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Analysis of Bitcoin and Blockchain using Game Theory and Behavioural Economics

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ABSTRACT

This paper presents a brief overview of the role that game theory plays in the Bitcoin market, with a focus on how human behaviour influences the market for digital currencies. Through this analysis the viability of digital currencies as a replacement for conventional money is explored.

Keywords- *Game Theory, Behavioural Economics, Bitcoin, Blockchain*

1. INTRODUCTION

Nash Equilibrium – a stable outcome where none of the players has any incentive to deviate as this would lead to their utility decreasing. Any finite game has a point of Nash Equilibrium

Dominant Strategy – a strategy that provides no incentive for the player to deviate from as it provides the greatest amount of utility. There are two types of dominant strategies: I) strictly dominant II) weakly dominant
The weakly dominant strategy that provides no incentive to deviate as the utility provided by all other strategies is either less or equal to the original utility. Its mathematical representation is $u_i(a_i , a_{-i}) \geq u_i(a_i', a_{-i})$ for player *i*. A strictly dominant strategy provides the greatest utility from the set of strategies of possible. Since it is always the best strategy for the player, the notation changes to $u_i(a_i , a_{-i}) > u_i(a_i', a_{-i})$.

Zero-Sum Games – a game in which the total utility at the end of the game (sigma of all players) is 0, essentially that one player gains at the expense of another

Schelling Point – a point in a multiplayer game that players choose by default, leading to cooperation when there is no communication
Rationality – an assumption of human behaviour based on rational choice theory wherein all economic agents seek to maximise their

payoff, that is, be selfish. This assumption is being debunked by behavioural psychology as people consider non-monetary implications and benevolence during their decision-making process.

Bounded Rationality – a phenomena that people tend to follow the path that is simple and familiar to them when given a choice despite being in a situation where they can cheat and improve their utility

Block – a part of the blockchain that is mined by special miners using computational energy and work.
Genesis is the first block of a block chain. The score of this block can be depicted by score(genesis)=0
The score of the 2nd block could be shown by score(block2) =Score(genesis)+proof of work (amount on computation of work done to create the block)

Hence, any x block on the chain can be written as score(blockx)=Score (block x-1) +proof of work. The block preceding the current block is called the parent block.

2. HISTORY

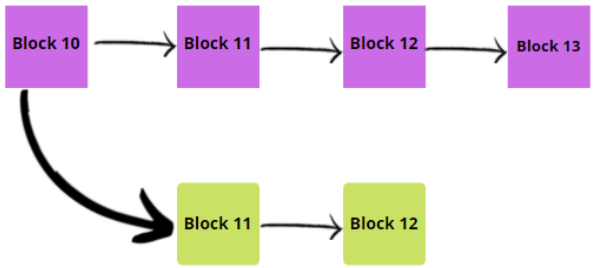
Economics, also known as the dismal science, often depicts a concerning outlook for humanity due to the nature of trade-offs. Game Theory, a field of applied mathematics cultivated by John Nash Neumann, seems to have an even more pessimistic nature. In the Scientific American (1962), Anatol Rapoport wrote "The Use and Misuse of Game Theory", a publication where he states that game theory views humans as primitive brutal creatures who aim only to maximise their own wellbeing – utility- without caring for anybody else. Given the timeline of game theory's progression and the catastrophic implications that Game Theory held for non-cooperative nuclear wars, public outcry led to game theory essentially being named the "science of conflict". Much of the turmoil around game theory comes from human rational choice theory, an assumption that has since been debunked by the new field of behavioural economics. Combining game theory and behavioural economics is a powerful tool as it considers both the mathematical and psychological applications of economics. The market for digital currencies has gained momentum in the media, and it is interesting to see how Bitcoin and Blockchain can be analysed using these two fields

3. BLOCKCHAIN TECHNOLOGY

Blockchain bitcoin is based on only 2 players: 1) senders 2) receivers

Users in bitcoin have only 2 functions available to them 1) send coins 2) receive coins

Blockchain is founded on the basis of miners that have a lot of power in the game and would rationally cheat as they have the incentive to do so. The only time in bitcoins history where a vulnerability was found was on 6th August 2010, an error wherein transactions weren't perfectly verified before being added to the blockchain's transaction log. This security fault was greatly exploited and over 184 billion bitcoins were generated before the flaw was corrected. In order to remove the incentive for miners to cheat, blockchain technology relies on game theory and a self-reinforcing Nash Equilibrium.
A diagrammatic representation of blockchain cheating goes as follows:



Miner X on block 10 spends 5 bitcoins to get 20 litecoin (hypothetically)

- Miner X creates a fork from block 10 and creates another block 11 without actually doing the transition. There are two block11s with 1 parent block10
- Miner X now has 20 litecoins and additional 10 bitcoins. In theory, Miner X can now mine on the green parallel chain and create extra bitcoins. This is termed as "double spending" and would cripple the Bitcoin system.

The idea of punishment now comes in the blockchain mechanism has vital role in this case. No other miner would bother mining on an invalid block as the parent block must be valid for the transaction to work, hence all additional chains would be ignored. Furthermore, miners won't waste their computational energy on a suboptimal block, as it would always be better to mine on block 13 than block 12 and be with the majority on miners.

It is only in a situation where most miners switch to a different chain (green) would such a chain-shift occur and, given that this is a n-player game with miners across the globe, coordination on such a scale is futile. Therefore, should Miner X choose to create an alternate chain, it would only be a waste of their computing energy and cause themselves disutility. The Nash Equilibrium is to always mine on the purple chain as any form of deviation is wasteful.

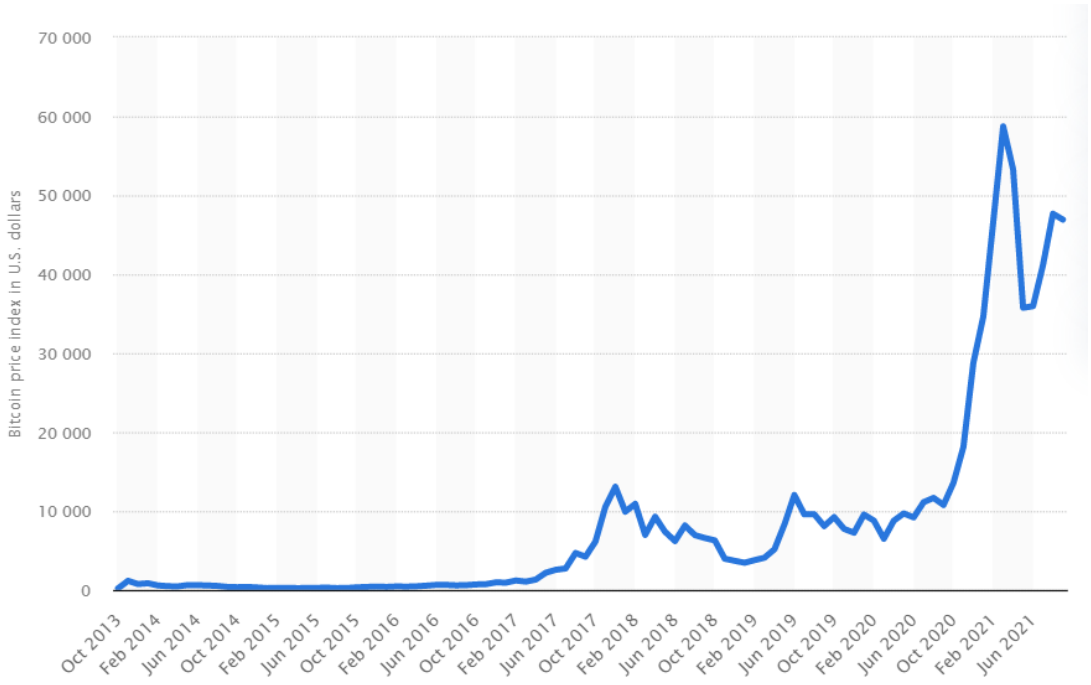
The reason why users tend to stay on the same chain instead of any alternative one is more psychological and can be explained through a combination of bounded rationality and the Schelling point, which means that players are used to the purple chain due to simplicity and familiarity, so they automatically use it.

4. CRYPTOCURRENCY BITCOIN

Bitcoin is the most famous and renowned cryptocurrency that has been built on the foundations of a blockchain technology, a robust form of encryption and security. On 18th August 2008, the domain name "bitcoin.org" was registered which was then followed by a paper released in October that documented the peer-to-peer network built on perfect information. Since its establishment, bitcoin has been a highly unstable currency with its price soaring and diving based on a variety of external factors. At the start of 2018, bitcoin's price crashed, losing more than 80% of its value due to several countries tightening regulations around crypto markets. In the summer of 2019, Bitcoin reached roughly $8000 in May, then lost $1000 in June only to near $14000 in July – an ode to its volatile. This behaviour from the price of bitcoin stems from the fact that the average person fails to understand the foundations of crypto as seen by pyramid schemes such as OneCoin.

More recently, Bitcoin has been gaining momentum in the media as more people buy in to the "currency of modern democracy". Advertisements about digital currencies have increased and "bitcoin" is becoming the buzz word due to comments from both Elon Musk and Warren Buffet, even though the latter wasn't positive. This is an example of the "herd" mentality wherein people buy in simply because other people have, which causes prices to soar until it comes crashing down. Such overvalued investment bubbles such as the "dot com" bubble leave a handful of investors rich at the cost of many.

Bitcoin Price from October 2013 to June 2021 (US Dollars)



Outside other concerns such as climate change and sustainability, the fundamental flaw of Bitcoin stems from economic restrictions, the fact there are a limited number of coins that can be mined. At a certain point, it will be impossible to continue mining bitcoins and hence the craze around Bitcoin will cease. At the end of the day, Bitcoin is a zero-sum game that allows people to buy in and buy out. For every person who becomes rich using Bitcoin, there are several who are losing out. Despite its revolutionary technology, Bitcoin doesn't let people to build wealth and capital which are fundamental features of money as stated by Adam Smith when he said wealth is an exponential function. That is, while the rich have gotten richer, so have the poorer. Bitcoin is more of an investment bubble than a legitimate replacement for money

5. CONCLUSION

While blockchain technology has great promise due to its encryption and speed, I think that bitcoin remains unfeasibly as a replacement to traditional money as it is a glorified form of coins and notes as a medium of exchange, without some of money's other utile functions such as the ability to make loan or gain interest. Additionally, established institutions such as the government, IMF, and central banks are unlikely to be replaced by a decentralised system due to the massive power they hold in today's world.

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