Obtaining an observable measure within a virtual world requires observing the measurement of productivity within GTA Online. As mentioned before, this measure comes out to be how much virtual currency, GTA\$, a player earns within GTA Online within a given time-frame. The following section discusses how to measure productivity. Wang et al, to measure productivity of a player they state that “given the amount of virtual currency, w_i , that a player can earn within a fixed period of playtime and the exchange rate between virtual currency and the real dollar, p_i , the monetary value of an avatar’s productivity, v_i , can be derived as”

$$v_i = w_i \times p_i$$

This equation implies that the productivity of a player is determined by two factors, one related to a player’s play-style and choices within a videogame and the exchange rate between virtual currency and real currency. Since there is an exchange rate between the virtual currency and real life currency, due to the microtransaction market, the subsequent step is to understand what specific elements of GTA Online affect the productivity of a player. Whilst there are numerous different activities and ways to earn GTA\$ in GTA Online, I will only be looking at the most effective ways which correspondingly are also the methods the majority of players use.

Since GTA Online is a game in which you play as a criminal, there are a variety of money-making methods themed around illegal and illicit activities and these will be referred to generally as businesses. However, there are three business categories that are unique in the sense that Rockstar designed them with the main focus being to earn the player GTA\$ as efficiently as possible. These are called passive businesses, active businesses and heists as Youtuber TGG categorises them as he has knowledgeable data on how to obtain GTA\$ within GTA Online (TGG, 2022). Each business has a unique method to earn GTA\$ but all share a common element: requiring the player to invest their own time into these businesses to earn GTA\$. Thus, knowing how much GTA\$ a player earns when using these businesses is crucial when estimating the monetary value of a player and in addition is also part of one of the factors within the monetary value equation. I will investigate what businesses a person uses

to make GTA\$ as a person can use multiple businesses at a time and each one gives a different amount of GTA\$ so observing their effects is useful in determining monetary value.

It is important to note that in the literature review I said that the concept of producing GTA\$ should be thought of as labour productivity based on gross output. Thus, I will not be observing the “added value” effect. In the context of GTA Online, this means that I will not take into account the costs for the player to set up these businesses as in GTA Online, in order to use/play these businesses you would need to buy them with GTA\$ before-hand. As mentioned, there are a number of ways to make money in GTA Online which can be used to purchase a player’s first business but these methods, such as racing, gambling or helping other players for GTA\$, lack a well-defined range of GTA\$ earnings. Businesses have a set range of how much GTA\$ can be made within an hour as all these businesses have a set minimum and maximum GTA\$ that can be earned within an hour.

3.2 Hypotheses

However, there are also external effects that I should gather data on to minimise heteroskedasticity. Whilst not being directly related to how much GTA\$ a player makes, these effects help categorise an individual and can further hypothesise what effects they will have on monetary value of a player.

H1.1: Players who have played for a longer time have a higher monetary value, N_i

H1.2: Players who have a higher player level have a higher monetary value, L_i

H1.3: Players who play more hours in a day have a higher monetary value, T_i

H1.4 Players who play more hours when specifically obtaining GTA\$ have a higher monetary value, R_i

Since obtaining GTA\$ requires the player’s time, it is natural to assume that a player who plays longer compared to others has higher possibility to obtain more GTA\$, thus having a higher monetary value. These hypotheses above follow this principle. A player who has invested substantial time in GTA Online has obtained a vast knowledge of how different elements of the game operate. In terms of obtaining GTA\$, they should already have acquired some businesses and researched methods into the most time efficient ways to play these businesses to obtain GTA\$. A person who is just starting out will have to research and

understand this knowledge and will not have access to the same resources in-game compared to a person who has a substantial amount of time invested in GTA Online.

H2: Players who play more during weekdays compared to weekends have a higher monetary value, D_i

According to Steamcharts, a website that monitors the player count of GTA Online on PC, there is a noticeable trend where there are more players on Saturday and Sunday compared to the rest of the week. This effect is mainly due to the fact that most people are off work and school hence more people have time to play GTA Online. However, this also is the time where most casual players play and they are casual in the sense that they will not mainly play to earn GTA\$ but rather do other activities in-game that are more fun. A person who plays more during weekdays has more time to do so and is more likely to be a player invested within the game. And if they are more invested in the game, they will be more focused on making GTA\$ to fund their lifestyle within GTA Online.

H3: Players who play together have a higher monetary value, A_i

GTA Online is a multiplayer game which means that you can invite strangers or friends to come and play with you. Naturally, they can also help you with businesses as more players make the majority of activities take less time to complete and more players allow you to earn more GTA\$ since you can produce more goods or steal more items to sell for GTA\$. Whilst you can play the same businesses alone, it will take the person longer to acquire goods to sell and you will acquire less in the same time-frame compared to if you had at least one person helping you. Thus, we assume that players who play together have a higher monetary

H4: Players who play as a grinder have a higher monetary value, O_i

A grinder is defined as a playstyle which exclusively focuses on acquiring the largest sum of GTA\$ most efficiently. Whilst there are other playstyles a player can choose, being a grinder solely relates to the acquisition of GTA\$ thus these players will have the highest monetary value. These players also use numerous businesses to maximise their GTA\$ output. There may be a correlation between this hypothesis and the amount of time a player has played GTA Online as a grinder needs to set up these businesses which takes time.

H5: Players who did not buy GTA Online when it was discounted have a higher monetary value, M_i

In order to play GTA Online, you have to pay for it. However, as with any consumer good, GTA Online has been discounted in the past. Goods are discounted so that the publisher can attract new consumers and increase sales volume. As mentioned before, GTA Online's main revenue comes from retaining players and enticing them to purchase microtransactions. Discounting GTA Online is one of the ways Rockstar entices players. So those who have purchased GTA Online when it was discounted are more likely to purchase microtransactions in order to obtain GTA\$ rather than investing time into the businesses since they have extra money left over. Compared to a person who purchased the game at full price, they likely understood the hurdles and challenges involved with obtaining GTA\$ and had a plan devised on how to obtain GTA\$ as a new player without relying on microtransactions.

H6: Players who do not pay for GTA+ have a higher monetary value, G_i

GTA + is an optional, monthly subscription service within GTA Online which provides the player with different virtual goods and GTA\$. Players who purchase this package are given a head start as they are given discounts to virtual goods. However every month there are new random discounts that can not be predicted and these range from new services to even more additional discounts. This service does not necessarily affect how much GTA\$ they can earn from the aforementioned businesses, only other smaller in-game activities like races and certain sourcing missions for example. So for a person who already has a set-up method for making GTA\$ this service does not necessarily help them with making GTA\$. In addition, this service entices users to purchase microtransactions as every package earns 15% more GTA\$ which effectively makes the user not want to earn GTA\$ by playing since it will be less worth it in their eyes.

H7: Players who do not purchase Shark Cards have a higher monetary value, $S_{1i}, S_{2i}, S_{3i}, S_{4i}$

Players who earn GTA\$ by playing the game do so because they do not want to pay real life money for a virtual currency. Their intuition is that if a resource can be earned freely, then it shall be earned freely. The option to purchase GTA\$ via packages called Shark Cards does

not make sense in their eyes. Therefore, those who do not purchase Shark Cards have a higher monetary value as they work more within GTA Online to acquire GTA\$ that could otherwise be purchased through microtransactions.

H8: Players who mainly play missions and use businesses to acquire GTA\$ have a higher monetary value, P_i, A_i, H_i

Whilst there are numerous ways to make GTA\$, the most effective ways to do so are through the aforementioned businesses. These activities' sole purpose is to make money for the player in the most efficient way possible. Whilst other activities such as racing or playing different game modes also earn you GTA\$, that is not their sole purpose and thus, they do not offer the same output of GTA\$ for the same time spent. So when a player uses a business as mentioned before, they should have a larger monetary value compared to players who do not use businesses to earn GTA\$. Adding to this, the players that say how many of the different types of businesses they use when obtaining GTA\$ will also have a larger monetary value.

H9: Players who experienced a higher CPI when they started playing GTA Online have a higher monetary value, I_i

A higher CPI leads to higher prices for virtual goods within GTA Online. Virtual goods need to fulfil either of three attributes: functional, hedonic or social (Lehdonvirta & Castronova, 2014). Every new content update incentivises the player to purchase virtual goods within it in order to progress within GTA Online. Whilst previous virtual goods are also available to purchase and are cheaper, many times that is not a fruitful strategy. This is due to the structure of online video games as Lehdonvirta & Castronova state. Oftentimes, newer virtual items of the same category have better features than their older counterparts. For instance, a new supercar within GTA Online is normally faster and newer properties allow for the player to make more money than before. Sometimes, newer virtual goods are simply more desirable to more players because they look better for the player compared to others. Finally, newer virtual goods can create a sense of "FOMO" (fear of missing out) if other players around you all have the newer virtual goods and you do not. All these factors encourage the player to buy new virtual goods. And since these new virtual goods come at a higher price, the player will thus increase their productivity of earning GTA\$ to be able to purchase them, thus leading to a higher monetary value when players experience a higher CPI.

The discussion above can be summarised into a linear regression model between the monetary value v_i and the hypotheses above:

$$v_i = \alpha_0 + \alpha_1 N_i + \alpha_2 L_i + \alpha_2 D_i + \alpha_3 A_i + \alpha_4 O_i + \alpha_5 M_i + \alpha_6 G_i + \alpha_7 S_i + \alpha_8 F_i + \alpha_9 P_i \\ + \alpha_{10} A_i + \alpha_{11} H_i + \alpha_{12} T_i + \alpha_{13} I_i$$

3.3 Inflation

A consequence of GTA Online's economy is inflation. Whilst new and more efficient methods of making GTA\$ have been introduced with multiple content updates, the prices of virtual goods have also increased and thus creating inflation according to the quantity theory of money as discussed prior. It will be interesting to measure inflation and how it has had an effect on the monetary value of a player. The following section discusses how to measure such an effect.

Measuring inflation is observed through tracking changes to the general price level. One common method that Lehdonvirta & Castronova use is the consumer price index (CPI). Their method is to decide on a basket of goods that represents roughly what an average user would be buying in a week. Then you note how much it would cost to buy that basket on the market at regular intervals, say weekly (Lehdonvirta & Castronova, 2014). The formula is as follows:

$$\text{CPI} = (\text{Cost of the basket this week} / \text{Cost of the basket in the base week}) \times 100$$

Naturally, this means that I need to come up with a method to illustrate a CPI for GTA Online. The way to do so is to look at each content update and create a basket of goods. This basket will include the different categories of virtual goods you can purchase within GTA Online, and these categories will be based on the virtual item's uses. So instead of looking at each sports car price for example, they will be categorised into categories such as cars, planes, boats and then take the average price for each to get a fair representation. This is because not all players buy the same exact same car but they do buy cars in general. This way, the CPI will be more applicable if it takes into consideration the average price of each categorical virtual item.

Since there are numerous virtual items a player can buy within GTA Online, I will group them into categories for easier analysis. The intuition behind this, in addition to making it easier to calculate, is that people buy different virtual items. So if one person buys a specific brand of car within the game, it is not certain that another person will buy that exact same model, hence making it difficult to compare. However, all players will purchase some type of vehicle, property and weapon within the game. The game requires the player to own one of each in order to do any sort of meaningful progress within GTA Online. The specific type of vehicle can vary, for example one person will buy a specific super car whereas another person will never purchase that supercar but instead will buy a plane. Since they are different, if I put these different vehicles into a category and then analyse that category, it will make a more truthful analysis. That is why for my basket of goods, I will find the average price of all goods within the categories for each meaningful content update. I will find the total average cost for every content update for the three categories. Then, I apply that data to find the relative CPI for each player and use that in my regression. The date is important as it will correspond to when an individual first started playing so the effect of inflation can be observed to when a person first started playing. For example, it is possible to observe the effect inflation had on the monetary value for an individual who started to play in the beginning compared to a person who started playing within the last month for example.

Although some updates release new content periodically, in the span of weeks, I feel that it is still useful to use the date of the initial release as a measurement. Since I will measure the CPI to the latest DLC a player was experiencing. So if a player for example joined GTA Online on August 22, 2017, they would still only be exposed to the content from the Gunrunning DLC, even though that DLC was released more than a month ago and the upcoming DLC is a week away. Furthermore, in the case that a person joined GTA Online when it was the start of a DLC with periodically released content, that means initially they will not experience all the content available, thus skewing the CPI. However, the people I interviewed still continue playing GTA Online so it does not matter since all the people I surveyed continued to play GTA Online, thus they will experience the CPI of all content in a DLC. Even if they do not initially experience that content, since they continue playing the game they will eventually experience all of the content for a periodically-content release DLC.

4 Data

Since this study focuses on GTA Online players, I have to obtain data from those who already have invested time within the game. It is not a good use of resources to get data on people who do not play GTA Online since they will not provide any useful data. However, GTA Online does not have a direct channel to players' data so the subsequent step is to gather data from third-party channels where GTA Online players gather as a community. This led me to the social media forum website Reddit in which there is a forum specifically for players of GTA Online called r/gtaonline. I asked the moderators beforehand if it is possible to collect data on the users within this subreddit and they said it was allowed. The reason for choosing r/gtaonline is that it fulfils the criteria of only investigating GTA Online players and it is a large community with over 1 million subscribers. This will ensure that I get a large amount of engagement for my survey leading to a large sample size.

In terms of the method of gathering data, I will conduct a survey. A survey can be designed to ask questions relating to the hypotheses mentioned in the methodology section and can be sent out to a large number of people, with limited resources. However, since I will be surveying specific members of a population, this does not make my survey random as I have a stratified sample. However, given that this paper is only interested in people who play GTA Online then a stratified sample is necessary. The survey is divided into two parts; one where I investigate general player characteristics and how they could affect monetary value and two the player characteristics specifically dedicated to the accumulation of GTA\$. The questions are designed to test for the aforementioned hypotheses. The survey format guarantees that my data will be panel data.

The CPI will be gathered on three categories of virtual goods purchasable within GTA Online through a GTA Online database called "gtabase.com". These three are vehicles, properties and weapons for which gtabase.com has data on all three and in addition, it can filter to when certain goods were released within each update. The reason for these three goods representing a basket of goods for a player is that these are the goods that a player must purchase in order to make any progress within the game. A player needs a vehicle to traverse around the large open world and in addition, needs a property to store the vehicles and also to start some important missions. Also, the missions in GTA Online require the player to eliminate other non-playable characters, NPCss, which requires the use of weapons which is also why

weapons are included in the basket of goods. Then, I will look at every major content update, also referred to as DLC, and sum up the prices of vehicles, properties and weapons associated with the update to get a value for the value of the basket of goods. Using the CPI formula with GTA Online's launch as base year to compare inflation, a CPI measurement for every content update will be obtained. Cross-referencing when a content update was released with when a person first started playing GTA Online, it allow for the observation of the CPI level a player was experiencing when first playing GTA Online and see how that affects monetary value when doing a regression analysis.

The dependent variable, monetary value, was calculated by using the equation below

$$v_i = w_i \times p_i$$

where w_i is the amount of virtual currency a player earns within a fixed time-frame and p_i is the exchange rate. w_i is known as each individual answered an amount of GTA\$ that they earn within a given day of playing GTA Online. To get w_i within a fixed time-frame however, I divided the amount of GTA\$ a player earns with the amount of time each individual specifically dedicated to obtaining GTA\$, so that the productivity value is written in terms of GTA\$ per hour. The exchange rate for GTA\$ I obtained by dividing by how much the largest Shark Card microtransaction costs in terms of a real-life currency, in this case €74.99, with the largest sum of GTA\$ you can purchase as a one-time package which is GTA\$10,000,000 (*Grand Theft Auto Online: Shark Cash Cards | Official Store | Rockstar Store*, 2023). So the exchange rate works out to be €7.499e-6 for each GTA\$1. So multiplying these together for every individual gets us the monetary value of each player.

The survey was posted on Reddit and was viewed by over 7,000 people and was available for 24 hours. The reason for the short availability is that due to it being on a forum where other people also create posts, the amount of people that will view my post will drastically shrink after 24 hours due to Reddit being a form of social media and I will have to compete with other posts. However, within that 24 hours I received 171 usable responses. I originally received 755 responses but removed 500 of them since they were the same invalid response since all stated that the individual started to play the game in October 2029 which is not possible since GTA Online was released on October 1, 2013. In addition, 85 responses contained the exact same information and since all those responses gave valid information, I removed all but one leaving me with 171 usable responses.

Table 1 in Appendix 1 shows the descriptive statistics of the variables collected from the survey. It is important to explain some patterns within the data that seem unusual. First is the data concerning the purchase of microtransactions. Out of 171 responses, 6 individuals had purchased microtransactions within the previous month of when the survey was sent out. This answer may be biased because of the subreddit which the survey was sent in. The subreddit has a large population in which people are against microtransactions as they believe the microtransactions are too expensive for what they offer. Thus, it is expected that there will not be large numbers of people who would purchase microtransactions.

Furthermore, there is a large range for the CPI values. This has to do with the nature of how virtual items are priced within GTA Online. For reference, the European Union had an annual inflation rate of 8.3% in March 2023 (EuroStat, 2023). An average CPI of 372.33 is an extremely high value if it is compared to the CPI of when the game was first released, which is 100, that means the average price level has grown by 172.33% which is extremely high (Lehdonvirta & Castronova, 2014). However within the context of GTA Online these values are to be expected. For example, the most expensive supercar, the “Adder”, cost GTA\$1,000,000. In subsequent updates, more supercars were released and at more expensive prices such as the “T20” which costs GTA\$2,200,000, more than double the price. However, it is important to note that the methods of obtaining GTA\$ have fluctuated. Originally, there was a mission called “Rooftop Rumble” that gave the player a very large sum of GTA\$ for the time it took to finish it. The mission took an average of 3 minutes to complete and gave the player an average of GTA\$20,000, giving them a productivity value of GTA\$400,000 an hour which was a large amount in 2013 when the average cost of the basket of goods in GTA Online was GTA\$448,379. This is an issue to Rockstar as they need to retain their player base and if every player can obtain all virtual items in a short time, there is no incentive for them to keep on playing and less incentive for them to purchase the microtransactions “Shark Cards”. Overtime, Rockstar updated missions such as “Rooftop Rumble” to make them longer and offer less GTA\$ in order to lower the circulation of GTA\$ within GTA Online. However, people still had a large amount of GTA\$ in their virtual bank account and Rockstar increased the prices of virtual goods at these high levels to help remove GTA\$ that players have already collected with these previously high-paying missions. And this is the trend Rockstar has had ever since the launch of GTA Online which explains the large CPI values.

5 Estimation

This section explores the determinants that affect the monetary value of a player in GTA Online. Using the Ordinary Least Squares (OLS) regression methodology, this section explores the key independent variables that affect the dependent variable which is the monetary value of a player. This section begins by addressing the various biases that could impact the data and analysis which is then followed by a series of data processing steps undertaken to ensure robustness of results. The results of two OLS regression analyses are presented, one with and without the inflation measurement of Consumer Price Index (CPI), which provides insight on what the effect of virtual inflation had on the monetary value of a player.

5.1 Biases and Data Processing

Since this study concerns the population of GTA Online players, this creates a sample selection bias as the analysis of the GTA Online players may not apply to broader gaming communities that have different playstyles and characteristics altogether. However, since this research is only concerned with the population of GTA Online players, this bias is to be expected.

In terms of method, a survey was sent out to an online gaming forum on one specific day to gather data. This presents various biases that should be accounted for. There are a variety of data source biases. Sending a survey to an online gaming forum risks volunteer bias, echo chamber effects, gaming preferences bias, response bias, Hawthorne effect. Those who are more passionate about GTA Online are more likely to answer my survey leading to overrepresentation of the most dedicated players and underrepresentation of more casual players. Surveying in a specific online forum presents an echo chamber effect where respondents have similar preferences. This could mean that attitudes towards certain surveyed characteristics will be less likely to be reported, such as the sale of Shark Cards for example. There might also be gaming preference biases, similar to echo chamber effects, as the online forum might have a tendency to favour one play style over another, hence causing overrepresentation of one specific playstyle over another which is not representative of the general GTA Online population. This effect is amplified with the self-selection bias of a survey since those willing to participate in a survey are more dedicated to GTA Online and

have different characteristics from non-respondents who are more casual players. There can also be a response bias since there is nothing stopping a respondent from responding untruthfully and giving false data which might not reflect the true data of GTA Online players. This ties in with the Hawthorne effect that causes participants to modify their views and answers when they know they are being surveyed which can lead to overestimations of certain characteristics like a higher player level because that is deemed to be more favourable than a lower player level. This is related to measurement bias where respondents do not provide accurate figures for data. This might be most significant in terms of asking the respondent their monetary value since that question relies on their intuition which always carries the risk of human error which causes respondents to provide a general estimation rather than a detailed figure. There is also timeframe bias as the time in which data was collected introduces biases due to possible in-game events that can cause a change in players' regular decisions and playstyles concerning monetary value.

With the different biases in mind, I shall first focus on reformatting and analysing my panel data so that they do not have said biases. The first procedure was to remove any data that causes measurement bias. This resulted in the removal of incorrect data, such as false reports of start date of playing GTA Online, and outliers, such as extremely large and borderline unobtainable monetary values, which resulted in 171 usable responses. From this point the data processing occurred.

First, I converted most categorical variables into binary variables so that they could be used in a linear regression. An outlining categorical variable is the type of businesses a player owns as this one was not converted to a binary variable. As mentioned before, there are three categories of businesses: passive, active, heists and within each business there are different types of passive, active businesses and heists. If I were to transform each one into a binary variable it would create a large amount of binary variables which would lead to a dummy variable trap. One or more dummy variables could be perfectly predicted by another variable and in my case it would be the playstyle of a player. One of the options for playstyles is grinder which is defined as a person who focuses mainly on obtaining GTA\$ and as such, would always use at least one of the businesses. This would cause the dummy variable trap. To counter this issue, I instead condensed the information into a numeric variable so I will look at it in terms of how many of each business a player owns. This also leads to more precise measurements and analysis. Instead of observing the effect simply having a type of

business has on monetary value, a quantifiable value allows for the observation of how many additional businesses impact the monetary value for example.

To address the problem of multicollinearity, I removed variables that had a correlation over 0.8 which luckily none of my variables had high correlation with one another. The largest correlation at 0.74 was between hours played in a day and grinding hours in a day which makes sense since both are related to how much time a person spends on GTA Online but since the correlation was low enough, I kept them both.

5.2 Regression Results

With the data formatted and ready for an OLS regression, I carried out two; one without the CPI measurement and one with the CPI measurement. I then did a coefficient test to account for heteroskedasticity and these results are shown in Table 2 with (a) being the coefficients without the CPI measurement and (b) the coefficients with the CPI measurement. Since my survey created several variables, the table will only show the variables that are linked to part 2 of my survey or at least statistically significant on a 10% level.

Table 2: OLS regression with coefficient test: monetary value as dependent variable

Variable	(a)	(b)
Part 1: General Player Characteristics		
Main general playstyle is grinder, $O_i = 1$	8.5 (4.7)*	8.2 (4.6)*
Megalodon Shark Card, S_{1i}	38.7 (17.6)**	39.1 (17.4)**
Whale Shark Card, S_{2i}	-59.1 (26.2)**	-58.9 (26.0)**
CPI, I_i	N/A	0.005 (0.005)
Part 2: Characteristics Directly Linked to Accumulation of GTA\$		
Passive businesses, P_i	-0.8 (0.7)	-0.9 (0.7)
Active businesses, A_i	-2.4 (2.2)	-2.3 (2.3)

Heists, H_i	0.5 (0.7)	0.5 (0.7)
Hours grinding GTA\$ per day, T_i	0.9 (0.9)	0.9 (0.9)
Intercept	9.1 (3.0)***	7.7 (2.8)***

Notes: Robust standard errors in parentheses. Values rounded up to 2 significant figures.

***/**/* denote statistical significance at 1%, 5% and 10% respectively. Units are written in terms of euros €. Column (a) represents coefficients without inflation. Column (b) represents coefficients with inflation.

Table 2 reports the coefficients that have a significant link to the monetary value of a player. I have to accept the null hypothesis, that there is no significant effect on the monetary value of a player for a majority of coefficients that were not significant at a 10% significance level; which includes the variables in Part 2.

In column (a), the coefficient for those whose main playstyle is grinder ($O_i = 1$) is statistically significant at a 10% significance level. It has a positive value of €8.5 which means that those who are grinders have a monetary value €8.5 higher than those who do not identify as a grinder in GTA Online. This suggests that players who mainly play GTA Online for the accumulation of GTA\$ tend to have an \$8.5 higher monetary value than those who do not play as a grinder, providing support for Hypothesis 4 (H4). Within GTA Online this makes sense as a grinder who produces more GTA\$ has a higher wealth, leading to a higher monetary value. When taking into account the effect of inflation in column (b), the monetary value decreases down to €8.2. This supports the research of many economists that increased inflation lowers real wages, in this case the monetary value of a player (Friedman et al., 2003). Furthermore, the coefficient estimates are more precise in column (b) indicating that adding inflation to the model creates more precise estimates.

In column (a), the coefficient for those who purchase a Megalodon Shark Card (S_{li}) is statistically significant at a 5% significance level. It has a positive value of €38.7 which suggests that those who purchase an additional unit of a Megalodon Shark Card increase their monetary value by €38.7. This suggests that a player purchasing a Megalodon Shark Card increases their monetary value by €38.7, leading to higher monetary values. It is important to

recall that the definition of monetary value concerns the accumulation of virtual currency via in-game productivity. Purchasing microtransactions, such as Shark Cards, are not considered in-game productivity. Thus, the coefficient of €38.7 does not have a valid interpretation in the context of GTA Online. It requires an interaction term along with it to get a more accurate estimation since a Shark Card purchase awards the player with virtual currency that can be used to support other variables such as the ownership of various businesses for example. The virtual currency that comes with the Shark Card itself is not considered in-game productivity, hence not considered monetary value. The coefficient in column (b) is larger at €39.1 but as mentioned previously, this coefficient estimate does not have a valid interpretation within the context of GTA Online. However, the coefficient does become more precise, further adding support that adding inflation to the model creates more precise estimates.

In column (a), the coefficient for those who purchase a Whale Shark Card (S_{2i}) is statistically significant at a 5% significance level. It has a negative value of -€59.1 which suggests that those who purchase an additional unit of a Whale Shark Card decrease their monetary value by €59.1. This suggests that a player purchasing a Whale Shark Card decreases their monetary value by €59.1, leading to lower monetary values. However, much like the Megalodon Shark Card, this coefficient does not have a meaningful interpretation within the context of GTA Online as this is not considered monetary value of a player. This variable requires an interaction term to get a more accurate and meaningful coefficient estimate that can be interpreted within the context of GTA Online.

Although Wang et al (2013) investigate MMORPGs and not GTA Online, their results share some variables that are useful to compare. They have the variable “micropayment” which is a binary variable for if a game allows a player to purchase virtual items with real money from the game provider. Their coefficient was statistically significant and negative which signifies that the monetary value of goods in MMORPGs that allow the player to purchase virtual items with real money have a lower monetary value on virtual goods. In terms of GTA Online, this could mean that the ability to purchase Shark Cards would lower the monetary value of players in GTA Online since they can be purchased with real money only.

In order to investigate the effect of inflation on the monetary value, I do another OLS regression with the same variables and include the relative CPI a player experienced when

they first started playing. However, the coefficient was not significant on a 5% significance level so we do not accept H9.

6 Discussion

Since my paper investigates the monetary value of GTA Online players, I needed to find a method to get accurate data on that. My chosen method was not the most accurate. With limited resources available, it is hard to obtain a precise measurement of a GTA Online player's monetary value. Within the settings menu in GTA Online, there exists data on the lifetime achievements of a player. One of them is an exact sum of all GTA\$ earned from when a player first began playing GTA Online. This gives us an exact monetary value of a player. To standardise the value in terms of a specific timeframe, there also exists data on the total hours a person has played GTA Online for. These two data will provide me a much more exact monetary value compared to my current method of simply asking what a player aims to earn within a day of obtaining GTA\$. However, there is an issue with the aforementioned method, it is too tedious to obtain. My current method falls under convenience sampling since I am gathering an estimated figure on a player's earnings. This is because I sent out a survey that is voluntary to take, thus the questions should be designed to take as little effort from the participant to answer because if the question is too complicated or requires a substantial amount of effort a participant will likely not fill it out. If I instead asked participants to log into the game and ask them to navigate various menus to find one specific value, very little will do so because it is a very tedious task, especially considering the survey is voluntary. In addition, only those who are heavily invested within GTA Online would be likely to answer a more detailed and specific question about their monetary value, thus the analysis of results will not be applicable to the casual player population of GTA Online. This is the issue Castranova (2001) addresses as well and it is an issue that is not possible to be avoided. One possible method is to develop weights for the population of a game to reflect the distribution of avatars; created by counting the population at various times. However, the weighting had little impact on the results (Castranova, 2001). Wang *et al.* (2013) obtained volunteers to participate in a controlled experiment where they obtained detailed information on each player's monetary value. This method would ensure a more accurate monetary value for players due to the controlled nature of the experiment however, due to limited resources and time scope, this was not possible to carry out for this study.

In terms of sample size, my data could have benefitted from a more diverse sample as currently it suffers from self-selection bias. For example, out of 171, only 6 people purchased any sort of microtransactions which is not a good representation of the entire population of GTA Online players. As mentioned before, sending my survey in a forum in Reddit presented bias since the subreddit has a negative attitude towards microtransactions since they are not worth their price. However this attitude is not shared by every GTA Online player which the sample from Reddit fails to capture. This makes it difficult to infer the results and to infer about the general population of GTA Online. As it stands, the interpretations of the results are mainly applicable to that of the subreddit, which was not the aim of this study as it aimed to obtain generalisations of the average GTA Online player. However, due to the fact that a survey was used to collect data, selection bias is to be expected (Greenacre, 2016).

To obtain an unbiased sample of GTA Online players, I would need to survey players directly in-game since every session is filled with random players, hence ensuring no bias in my sample. However there is an issue with this as there is no available method to do this. The only feasible way would be to directly message every player in every session which is tedious and would be no guarantee that they would respond to my survey. I do not have access to the raw data that Rockstar does in order to do a more thorough analysis which stores player data on various aspects such as the variables chosen in this study. As mentioned previously, Wang *et al.* (2013) conducted a controlled experiment with volunteers to obtain their monetary value. This would be possible to carry out within Umeå University as there are numerous students which statistically would give enough volunteers to obtain a suitable sample size. This will also ensure a more random sample which would give a sample more representative of a general population, thus enabling the option to make inferences that are applicable to a general population.

My survey did not ask what gaming system the participants mainly played GTA Online on. This could have helped in determining the monetary value of a player because there is one system in which players can earn more GTA\$ and that is PC. GTA Online is available to both consoles and PC but within the PC version of the game, there have been numerous reports of exploits and hacks directly linked to earning a large sum of GTA\$ which would inflate a player's monetary value. However, since I did not test for this link, it is not possible to draw any conclusions on it at this point. Furthermore, I am not guaranteed to receive responses

from people who do engage in the exploitation of GTA\$ but in either case an interesting variable to investigate for future research.

In addition to a variety of inflation rates, my survey did not take note that players' play style has evolved over time. So although a person might identify as a grinder now, that may not have been their playstyle a couple years ago. If I had carried out my experiment from 2013, I could monitor the changes in an individual's playstyle or otherwise characteristics along with the change in their monetary value and I could measure how a person's evolution of their characteristics could have also had an impact on their monetary value. Again, due to time limitations this is not possible to carry out but perhaps is good to note for future research on monetary value of a player. To account for this, a longitudinal study should have been conducted to monitor player behaviour over time. The study could observe the change in players' behaviour and link it to various aspects of when GTA Online's economy was changed and observe if there is a link between. Previous studies have carried out longitudinal studies on GTA player's behaviour evolution over time in terms of player's violence tendencies. Considering there are studies supporting the idea that GTA players' behaviour evolves over time, it provides incentive to account for them in future studies (Coyne & Stockdale, 2021)

The inflation variable of CPI was not significant. Due to resource limitations, I could not measure the inflation of every content update and the monetary value of a player associated with that content update. In order to do that, I would have to have begun this research all the way back in 2013, when GTA Online was first released. If I did so, I could more accurately see the effect inflation had on monetary value. As mentioned before, some content updates had a high CPI value but also introduced new businesses which can give a player a higher productivity level; in a way off-setting the CPI since the player can earn a large amount of GTA\$ to make up for the inflated prices. It would be interesting to see how a player's monetary value evolved over the lifespan of GTA Online and see how the corresponding inflation rate affected the monetary value. However, that is not possible to do, at least with the resources available to me. That is why I measured the CPI of when a player first started playing GTA Online to see if the environment in which a player was presented with had any impact on their current monetary value. This way, I had a variety of inflation rates attributed to every player which allowed me to do a regression with an inflation rate variable. I would not be able to do a regression if I only focused on one inflation rate which would be the

current one from the latest content update since everyone will experience the same inflation rate and have an associated monetary value but I will not be able to compare it with other inflation rates.

Whilst there are limited studies investigating inflation within virtual economies, they provide an insight on their method for evaluating virtual economies. Artificial Intelligence has been used to evaluate how different tax policies can be evaluated in terms of their effects on specific economies (Zheng et al., 2020). Traditionally various modelling techniques were used to test virtual economies such as a graph based programming language called Machinations which enables the ability to track resource flow between players (Adams & Dormans, 2012). Research concerning inflation includes using simulated game economies using Unity which trains AI models which create and sell resources that are then used to record the prices of transactions (Stephens & Exton, 2021). Although these techniques are more advanced and rely more on technology and artificial intelligence, they are useful as a guide since they share a common habit of investigating resource tracking. Within the context of GTA Online, it relates to the accumulation of virtual currency and how the virtual currency has been spent on virtual goods. And since virtual goods have increased in prices, the measure of inflation is valid to observe.

7 Conclusion

In this study, I examined the various variables that affect a GTA Online player's monetary value with an additional emphasis on inflation using data from my own survey I conducted within the online forum Reddit.

Using the data from my survey, the significant results were that the type of playstyle a player has and the amount of microtransactions purchased have a significant effect on the monetary value of a player. A player who identifies as a grinder has a €8.5 higher monetary value than someone who does not identify as a grinder. This could be due to a grinder focusing more of their time into obtaining GTA\$ than the average player. The average monetary value is €8.1 and if it is assumed that the average player balances their activities into two categories; one that earns money and another that rewards fun, a grinder focuses most of their time on activities that earn money. Thus, a grinder can almost double their monetary value compared to that of an average GTA Online player.

A person who buys one Megalodon Shark Card increases their monetary value by €38.7 whereas a person who buys one Whale Shark Card decreases their monetary value by -€59.1. However, GTA\$ acquired through a Shark Card purchase is not valid as monetary value for a player due to the fact that it is not part of in-game productivity. It was purchased with real money and not through in-game activities hence, these values are not able to be interpreted in a meaningful way in relation to GTA Online. These would need to be combined with other related variables in an interaction term in order to obtain a more meaningful analysis.

Although I had data on more variables, they were not significant on a 5% significance level due to sampling error and limitations time for data collection. This is partly why I could not find a significant relationship between inflation and monetary value. In order to do so, I would have had to gather the monetary value of a player over the lifespan of GTA Online to see exactly how the inflation within a content update at a specific time impacted the monetary value of a player within that same content update.

With the limitations presented in my study, it provides a better understanding for future research into this topic. When collecting data for the investigation of monetary value for a virtual economy, it should be done over a time frame. This time frame should be based on the prices of virtual goods within the economy in the sense that you should observe the monetary value of every player whenever there is a price change in virtual goods. This will allow for a potential fixed estimate regression when there is panel data over a specific time period. In addition, collecting data over time can also help create more statistically significant figures and a more thorough analysis of the determinants of the monetary value of a player.

Knowing what determines the monetary value of a player and by what amount can help game developers understand how to update a game's economy to suit a players needs; whether players complain that they do not earn enough to keep up with the virtual economy or that the players produce too much and the economy is not a good sink for all of the virtual currency. It can also help the player understand their productivity and what would be the most efficient way to increase it based on the activities a virtual economy provides for them.

References

- Adams, E., & Dormans, J. (2012). *Game mechanics: Advanced game design*. New Riders.
- Armstrong, A., & Hagel III, J. (1998). *The Real Value of On-Line Communities*.
- Castronova, E. (2001). Virtual Worlds: A First-Hand Account of Market and Society on the Cyberian Frontier. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.294828>
- Chen, N., Elmachtoub, A., Hamilton, M., & Lei, X. (2019). Loot Box Pricing and Design. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.3430125>
- Chen, P. P., Guitart, A., Del Rio, A. F., & Perianez, A. (2018). Customer Lifetime Value in Video Games Using Deep Learning and Parametric Models. *2018 IEEE International Conference on Big Data (Big Data)*, 2134–2140.
<https://doi.org/10.1109/BigData.2018.8622151>
- Christensen, P. (2021). *Microtransactions: Redefining Revenue in the Video Game Industry*.
<https://scholarsarchive.byu.edu/cgi/viewcontent.cgi?article=1241&context=marriottstudentreview>
- Coyne, S. M., & Stockdale, L. (2021). Growing Up with Grand Theft Auto: A 10-Year Study of Longitudinal Growth of Violent Video Game Play in Adolescents. *Cyberpsychology, Behavior, and Social Networking*, *24*(1), 11–16.
<https://doi.org/10.1089/cyber.2020.0049>
- Drummond, A., & Sauer, J. D. (2018). Video game loot boxes are psychologically akin to gambling. *Nature Human Behaviour*, *2*(8), Article 8.
<https://doi.org/10.1038/s41562-018-0360-1>
- Edward Castronova. (2015, July 1). About. *Words and Games*.
<https://edwardcastronova.com/about/>
- EuroStat. (2023). *Annual inflation down to 6.9% in the euro area*.
<https://ec.europa.eu/eurostat/documents/2995521/16324910/2-19042023-AP-EN.pdf/f>

f3d6b28-9c8f-41cd-714f-d1fd38af0b15

Fisher, I. (2006). *The Purchasing Power of Money: Its Determination and Relation to Credit Interest and Crises*. Cosimo Classics.

https://oll-resources.s3.us-east-2.amazonaws.com/oll3/store/titles/1165/0133_Bk.pdf

Franceschi, M., Brocard, J., Follert, F., & Gouguet, J. (2023). Determinants of football players' valuation: A systematic review. *Journal of Economic Surveys*, joes.12552.

<https://doi.org/10.1111/joes.12552>

Friedman, M., Goodhart, C. A. E., & Wood, G. (Eds.). (2003). *Money, inflation and the constitutional position of the central bank* (1. publ). Institute of Economic Affairs.

Geng, W., & Chen, Z. (2019). Optimal Pricing of Virtual Goods with Conspicuous Features in a Freemium Model. *International Journal of Electronic Commerce*, 23(3),

427–449. <https://doi.org/10.1080/10864415.2019.1619911>

Gibson, E., Griffiths, M. D., Calado, F., & Harris, A. (2022). The relationship between videogame micro-transactions and problem gaming and gambling: A systematic review. *Computers in Human Behavior*, 131, 107219.

<https://doi.org/10.1016/j.chb.2022.107219>

González-González, C., & Blanco-Izquierdo, F. (2012). Designing social videogames for educational uses. *Computers & Education*, 58(1), 250–262.

<https://doi.org/10.1016/j.compedu.2011.08.014>

Grand Theft Auto Online | *GTA Wiki* | *Fandom*. (n.d.). Retrieved 29 April 2023, from

https://gta.fandom.com/wiki/Grand_Theft_Auto_Online#Setting

Grand Theft Auto Online: Shark Cash Cards | *Official Store* | *Rockstar Store*. (n.d.).

Retrieved 20 May 2023, from

<https://store.rockstargames.com/buy-gta-v-shark-cash-cards>

Granic, I., Lobel, A., & Engels, R. C. M. E. (2014). The benefits of playing video games.

- American Psychologist*, 69(1), 66–78. <https://doi.org/10.1037/a0034857>
- Greenacre, Z. A. (2016). The Importance of Selection Bias in Internet Surveys. *Open Journal of Statistics*, 06(03), 397–404. <https://doi.org/10.4236/ojs.2016.63035>
- Huhh, J.-S. (2008). Simple Economics of Real-Money Trading in Online Games. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.1089307>
- Humphrey, T. (1974). The quantity theory of money: Its historical evolution and role in policy debates. *Economic Review*, 2–19.
- Lehdonvirta, V. (2005). *Virtual Economics: Applying Economics to the Study of Game Worlds* (SSRN Scholarly Paper 1630302). <https://papers.ssrn.com/abstract=1630302>
- Lehdonvirta, V., & Castronova, E. (2014). *Virtual economies: Design and analysis*. MIT Press.
- Lescop, D., & Lescop, E. (2014). *Exploring Mobile Gaming Revenues: The Price Tag of Impatience, Stress and Release*. 94.
- Li, Z., & Huang, K. (2014). *The Monetary Value of Twitter Followers: Evidences from NBA Players*.
- Liu, C. Z., Au, Y. A., & Choi, H. S. (2014). Effects of Freemium Strategy in the Mobile App Market: An Empirical Study of Google Play. *Journal of Management Information Systems*, 31(3), 326–354. <https://doi.org/10.1080/07421222.2014.995564>
- Malaby, T. (2006). Parlaying Value: Capital in and Beyond Virtual Worlds. *Games and Culture*, 1(2), 141–162. <https://doi.org/10.1177/1555412006286688>
- Mayer-Schoenberger, V., & Crowley, J. R. (2005). Napster's Second Life? - The Regulatory Challenges of Virtual Worlds. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.822385>
- McCaffrey, M. (2019). The macro problem of microtransactions: The self-regulatory challenges of video game loot boxes. *Business Horizons*, 62(4), 483–495.

<https://doi.org/10.1016/j.bushor.2019.03.001>

McClure, R. F., & Mears, F. G. (1986). Videogame Playing and Psychopathology.

Psychological Reports, 59(1), 59–62. <https://doi.org/10.2466/pr0.1986.59.1.59>

Ondrejka, C. R. (2004). Living on the Edge: Digital Worlds Which Embrace the Real World.

SSRN Electronic Journal. <https://doi.org/10.2139/ssrn.555661>

Schreyer, P. (2001). *Measuring productivity: Measurement of aggregate and industry-level productivity growth ; OECD manual*. OECD.

Stephens, C., & Exton, C. (2021). *Measuring Inflation within Virtual Economies using Deep Reinforcement Learning*. 444–453.

TGG. (2022, January 9). *GTA ONLINE FOR DUMMIES! Beginner Guide to EVERY Business in GTA Online—Make More Money SOLO*. Youtube.

<https://www.youtube.com/>

Westermarck, A. (2019). *How can various structural changes in the economy affect wages and inflation*.

[https://www.riksbank.se/globalassets/media/rapporter/pov/artiklar/engelska/2019/191](https://www.riksbank.se/globalassets/media/rapporter/pov/artiklar/engelska/2019/191010/2019_2-how-can-various-structural-changes-in-the-economy-affect-wages-and-inflation.pdf)

[010/2019_2-how-can-various-structural-changes-in-the-economy-affect-wages-and-inflation.pdf](https://www.riksbank.se/globalassets/media/rapporter/pov/artiklar/engelska/2019/191010/2019_2-how-can-various-structural-changes-in-the-economy-affect-wages-and-inflation.pdf)

Zheng, S., Trott, A., Srinivasa, S., Naik, N., Gruesbeck, M., Parkes, D. C., & Socher, R.

(2020). *The AI Economist: Improving Equality and Productivity with AI-Driven Tax Policies*. <https://doi.org/10.48550/ARXIV.2004.13332>

Appendix 1: Descriptive Statistics

Table 1: Descriptive Statistics

Variable Name	Measurement	Mean	Minimum	Maximum
Part 1: General Player Characteristics				
Start date, N_i	The date which the player first started to play GTA Online	2017-05-17	2013-10-01	2023-03-23
Player level, L_i	The level of a player within GTA Online	446	38	8000
Hours playing GTAS per day, R_i	Hours a person spends playing GTA Online casually	3.2	0	20
Main days of play-time, D_i	$D_i = 1$ if the player plays more on weekdays (mon-fri). $D_i = 0$ if player plays more on weekends (sat-sun)	0.58	0	1
Playing alone, A_i	$A_i = 1$ if player mainly plays alone $A_i = 0$ if player	0.82	0	1

	plays mainly with others			
Main general playstyle is grinder, O_i	$O_i = 1$ if player mainly plays as a grinder $O_i = 0$ if player does not mainly play as a grinder	0.39	0	1
Price GTA Online was purchased, M_i	$M_i = 1$ if player purchased GTA Online when it was discounted in some way $M_i = 0$ if player purchased GTA Online at full price	0.42	0	1
Subscription to GTA+, G_i	$G_i = 1$ if player purchased GTA+ subscription $G_i = 0$ if player did not purchase GTA+ subscription	0.13	0	1
Megalodon Shark Card, S_{li}	The amount of Megalodon Shark Cards a player has	0.05	0	3

	purchased a month before the release of the survey			
Whale Shark Card, S_{2i}	The amount of Megalodon Shark Cards a player has purchased a month before the release of the survey	0.05	0	3
Great White Shark Card, S_{3i}	The amount of Megalodon Shark Cards a player has purchased a month before the release of the survey	0.06	0	3
Tiger Shark Card, S_{4i}	The amount of Megalodon Shark Cards a player has purchased a month before the release of the survey	0.04	0	3
CPI, I_i	Relative CPI for each player	372.33	14.07	1134.48

	when they first started playing. Calculated by finding the CPI of each content update with game launch as base year and corresponding to when a person first started playing			
Part 2: Characteristics Directly Linked to Accumulation of GTA\$				
Passive businesses, P_i	The number of passive businesses a player uses when trying to obtain GTA\$, if any	3.01	0	8
Active businesses, A_i	The number of active businesses a player uses when trying to obtain GTA\$, if any	1.86	0	5
Heists, H_i	The number of heists a player uses when	1.92	0	11

	trying to obtain GTA\$, if any			
Hours grinding GTA\$ per day, T_i	The amount of hours a player typically plays when specifically aiming to obtain GTA\$ per day	3.35	0	20
Monetary value, V_i	The value of GTA\$ that a player acquires within an hour in terms of the Euro	8.1	0	281.1