Bitcoin Hardware & Mining
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Introduction

The bitcoin protocol stipulates that the supply will be 21 million bitcoins. Bitcoin mining is the process to introduce bitcoins into the system. Miners are incentivised with mining and transaction fees and serves the purpose of disseminating new coins in a decentralised manner as well as motivating people to provide security for the bitcoin system.

Technically, mining is the process of adding transaction records to Bitcoin’s public ledger of past transactions – or the blockchain – which serves to validate and confirm transactions to the rest of the network as having taken place. Mining is specifically designed to be resource-intensive and difficult in order to maintain a steady rate of block production by miners.

As such, an understanding of mining equipment production and supply and mining pool operations is essential to building a comprehensive analysis and outlook on the bitcoin mining industry.

(All figures are quoted in US$ in this report)

Bitcoin Industry Value Chain Overview

Source: Frost & Sullivan

The focus on this paper is in the hardware supply and mining sectors (highlighted below):
The blockchain hardware market primarily comprises cryptocurrency mining machines. Sales revenue of blockchain hardware industry has seen strong growth on the back of the rising value of the cryptocurrency market along with innovation in new mining machinery.

Global sales revenue of blockchain hardware increased at a CAGR of 207.8% from RMB70 million in 2012 to RMB19.3 billion in 2017. It is expected to grow at a CAGR of 72.1% to RMB98.5 billion in 2020 (source: Frost and Sullivan).
Bitcoin ASIC Design

In specific to bitcoin mining, miners (individual or pools) have used various types of hardware over time to mine blocks. Application-specific integrated circuit (“ASIC”) is an integrated circuit customised for a specific use (“specialised hardware”).

In bitcoin mining hardware, ASICs were the next step of development after general purpose CPUs, GPUs and FPGAs (“non-specialised hardware”), outperforming the non-specialised hardware in both speed and efficiency.

Almost all the bitcoin ASIC chips generally can only be used for bitcoin mining and are tailored for the bitcoin mining algorithm (SHA-256). Other non-bitcoin specific ASIC chips are used for the mining of different cryptocurrencies based on their various mining algorithms such as Ethereum (Ehash algorithm), Litecoin (Scrypt) and Dash (X11). Note that this research paper will focus specifically on bitcoin mining.

Market share: The bitcoin ASIC design market is dominated by Bitmain - a China-based bitcoin equipment supply and mining company – which holds an estimate of around 75% of market share. Canaan Creative represents the 2nd largest player in this market with approximately 15% market share. Both companies are seeking for an IPO listing in the Hong Kong Stock Exchange in Q42018.

Source: Bernstein

Bitcoin ASIC product: Bitmain’s core product for bitcoin mining are the Antminer S9j which currently costs $535 and has a hash rate of 14.5T/s (Tera hashes per second).

In basic terms, the hash rate in this context represents the efficiency of the mining equipment (the speed at which a computer is completing an operation in the bitcoin code). A higher hash rate is better when mining as it increases your opportunity of finding the next block and receiving the award.

The hash rate and equipment costs are two key variables in determining the profitability of miners. Please refer to the mining section of this paper for further elaboration on this aspect. Note that the industry standard for bitcoin equipment replace period is 2-3 years.

A list of Bitmain’s equipment supply can be found here

Source: Bitmain

Bitcoin mining ASICs manufacturers are making a relatively high operating margin at present but it is yet to be seen whether they can expand their revenue base due to concerns of hashrate centralisation and instability of transaction fees.
ASIC and AI

A significant trend in the bitcoin mining equipment and ASIC design sector is the pivot into the Artificial Intelligence (“AI”) and deep learning sector by major players such as Bitmain, Canaan Creative and Ebang (also looking for IPO listing on the Hong Kong Stock Exchange).

Deep learning is essential to the progression of AI development. The training and inference aspects of deep learning require vast amounts of computing power. Currently chips including CPUs, GPUs, FPGAs and ASICs are often used as accelerations for deep learning.

Each chip type has redeeming qualities that support AI accelerator use:

<table>
<thead>
<tr>
<th>Chip</th>
<th>Assessment</th>
<th>Training Rank</th>
<th>Inference Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU</td>
<td>General-purpose, already in servers and PCs and sufficient for inferencing. Serial-processing is less efficient than parallel-processing.</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>GPU</td>
<td>Highly parallel, high performance, uses popular AI framework (CUDA) Less sufficient than FPGAs, lower scalability, inefficient unless fully utilised</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>FPGA</td>
<td>Reconfigurable functionality, good for constantly evolving workloads, efficient Difficult to program, lower performance versus GPUs, no major AI framework</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>ASIC</td>
<td>High computing performance, highly energy efficient, fully customised Expensive, requires high volumes to be practical, quickly outdated, less flexible</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

Source: Morningstar

- ASIC is expected to gain market share in AI training and inference, with a CAGR of 66% from 2017 to 2020.
- ASICs are expected to gradually become a more popular computational source of chips for certain AI algorithms as ASICs, by nature, can deliver enhanced power consumption efficiency through customisation, and achieve better computational performance for specific algorithms and data structure to meet end customers’ requirements.
- The adoption of ASICs in AI applications has been limited, however there are various types of players trying to tap into this market.
  - Global technology giants typically leverage their strong financial resources to build in-house ASIC development teams or invest in integrated circuit designers to build ASIC capabilities. Their focus is on the development of an AI ecosystem.
  - Focused ASIC design players such as cryptocurrency mining hardware providers, can leverage strong R&D to capture AI market growth through building AI chip design

ASICs and processors suitable for parallel computing such as GPUs are expected to become the mainstream ICs providing computational power and support long term growth of AI. ASICs and GPUs looks to complement each other in solving complex computational problems for AI, in front end and back end applications respectively.

There are some key challenges for AI diversification:
The market is much more competitive than ASICs for bitcoin mining with key market leaders such as Nvidia in play and with some large users having moved into producing their own chips to reduce reliance on the Nvidia – Google TPU. In addition, there are also other emerging Chinese manufacturers in the sector as the Chinese government has shown a very pro-AI stance which will likely attract a number of competing players in the industry.

The AI algorithm is evolving and therefore investing heavily in extremely specialised ASICs may not be the most popular investment and therefore it is more likely that research investments will be smaller and the entry barrier will also be smaller as a result.

Note that the way computing power is used to solve a bitcoin computational puzzle has not changed much since the beginning. Machine learning presents a different situation – if the business goal is to solve a machine learning problem faster, this can be done through both improving the algorithm and improving the chips. However, improving the algorithm is much less capital intensive and is likely the more flexible option.

**Bitcoin Mining**

The mining mechanism incentivises participants to verify transactions and create more nodes on the blockchain. The general process for cryptocurrency mining can be simplified as follows:

- **Cryptocurrencies** operate on blockchain that groups blocks of transactions and links each block to a chain in chronological order.
- **Miners** use specialist hardware, or ‘rigs’, to crack complex algorithms that verify a transaction block.
- The successful miner then gets rewarded with cryptocurrencies such as Bitcoin or Ether.
- Miners often join forces in mining ‘pools’ to increase their chance of breaking the code first, and receiving the rewards.

In the case of Bitcoin’s ‘proof of work’ consensus mechanism, participants contribute their computing power to verify transactions and receive bitcoins as incentive in return.

The computing power required to mine each additional bitcoin has grown in order to maintain a stable supply. The massive and increasing computing power requirement to support the bitcoin network is a key driver in the development and innovation of semiconductor solutions for complex computational problems.

**Overview of the Bitcoin Mining Market**

The global mining market is estimated to be worth $4billion with over 100,000 miners and approximately 10,000 nodes. As at 2018, it is estimated that mining consumes 0.13% of all the electricity consumed.

Bitcoin supply is limited to 21 million which will deplete by approximately 2140. More than 17 million of bitcoin has already been mined. Until then, the number of bitcoins awarded for solving a block in the blockchain (the block reward) halves at every 210,000 blocks produced, or approximately every four years based on current time it takes on average to discover a new block.

The time it takes varies depending two key variables:
1. **Network difficulty:** The complexity of the task that miners needs to solve to create the block. The network difficulty changes every 2,016 blocks and the factor is estimated to be compounding at around 35%-55% per month to balance the bitcoin supply. For further technical explanations of network difficulty, you can refer [here](#).

Source: www.blockchain.com

2. **Mining power:** Mining power is driven by the aforementioned hardware efficiency and hashrates. For a more detailed overview of bitcoin supply please refer to the appendix.

Due to the limited supply, for miners this means their incentives will gradually approximate from a reward of transaction fees + bitcoin to just transaction fees:

```
<table>
<thead>
<tr>
<th>Year</th>
<th>Bitcoin Minted</th>
<th>Average Bitcoin per Block</th>
<th>Bitcoin Price Range</th>
<th>Number of Transactions</th>
<th>Total Mining Revenue</th>
<th>Transaction Fee</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>1,617,800.0</td>
<td>50.0</td>
<td>—</td>
<td>0.03</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>2010</td>
<td>3,394,800.0</td>
<td>50.0</td>
<td>0.35</td>
<td>0.18</td>
<td>0.22</td>
<td>0.00</td>
</tr>
<tr>
<td>2011</td>
<td>2,981,900.0</td>
<td>50.0</td>
<td>0.30-29.25</td>
<td>1.90</td>
<td>17.58</td>
<td>0.03</td>
</tr>
<tr>
<td>2012</td>
<td>2,615,700.0</td>
<td>48.0</td>
<td>4.23-13.67</td>
<td>8.43</td>
<td>21.06</td>
<td>0.06</td>
</tr>
<tr>
<td>2013</td>
<td>1,585,175.0</td>
<td>25.0</td>
<td>13.25-1,102.54</td>
<td>19.62</td>
<td>307.02</td>
<td>2.18</td>
</tr>
<tr>
<td>2014</td>
<td>1,472,425.0</td>
<td>25.0</td>
<td>30.81-957.35</td>
<td>25.24</td>
<td>789.83</td>
<td>2.45</td>
</tr>
<tr>
<td>2015</td>
<td>1,358,275.0</td>
<td>25.0</td>
<td>192.13-461.99</td>
<td>45.60</td>
<td>374.96</td>
<td>2.33</td>
</tr>
<tr>
<td>2016</td>
<td>1,047,500.0</td>
<td>19.1</td>
<td>373.13-971.26</td>
<td>82.54</td>
<td>571.02</td>
<td>13.56</td>
</tr>
<tr>
<td>2017</td>
<td>698,912.5</td>
<td>12.5</td>
<td>797.60-19,193.72</td>
<td>104.02</td>
<td>3,332.64</td>
<td>542.71</td>
</tr>
<tr>
<td>2018</td>
<td>248,587.5</td>
<td>12.5</td>
<td>6,648.33-17,095.19</td>
<td>27.41</td>
<td>2,719.70</td>
<td>254.34</td>
</tr>
</tbody>
</table>
```

*(Updated: May 2018)*
Economic Returns of Bitcoin Mining

The expected economic return of bitcoin mining activities is driven by a number of factors including:

- Bitcoin price
- Power requirement and electricity price
- Hashrate of mining equipment
- Hardware cost
- Total network hashrate
- Difficulty factor of mining

Due to the volatility of some of the factors, such as bitcoin price, the economic return calculations need to be updated constantly. For further calculation on economic returns in relations to bitcoin mining, you may refer to coinwarz.

Outside of bitcoin, many major cryptocurrencies are making efforts to move at least partly away from the proof of work mechanism, for example Ethereum’s Casper development to move to a proof of stake consensus mechanism. You can read more about it in this informative article here.

As the revenue base for both bitcoin ASIC manufacturers and mining players is a derivative of the total market capitalisation for proof of work cryptocurrencies, the consensus mechanism shift indicates a potential challenge for the quality of revenue which is offset by a potential for price of these cryptocurrencies to go up (but this is inherently more speculative and high risk in nature).

Competitive Analysis

We provide a summary below of the bitcoin mining pool market share as represented by an estimation of hashrate distribution amongst the largest mining pools:
The dominant player in the bitcoin mining pool sector is Bitmain, who controls the top 2 mining pools (BTC.com and AntPool) and has invested in a 3rd pool (ViaBTC) which combined together accounts for over 50% of the potential mining pool share. A further analysis of the Bitmain business is provided below:

**Bitmain** was founded by Jihan Wu in 2013. Headquartered in China, it was presence in 7 countries and approximately 1,000 employees.

**Bitmain** As at July 2018, it has a valuation of approximately $12bn based on series A and series B financing of $50m and $400m respectively. Reported revenues are around $2.5bn-3.0bn (~5-6x multiple) and operating profit margin of around 60%.

Bitmain’s core strength lies in having key support from the Chinese government, having a leading market position with approximately 75% and 40%+ market share in bitcoin mining equipment supply and mining pool respectively and subsequently an increase in economies of scale in its mining activities. Key risks lies in regulatory changes including China crypto trading ban and electricity regulations in jurisdictions such as Canada along with bitcoin price volatility. One of the key strategic shifts is the focus on AI equipment supply with a view to tap into the China AI market against an estimated market size of $60bn and pro-AI Chinese government.

**Bitcoin Mining – Key Risks Analysis**

We outline below the three perceived risks in each area (industry, operational and regulatory) based on miner sentiments in order of degree of concern:

<table>
<thead>
<tr>
<th>Industry</th>
<th>Operational</th>
<th>Regulatory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centralisation of hashing in power (control) and location (geography)</td>
<td>Sudden large BTC price drop</td>
<td>Tighter regulation to create barriers to mining/crypto adoption</td>
</tr>
<tr>
<td>Miner fees not compensating decrease in block reward</td>
<td>Competition</td>
<td>Increase taxation on mining profits</td>
</tr>
<tr>
<td>Lack of liquidity in crypto market</td>
<td>Insufficient capital to replace and upgrade infrastructure</td>
<td>Government ban of crypto</td>
</tr>
</tbody>
</table>

**Industry**

**Centralisation**

Decentralisation or the lack of control by a central authority or middleman is a key basis for supporters of bitcoin and other blockchain technology. The prospect of trust built on decentralisation has seen growing numbers of concern such as the concentration of:

- Mining pools controlled by a few centralised players *(e.g. BTC.com)*
  The prospect of people turning away under the fear of say a 51% attack can adversely impact the market demand.

- Mining pool geographic concentration in areas such as China
The trend has seen large miners being diversified in their geographical bases, with common factors for good location choice such as cool climates, availability of cheap renewable energy, high-speed internet and business-friendly governments. As such, miner concentration has also been increasing in Nordic countries, north-western parts of the United States and Canada.

**Miners fees not compensating decrease in block reward**

Transaction fees as a % of total income from bitcoin mining were mostly below 3% for 2017 and early 2018 so should this become the only primary income, bitcoin mining activities will likely decrease significantly.

**Lack of liquidity in crypto market**

A risk of losing market for bitcoin mining systems and equipment. A technological breakthrough in altcoins which generally proposes better technology, capabilities and wider set of use cases would reduce the demand for bitcoin mining substantially.

However, bitcoin will likely remain in its dominant position in the near future as a result of the position it has gained in the market and in people’s perception due to its first mover advantage.

Moreover, the development of blockchain technology is in its early stage, and it may not gain wide market acceptance in the future. If the promise of widespread application across financial services, payments, IoT, cybersecurity, cloud computing etc. falls apart, there will be weak market demand for mining pools and equipment. From the momentum, investment and widespread application and Proof of Concept (“PoC”) testing in this sector, the underlying blockchain technology holds the potential to be the next horizon of technological innovation.

**Operational**

**Bitcoin price volatility**

Revenues are generally dominated in BTC and with any significant price drops or any network transaction fee decline, the expected economic return will diminish and thus the demand for mining equipment supply and operations will reduce.

**Competition**

The market is dominated by several key players which makes it difficult for smaller players to compete.

**Insufficient capital to replace and upgrade infrastructure**

Market players are seeking additional sources of funding (e.g. IPO listings) in order to obtain sufficient capital to address replacement and upgrading needs.

**Regulatory**

Changes in government policies, taxes, general economic and fiscal conditions and political events can all change the regulatory landscape for the cryptocurrency industry.
### Appendix 1: Bitcoin Supply Schedule

<table>
<thead>
<tr>
<th>Block</th>
<th>Reward Era</th>
<th>Block Reward (BTC/block)</th>
<th>Start BTC</th>
<th>BTC Added</th>
<th>End BTC</th>
<th>Inflation Rate (BTC Increase %)</th>
<th>End BTC % of Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>50</td>
<td>-</td>
<td>10,500,000</td>
<td>10,500,000</td>
<td>infinite</td>
<td>50.00%</td>
</tr>
<tr>
<td>210,000</td>
<td>2</td>
<td>25</td>
<td>10,500,000</td>
<td>5,250,000</td>
<td>15,750,000</td>
<td>50.00%</td>
<td>75.00%</td>
</tr>
<tr>
<td>420,000</td>
<td>3</td>
<td>13</td>
<td>15,750,000</td>
<td>2,625,000</td>
<td>18,375,000</td>
<td>16.67%</td>
<td>87.50%</td>
</tr>
<tr>
<td>630,000</td>
<td>4</td>
<td>6</td>
<td>18,375,000</td>
<td>1,312,500</td>
<td>19,687,500</td>
<td>7.14%</td>
<td>93.75%</td>
</tr>
<tr>
<td>840,000</td>
<td>5</td>
<td>3</td>
<td>19,687,500</td>
<td>656,250</td>
<td>20,343,750</td>
<td>3.33%</td>
<td>96.88%</td>
</tr>
<tr>
<td>1,050,000</td>
<td>6</td>
<td>2</td>
<td>20,343,750</td>
<td>328,125</td>
<td>20,671,875</td>
<td>1.61%</td>
<td>98.44%</td>
</tr>
<tr>
<td>1,260,000</td>
<td>7</td>
<td>1</td>
<td>20,671,875</td>
<td>164,063</td>
<td>20,835,938</td>
<td>0.79%</td>
<td>99.22%</td>
</tr>
<tr>
<td>1,470,000</td>
<td>8</td>
<td>0</td>
<td>20,835,938</td>
<td>82,031</td>
<td>20,917,969</td>
<td>0.39%</td>
<td>99.61%</td>
</tr>
<tr>
<td>1,680,000</td>
<td>9</td>
<td>0</td>
<td>20,917,969</td>
<td>41,016</td>
<td>20,958,984</td>
<td>0.20%</td>
<td>99.80%</td>
</tr>
<tr>
<td>1,890,000</td>
<td>10</td>
<td>0</td>
<td>20,958,984</td>
<td>20,508</td>
<td>20,979,492</td>
<td>0.10%</td>
<td>99.90%</td>
</tr>
<tr>
<td>2,100,000</td>
<td>11</td>
<td>0</td>
<td>20,979,492</td>
<td>10,254</td>
<td>20,989,746</td>
<td>0.05%</td>
<td>99.95%</td>
</tr>
<tr>
<td>2,310,000</td>
<td>12</td>
<td>0</td>
<td>20,989,746</td>
<td>5,127</td>
<td>20,994,873</td>
<td>0.02%</td>
<td>99.98%</td>
</tr>
<tr>
<td>2,520,000</td>
<td>13</td>
<td>0</td>
<td>20,994,873</td>
<td>2,563</td>
<td>20,997,437</td>
<td>0.01%</td>
<td>99.99%</td>
</tr>
<tr>
<td>2,730,000</td>
<td>14</td>
<td>0</td>
<td>20,997,437</td>
<td>1,282</td>
<td>20,998,718</td>
<td>0.01%</td>
<td>99.99%</td>
</tr>
<tr>
<td>2,940,000</td>
<td>15</td>
<td>0</td>
<td>20,998,718</td>
<td>641</td>
<td>20,999,359</td>
<td>0.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td>3,150,000</td>
<td>16</td>
<td>0</td>
<td>20,999,359</td>
<td>320</td>
<td>20,999,680</td>
<td>0.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td>3,360,000</td>
<td>17</td>
<td>0</td>
<td>20,999,680</td>
<td>160</td>
<td>20,999,840</td>
<td>0.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td>3,570,000</td>
<td>18</td>
<td>0</td>
<td>20,999,840</td>
<td>80</td>
<td>20,999,920</td>
<td>0.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td>3,780,000</td>
<td>19</td>
<td>0</td>
<td>20,999,920</td>
<td>40</td>
<td>20,999,960</td>
<td>0.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td>3,990,000</td>
<td>20</td>
<td>0</td>
<td>20,999,960</td>
<td>20</td>
<td>20,999,980</td>
<td>0.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td>4,200,000</td>
<td>21</td>
<td>0</td>
<td>20,999,980</td>
<td>10</td>
<td>20,999,990</td>
<td>0.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td>4,410,000</td>
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<td>20,999,995</td>
<td>0.00%</td>
<td>100.00%</td>
</tr>
<tr>
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<td>0</td>
<td>20,999,995</td>
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<td>20,999,997</td>
<td>0.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td>4,830,000</td>
<td>24</td>
<td>0</td>
<td>20,999,997</td>
<td>1</td>
<td>20,999,999</td>
<td>0.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td>5,040,000</td>
<td>25</td>
<td>0</td>
<td>20,999,999</td>
<td>1</td>
<td>20,999,999</td>
<td>0.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td>5,250,000</td>
<td>26</td>
<td>0</td>
<td>20,999,999</td>
<td>0</td>
<td>21,000,000</td>
<td>0.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td>5,460,000</td>
<td>27</td>
<td>0</td>
<td>21,000,000</td>
<td>0</td>
<td>21,000,000</td>
<td>0.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td>5,670,000</td>
<td>28</td>
<td>0</td>
<td>21,000,000</td>
<td>0</td>
<td>21,000,000</td>
<td>0.00%</td>
<td>100.00%</td>
</tr>
<tr>
<td>5,880,000</td>
<td>29</td>
<td>0</td>
<td>21,000,000</td>
<td>0</td>
<td>21,000,000</td>
<td>0.00%</td>
<td>100.00%</td>
</tr>
<tr>
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<td>100.00%</td>
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<tr>
<td>6,300,000</td>
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<tr>
<td>6,510,000</td>
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</tr>
<tr>
<td>6,720,000</td>
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<td>100.00%</td>
</tr>
<tr>
<td>6,930,000</td>
<td>34</td>
<td>-</td>
<td>21,000,000</td>
<td>-</td>
<td>21,000,000</td>
<td>0.00%</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

**Block reward**: Block reward (as measured by BTC per block produced) halves every 210,000 blocks produced (approximately just under every 4 years under current mining rate).

**BTC Supply**: Initial bitcoin supply of 10.5m (50%) released. Subsequently the BTC supply is halved every reward era based on the block reward mechanism.

**Inflation Rate (%):** As a measure of bitcoin increase for the period...
Contact US

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No one should act on such information without appropriate professional advice after a thorough examination of the particular situation.