Bitcoin and Virtual Currencies

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Bitcoin and Virtual Currencies and the Blockchain

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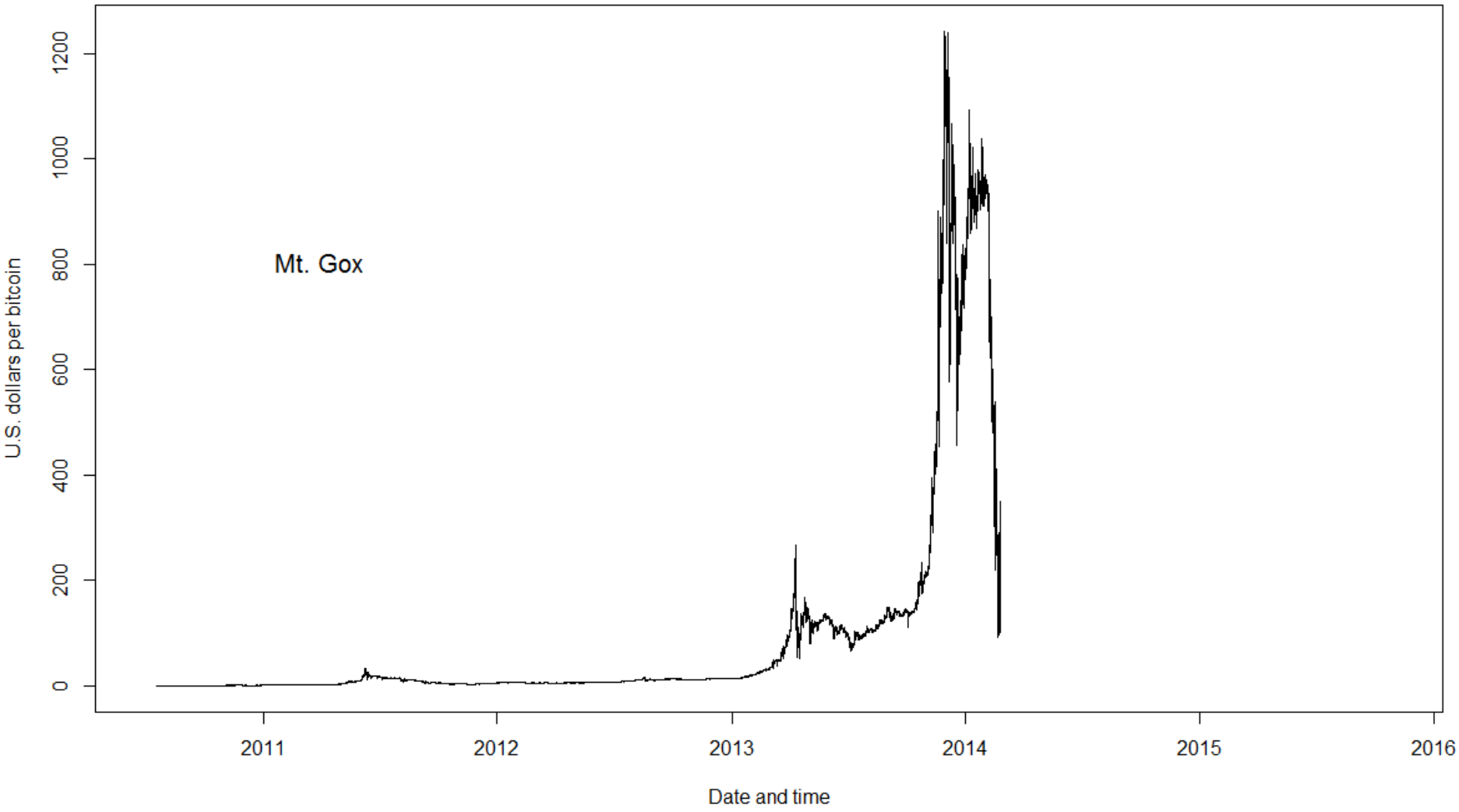
Price of Bitcoin
Mt. Gox Exchange
7/17/2010 to 2/14/2014



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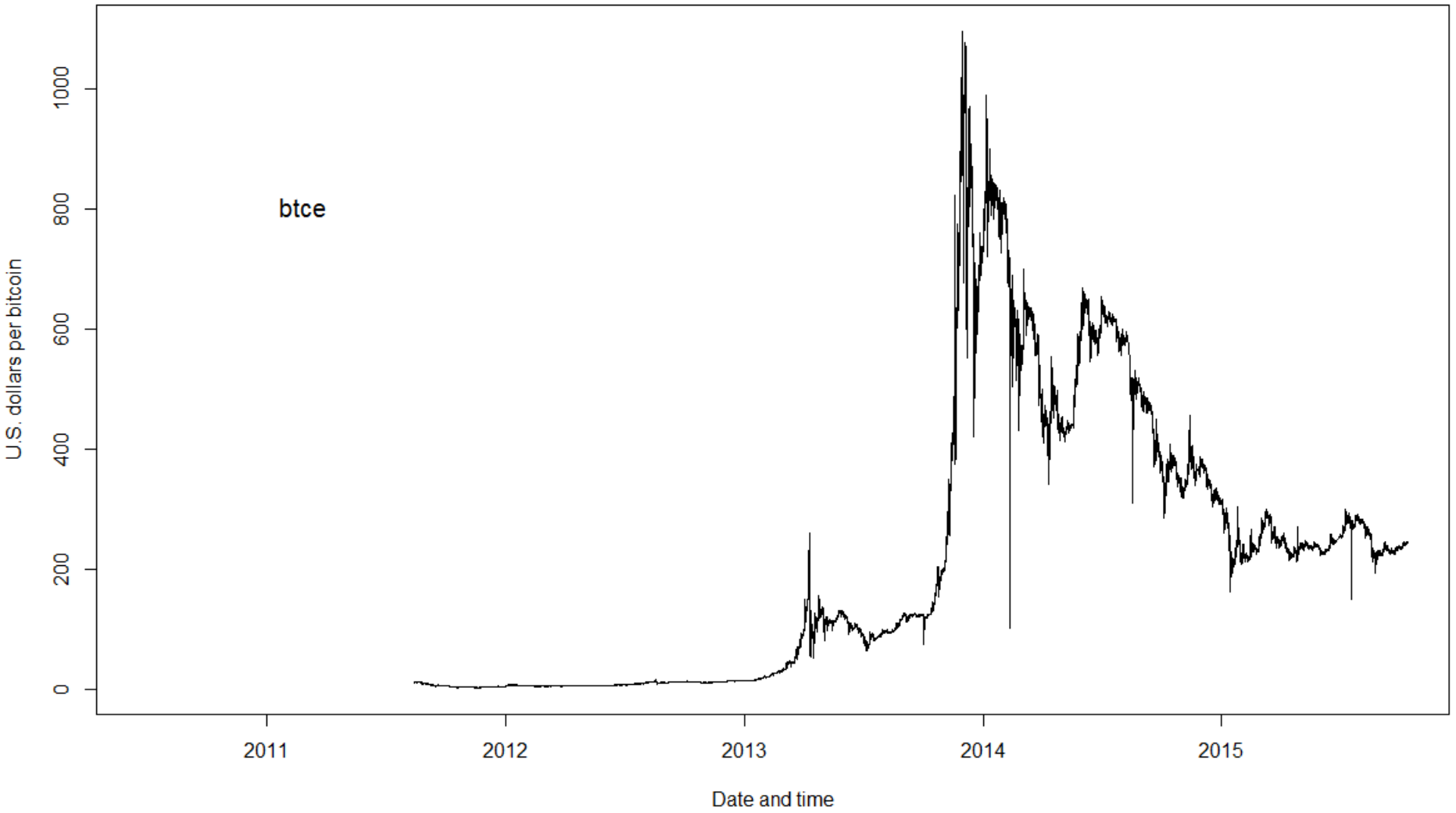

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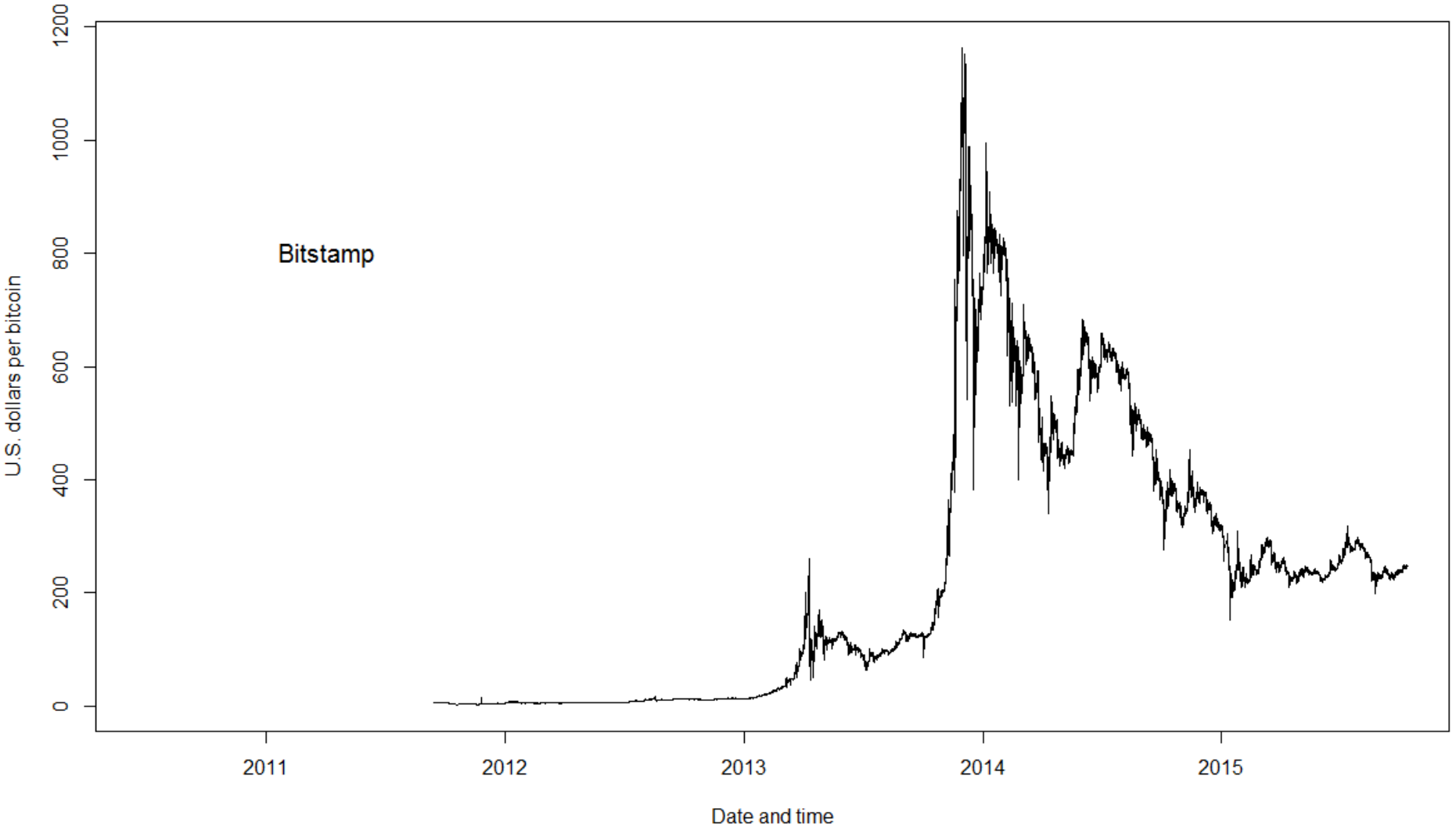


Introduction

- Digital currency has been next best thing since 1990s
- Digital currency is money which
  - Is an asset held by the owner of the money and not a liability of a financial institution
  - Can be used to buy something from someone else without the intervention of an outside party

Introduction

- Digital currency has been next best thing since 1990s
- Digital currency
- Virtual currency is another name for digital currency because the currency may have no physical representation other than bits and bytes

Introduction

- Digital currency has been next best thing since 1990s
- Digital currency
- Virtual currency
- Cryptocurrency
  - Digital currency with cryptography an important part of its implementation
  - Bitcoin and similar currencies

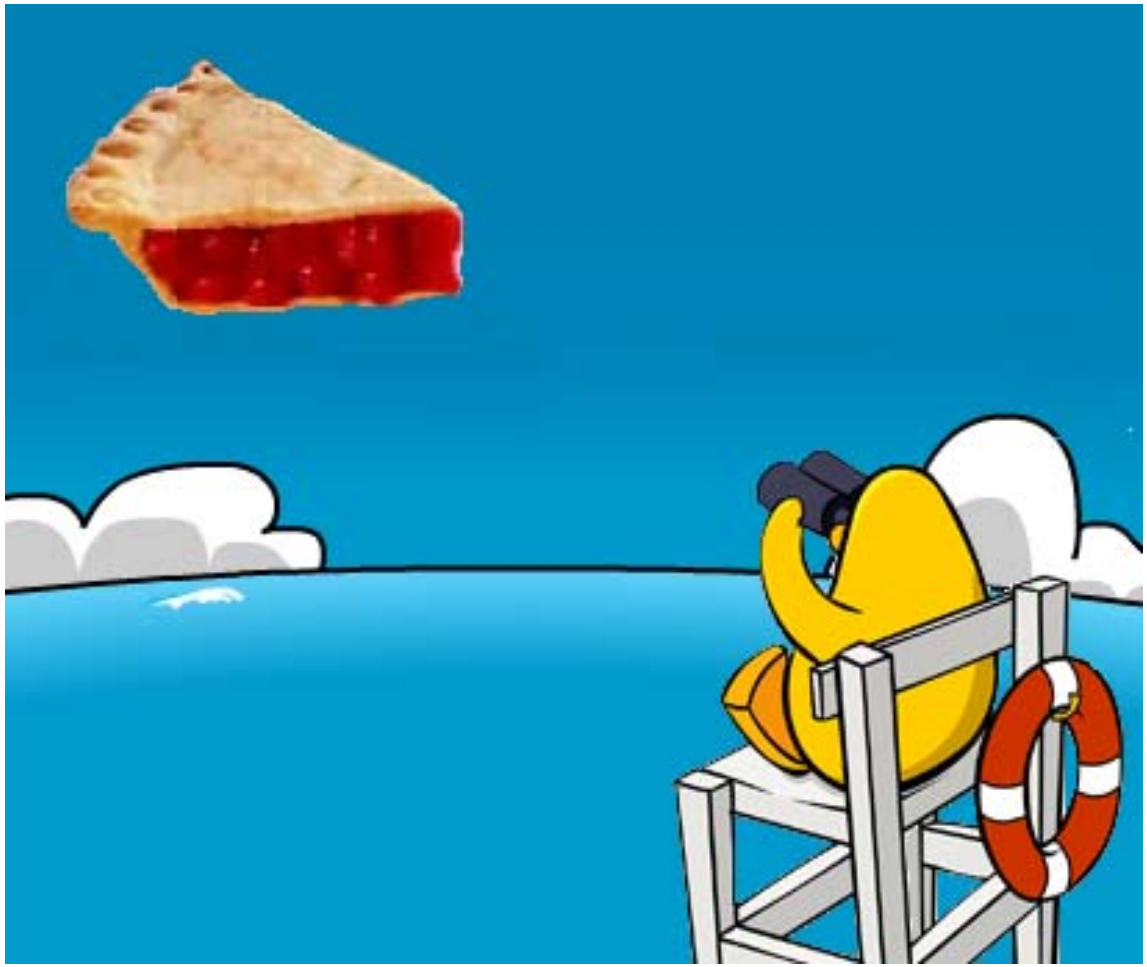
Introduction

- Digital currency has been next best thing since 1990s
- Digital currency
- Virtual currency
- Cryptocurrency
- Blockchain securely keeps track of changes in ownership of cryptocurrency

Bitcoin and the Blockchain in the Wall Street Journal

- Barclays Puts Big Banks One Step Closer to Bitcoin (9/2)
- Visa, Nasdaq, Others Invest $30 Million in Bitcoin-Related Startup (9/9)
- State Street Experiments with Blockchain for Institutional Banking (9/25)
- Blockchain is on the Agenda at State Street (9/28)
- UBS Working with Blockchain Prototypes (10/2)

Pie in the Sky?



Source: shadowproof.com

Computers

- “I see no reason why anyone would want a computer in their home.”
  - Kenneth Olsen, president of DEC, 1977

Cray Supercomputer 1979

Source: Deutches Museum

A 15-Times Faster Computer Today

Source: Samsung

Organization of Rest of Talk

- Use Bitcoin to make the discussion more concrete and precise
- Basic Issues
  - Supply
  - Demand
  - Equilibrium
  - Volatility
- Blockchain generally

Single Biggest Technical Issue for Digital Currencies

- Double spending

Source: gizmodo.com

Supply of Cryptocurrencies

- Bitcoin
- Litecoin
- Ripple

Economics of Bitcoin

- Demand
- Supply

Issues for Supply

- How created?
- What determines the nominal quantity of money?
- Who gets any revenue from creating money?
- How prevent double spending?

Origination of Bitcoin

- Satoshi Nakamoto
  - Paper in 2008
  - Details worked out in user group for programmers
  - Rules for supply
  - Fixed final number of bitcoins
    - 21 million
    - Actual quantity increases gradually over time
    - Rate of increase falling by about half every four years
    - Other currencies have other non-state-dependent rules

Supply of New Bitcoins

- “Miners” increase the number of bitcoins
- Mining is the solution of a computational problem
  - Requires work to solve the problem
    - Computer time
    - Electricity
  - Easy to verify that the problem has been solved
    - Hard to solve itself
- Software widely available
  - Open source

Double Spending

- How avoid double spending after created?
- Open-source software
- Peer-to-peer network

Client-Server Network

Peer-to-Peer Network

Maintaining the Record of Ownership and Transactions

- Why does anyone maintain a database?
  - All miners maintain such a database to know where they are in mining and to tell others
- Certification of a mining solution related to keeping record of transactions

Blockchain Is Record of Transactions

- Every transaction includes
  - Address to which bitcoins sent
  - Number of bitcoins sent
  - Digital signature of party sending the bitcoins

Basic Elements of Blockchain

- Each block in the blockchain is a record including
  - Address of party receiving transaction fee and new bitcoins
  - Hash of previous block
  - Transactions
  - Open field to alter hash (nonce)
    - Some other characters can be altered also

Miner Solves a Numerical Problem

- Compute hash of block's header which is less than or equal to a pre-specified value
  - Unique because transactions includes bitcoins to miner
- *h=H(M,nonce+other spaces)*
- *h* <= pre-specified value
- *Nonce* is set of spaces that can be altered, leading to altered *h*
  - The effect of changing nonce on *h* is unpredictable

A Bit of Detail about Maintaining the Record of Transactions

- Maintaining a record with a peer-to-peer network requires a protocol for coming to a consensus about transactions and solutions of mining problem
  - Keep chain of transactions
  - Resolve a block approximately every ten minutes
  - Longest chain is correct one

Maintaining the Record of Transactions without Mining

- Transactions fees
- Also motivates miners to include particular transactions

Who Decides Difficulty of Computational Problem?

- Solving computational problem and getting new bitcoins is a winner-takes-all game
  - Miners pool efforts in mining pools these days
- Difficulty such that a new block is finalized every 10 minutes
- Difficulty is set by consensus and announced by Gavin Andresen
  - Chief Scientist at Bitcoin Foundation
  - Satoshi Nakamura handed off leadership to him

Bitcoin Foundation and Leadership

- Software is open source
  - Anyone can take source code and start own currency
- Andresen and Bitcoin Foundation lead development and adherence to protocol
- Andresen worked for the Bitcoin Foundation for a while and no longer does

Anonymous?

- Not a design goal
- Not hard to collect information on activity of any address
- No
  - Reid and Harrigan (2013)
  - Ron and Shamir (2013)
  - Meiklejohn et al. (2013)

Demand for Digital Currency

- General trend toward digital representations of many things
- $5,000 of digital currency can be more convenient than 250 $20 bills
  - $300 of digital currency can be more convenient than 15 $20 bills

Demand for Digital Currency

- General trend toward digital representations of many things
- $5,000 of digital currency can be more convenient than 250 $20 bills
  - $300 of digital currency can be more convenient than 15 $20 bills
- Easier to smuggle bitcoins out of the country
- Silk Road
- Satoshi Dice

Value in Equilibrium

- Irredeemable paper money has a bad reputation
  - Full-bodied money
  - Digital representation does not improve issue
  - Free entry
- Is there an equilibrium in which digital currency has a positive value?
  - Marimon, Nicolini and Teles (2012)
  - Araujo and Camargo (2008)

Use in Exchanges for Goods and Services

- Not much evidence about that
  - There are analyses of transactions in blockchain but don't now what was traded for bitcoins
- Hill (Forbes, 2013) in San Francisco
- Couple in Utah
- Topic of discussion in Argentina
- Greece (Tsanidis, Nerantzaki, Karavasilis, Vrana, 2015)
- Silk Road

Uses in International Transfers

- Remittances
- Circumventing capital controls

Information from Blockchain

- Ron and Shamir (2013) analyze the blockchain through May 13, 2012
- Estimate turnover of bitcoins and identify "entities"
- Total transfers of about 423 million bitcoins
- About 3.7 million different addresses
  - About 1.9 million different entities with transactions
  - 609,000 additional addresses had never sent a bitcoin

Information from Blockchain II

- Distribution of transactions by entity highly skewed
  - 78 percent of all bitcoins were at addresses which had never sent a bitcoin to another address.
  - 97 percent of all entities have fewer than 10 transactions
  - 75 entities have at least 5,000 transactions

Information from Blockchain III

- Average entity held 3.7 bitcoins, although the distribution was very skewed
  - Average balance was about $100 at about $30 per bitcoin
  - 85 percent of all entities held less than 0.01 bitcoins
  - One entity held between 200,000 and 400,000 bitcoins worth about $6 to $12 million
  - About half of bitcoins were held by entities with 1,000 to 10,000 bitcoins

Trades of Bitcoins for Dollars

- Mt. Gox exchange in Tokyo
  - 7.7 million unique trades
- Btce
  - 22 million trades
- Bitstamp
  - 7.4 million unique trades

The Exchanges

- No brokers
- Limit orders and market orders
- Can see order book online and submit orders

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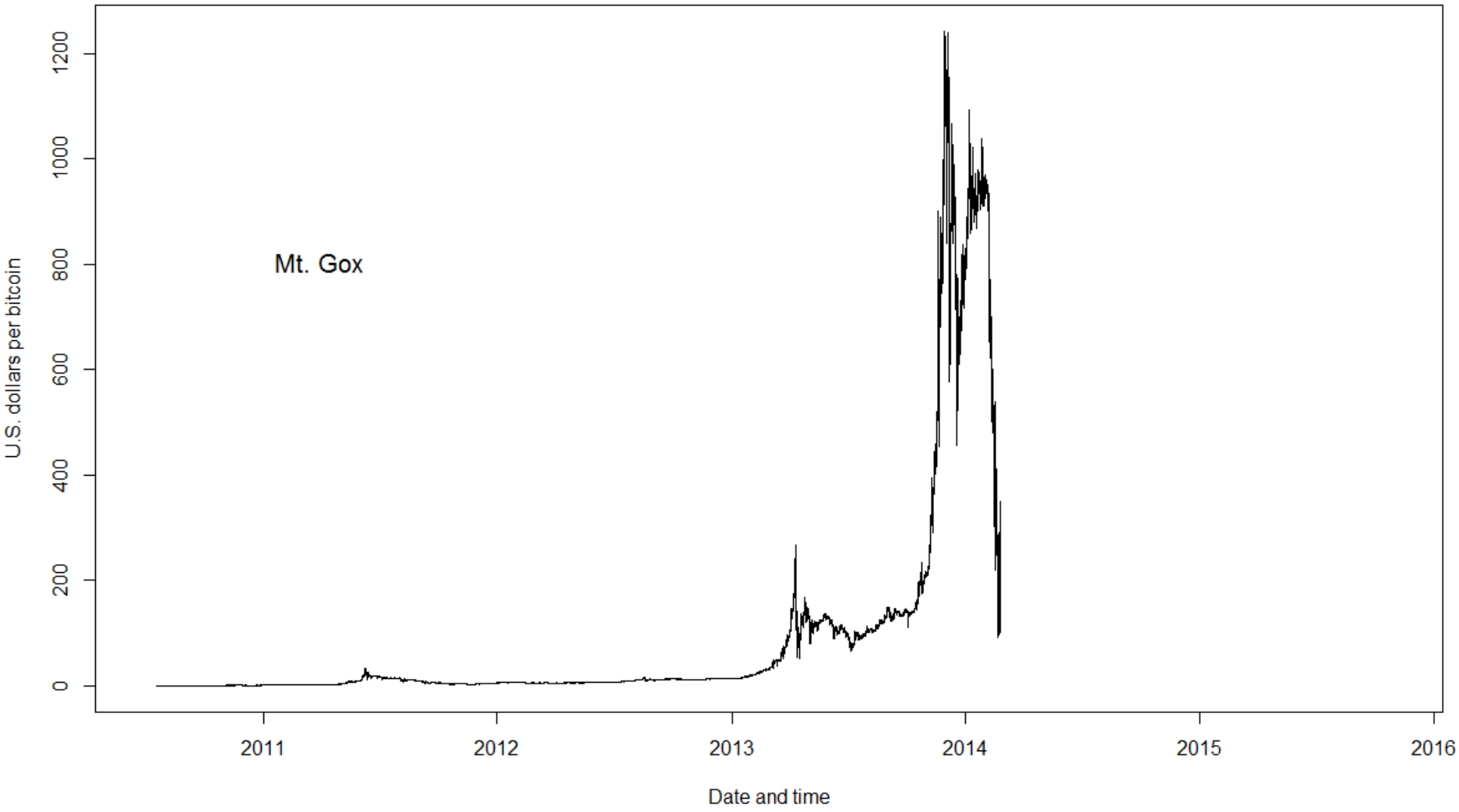

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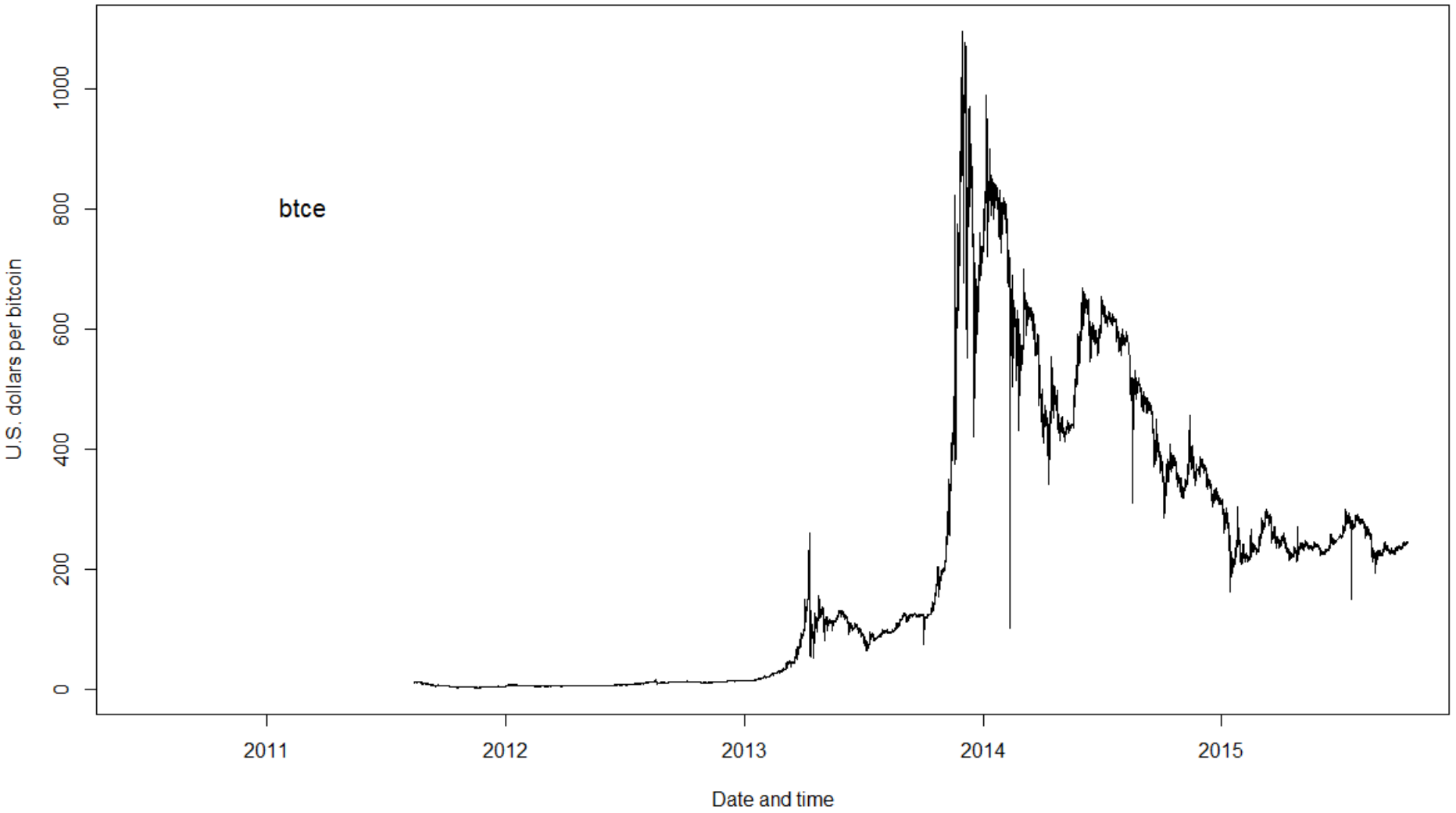

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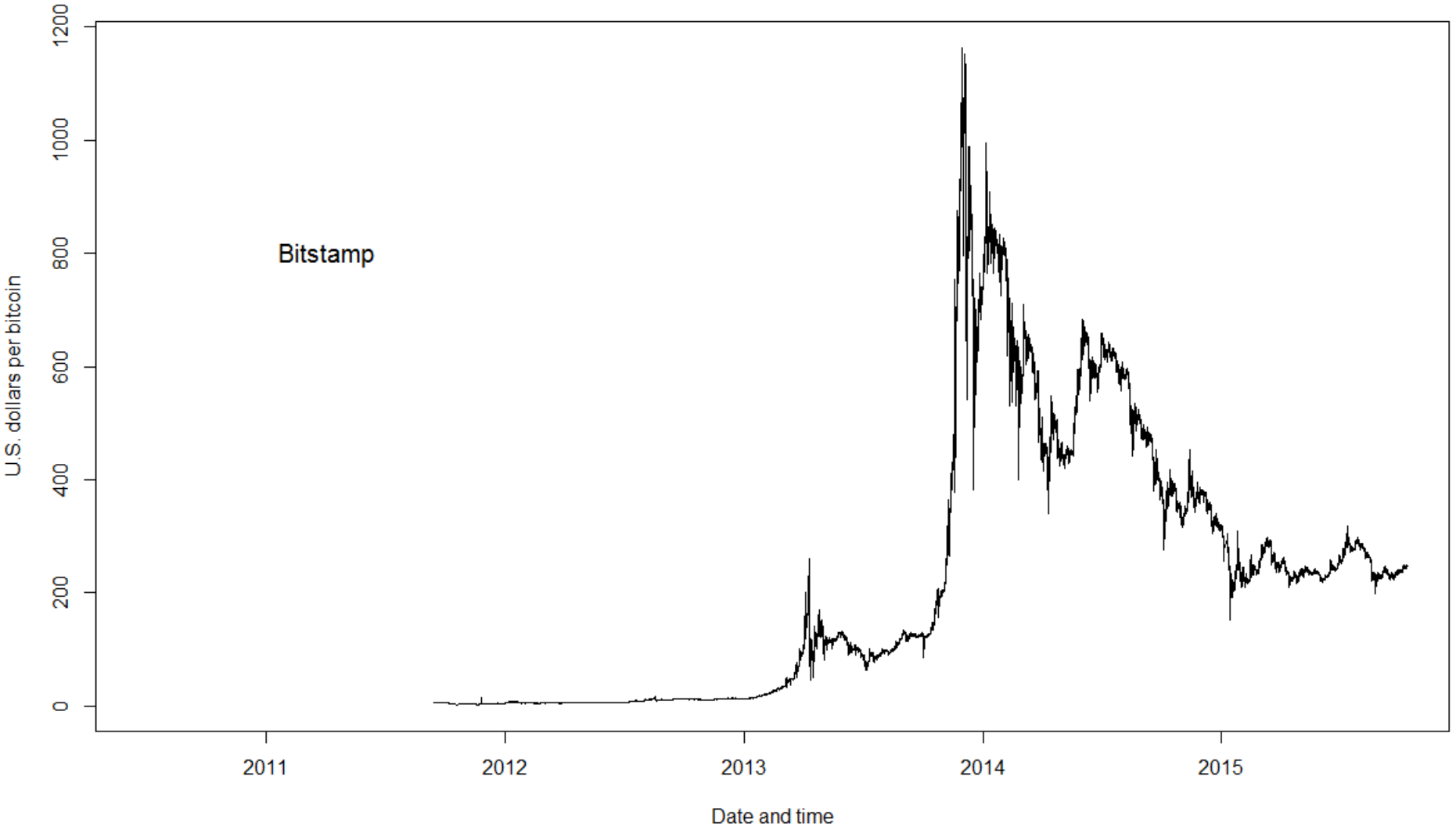

Price High or Low?

- October 31, 2015
- Value of bitcoins in dollars about $3.7 billion
  - Price about $250 per bitcoin
  - About 14.72 million bitcoins in existence in world
- M2 at end of September 2015 about $12.2 trillion
- Value of bitcoins worldwide about 0.03% of value of U.S. money

Price High or Low as Bank Reserves?

- U.S. bank reserves were $8.75 billion before Financial Crisis of 2007-2008
- Value of bitcoins about $3.7 billion
- About 42 percent of U.S. bank reserves

Price High or Low?

- Maximum of 21 billion bitcoins ever suggests that bitcoins likely to appreciate if used much in transactions
  - 0.03% of U.S. M2
  - 42 percent of U.S. reserves before financial crisis

Volatility of Price versus Return

- Price is wrong metric for volatility
- Return is right metric for volatility

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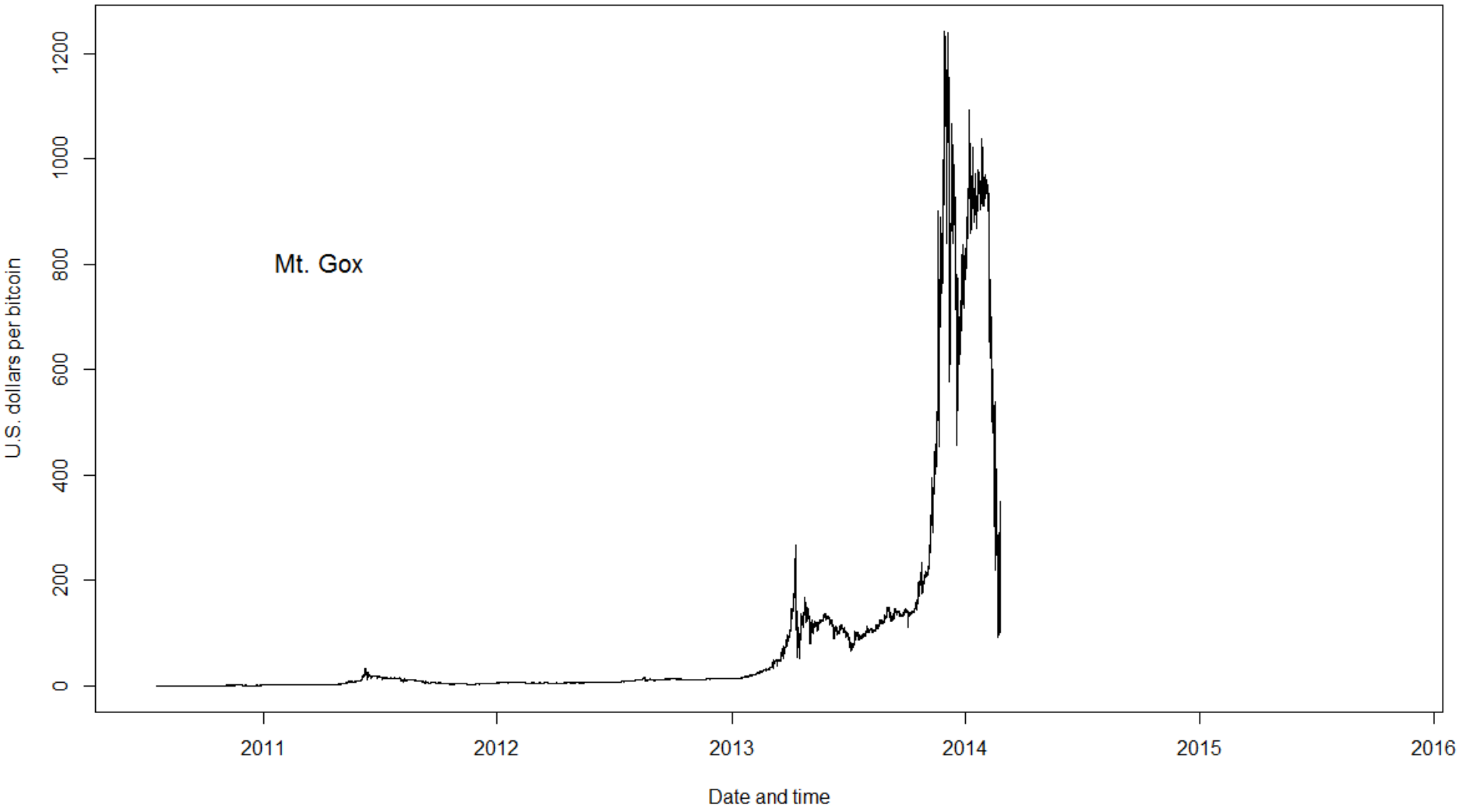

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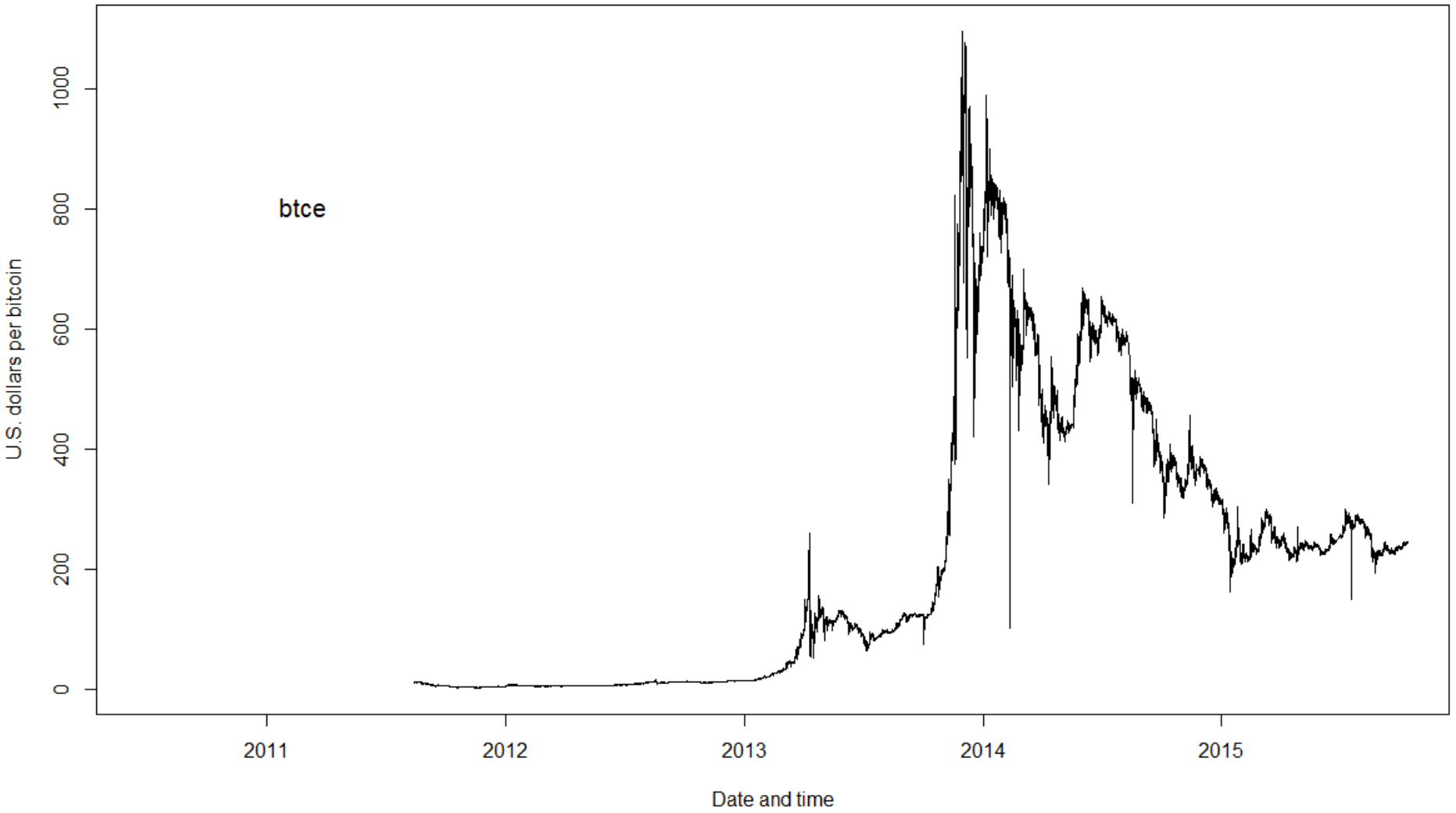

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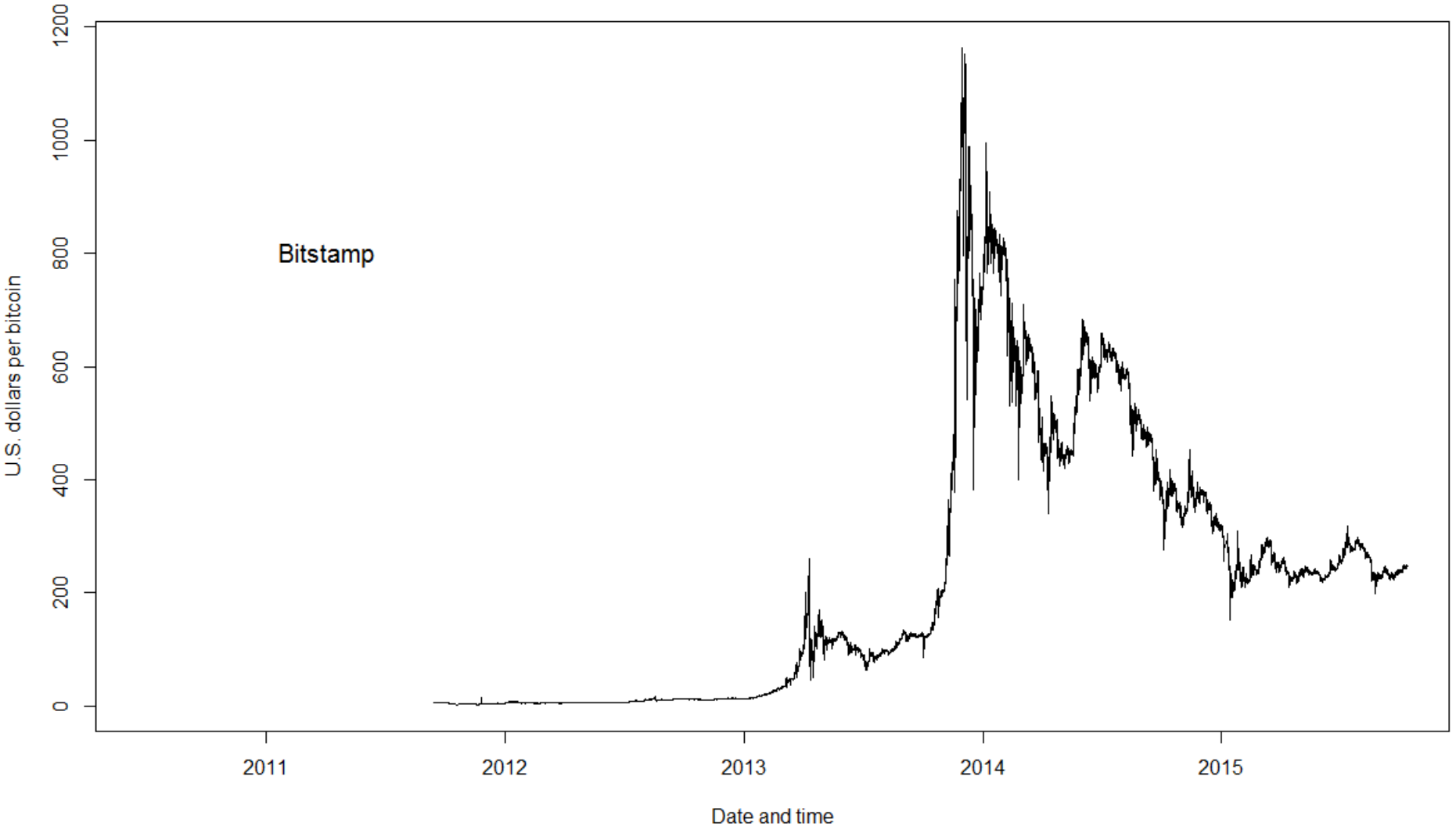
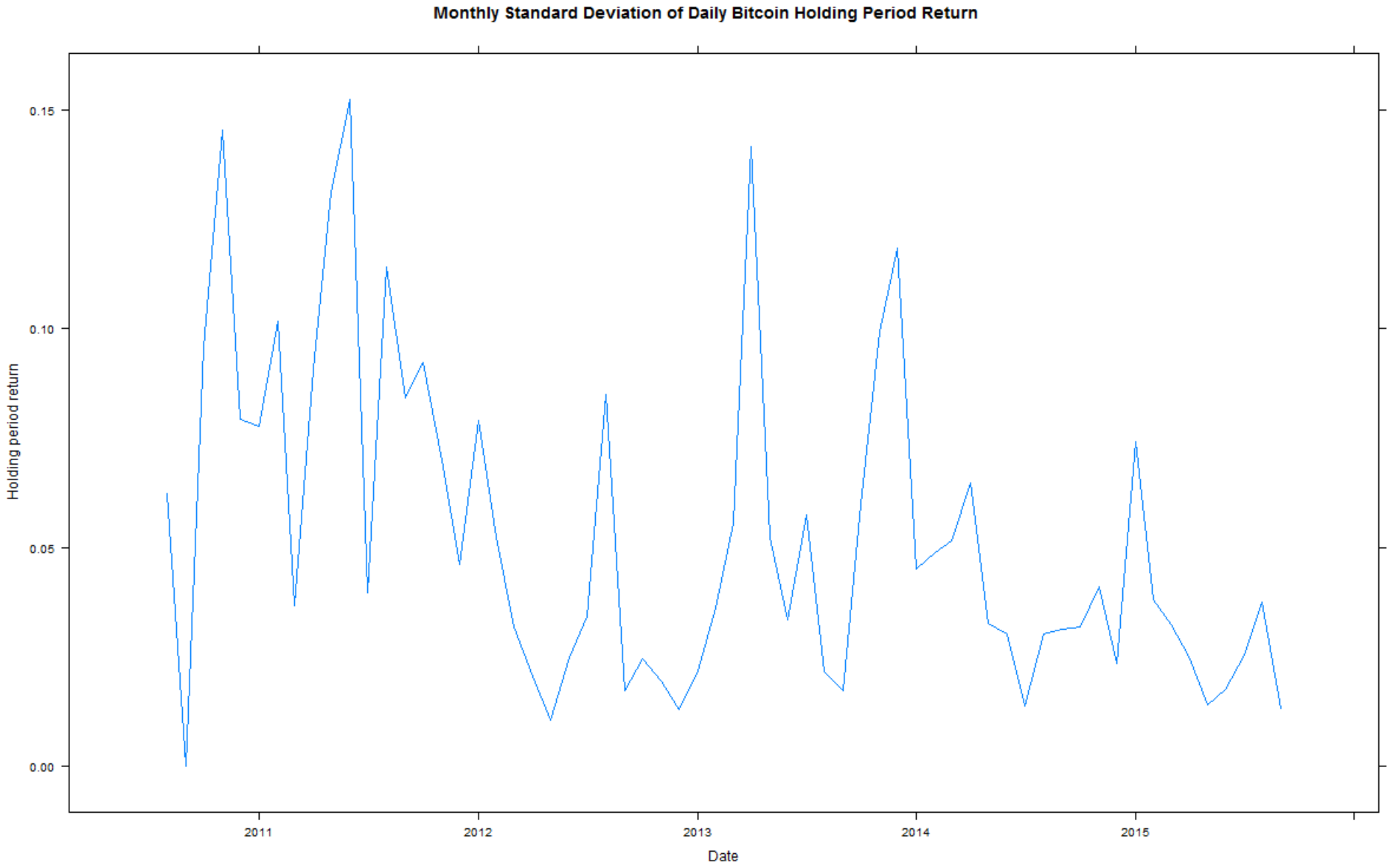


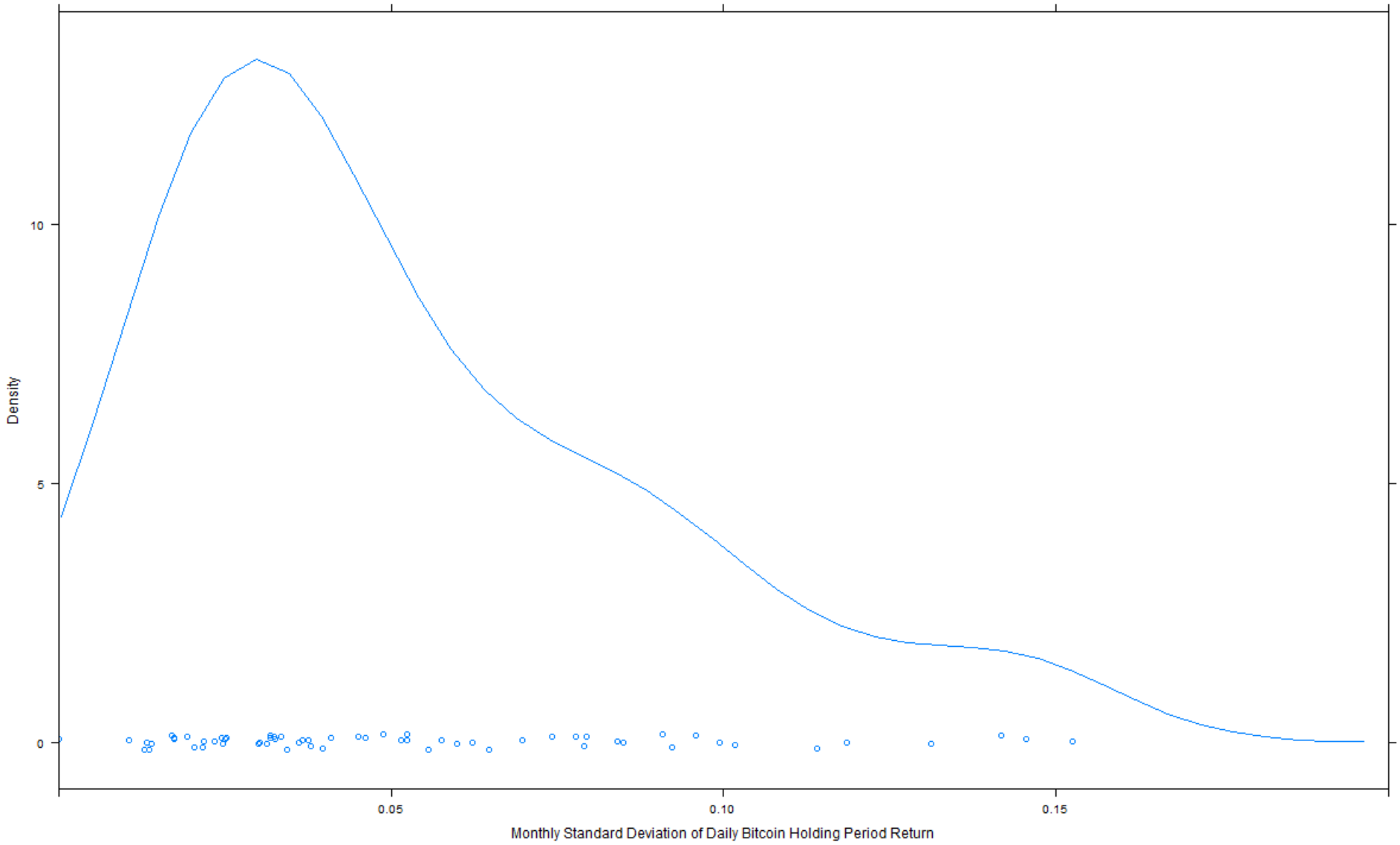
Volatility of Returns

Standard Deviation over Time



Volatility of Returns

Density



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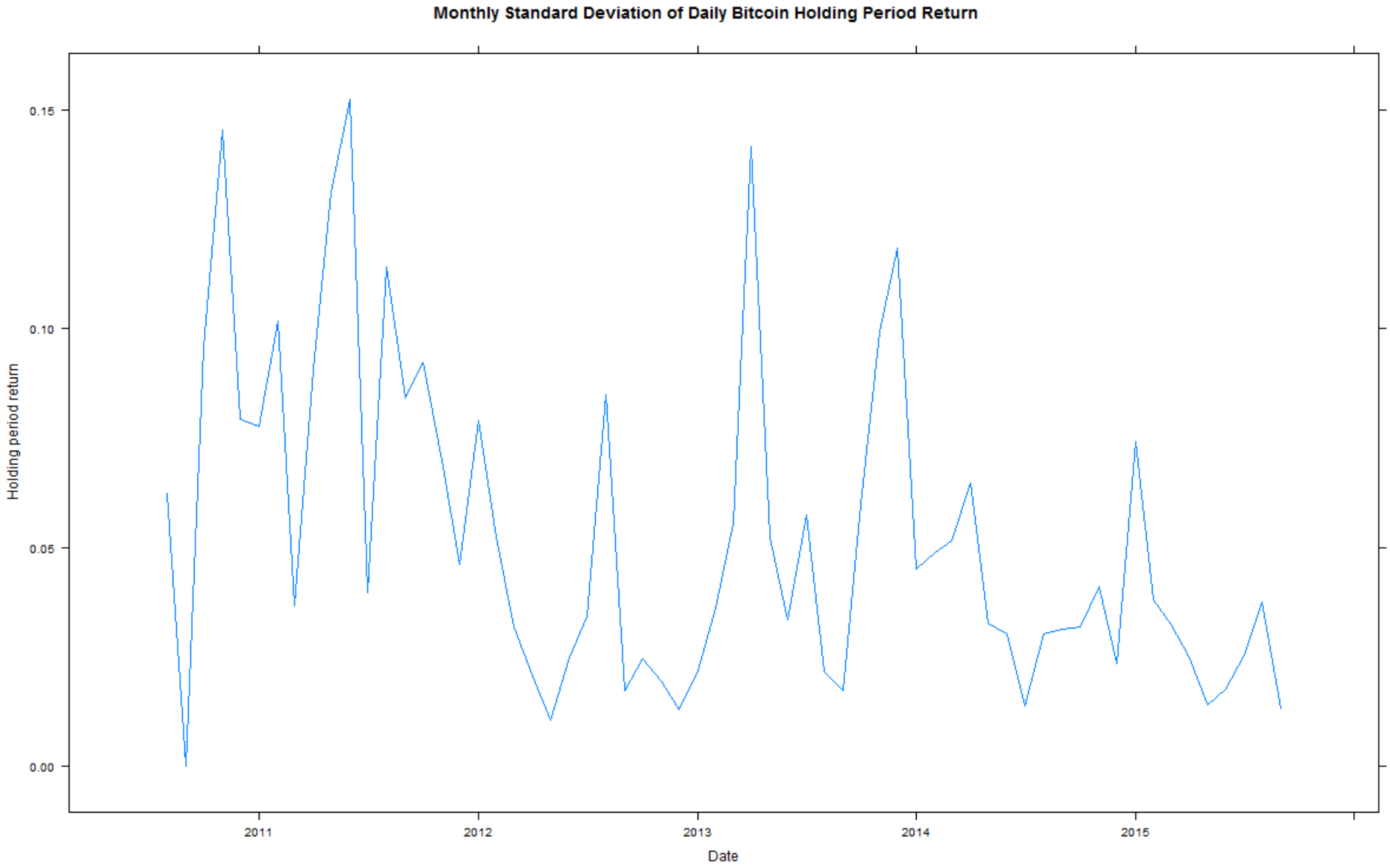
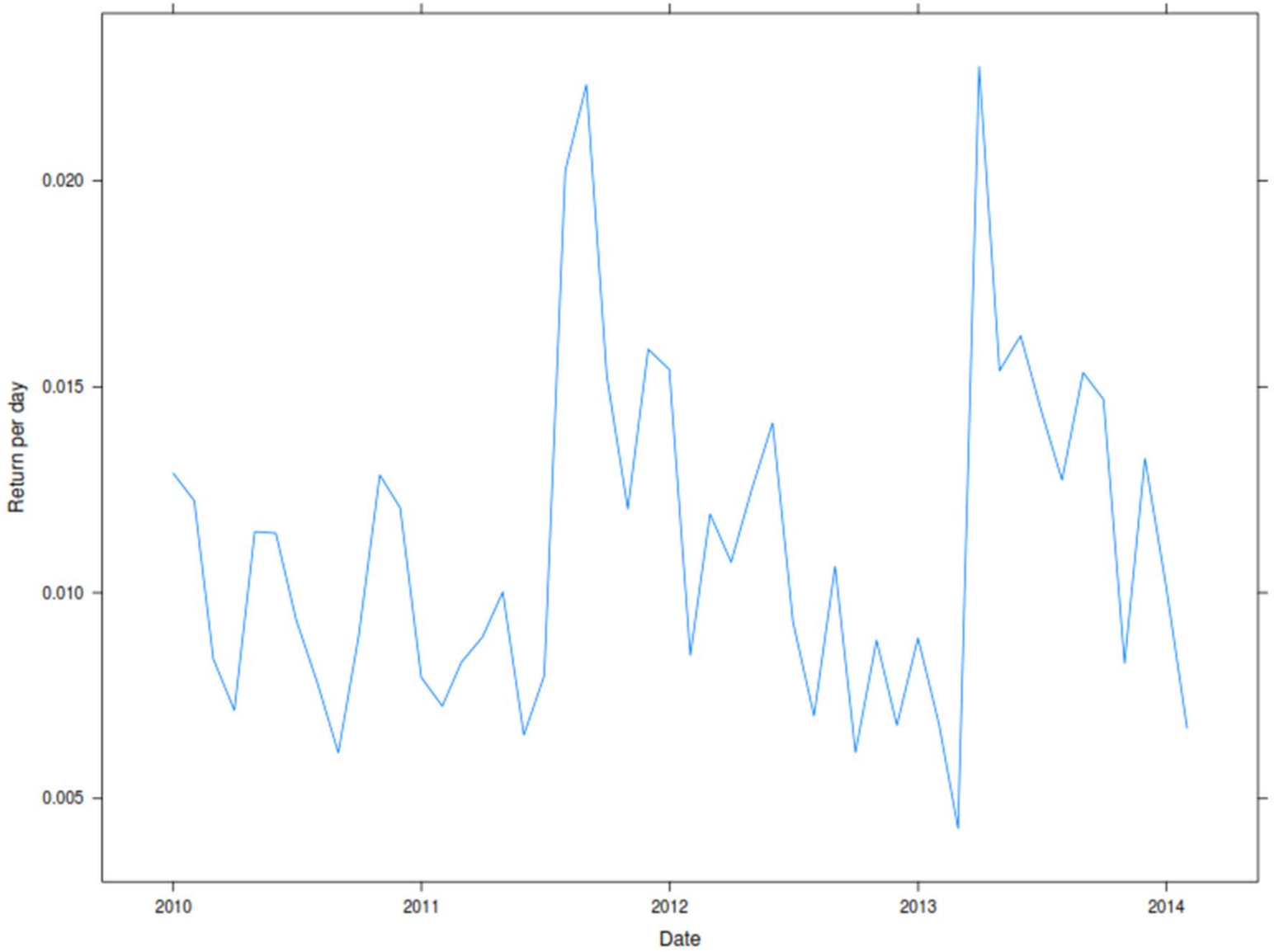


Volatility of Gold's Returns



Volatility of FX Returns

- 23 currencies with daily exchange rates provided by Federal Reserve Bank of St. Louis
- Monthly standard deviations of daily returns
- Minimum Hong Kong .0061% per day
- Maximum Venezuela 23.6% per day

Value Volatile?

- Not so much as to be highly volatile
- Not a unit of account generally either
  - Dell does not keep a stable price in bitcoins

Conclusion Bitcoin

- There is no fundamental flaw in Bitcoin that indicates its inevitable demise
  - Reputational equilibrium with knowable quantity
- Can have a positive value in equilibrium
- Free entry at zero marginal cost may be an issue but
  - Importance of liquidity
  - Identifiability of individual currencies

Conclusion Bitcoin

- Bitcoin is not obviously the ideal digital currency
  - Mining is not the only possible solution for creating bitcoins
    - Rule for creating money may waste resources
  - Fixed final quantity of bitcoins means continuing increases in price
    - Increase in demand
    - Loss of bitcoins

Conclusion Bitcoin

- Possible that people in U.S. will be paying their rent in bitcoins or another private digital currency
- I am dubious
  - People prefer to avoid exchange risk by having assets and liabilities in same currency
- Bitcoin and similar currencies are more likely to be used as base money for some transfers
  - Foreign exchange transactions
  - Remittances
- New asset class

Conclusion Bitcoin

- The blockchain and peer-to-peer impersonal verification of transactions is the big innovation
- Many open economic and financial questions
  - Game-theory solution of blockchain protocol
  - Operation of peer-to-peer exchange

The Blockchain in the Wall Street Journal

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The Blockchain

- What is all the discussion about?
- The blockchain is a peer-to-peer protocol for settling transactions
  - The Bitcoin protocol works for anonymous agents
  - Uses miners to settle transactions
  - “Trustless”
- The blockchain is called “blockchain” because it is a chain with blocks of transactions

The Blockchain

- Other possible uses besides Bitcoin
  - Settling other transactions
  - Contracts

Blockchain as Public Ledger

- The blockchain is a ledger of all transactions
- Transactions in Bitcoin are pseudo-anonymous
  - Address in blockchain is public
  - Don‘t know who has address, don’t know who did those transactions
  - If know who has address, know all transactions with by that person with that address

Blockchain and Payments

- The blockchain is an open protocol for settling payments across agents
  - No reason it has to be confined to Bitcoin
  - No reason it has to operate with miners competing
- Can operate with trusted agents
  - Real-time gross settlement
- Lots of issues
  - Prevent alterations
  - Finality

Blockchain and Ownership

- Author of book put a hash of the book's text on the blockchain before sending it to publishers
- Stock
  - NASDAQ is exploring using a blockchain for stock ownership
  - Obviously could use it for non-listed stocks
- Title to house
  - Legal issues

The Blockchain and Escrow

- Escrow on a house
  - Buyer transfers funds to bank of seller's agent
    - Returned if deal falls through
    - Cashed if house deal goes through or buyer backs out
    - Two of buyer's agent, seller's agent and buyer agree
- On blockchain
  - Put a "smart contract" for a transfer on the blockchain
    - Executed if two of these participants agree
    - Otherwise expires

Bitcoin and the Blockchain

- The blockchain is a big innovation
- Otherwise Bitcoin is similar to prior proposals
- The blockchain has the potential to alter many financial transactions

References

- Many papers on Bitcoin now
  - Economics and Computer Science
  - SSRN and Google Scholar
- My papers
  - "The Economics of Bitcoin and Similar Private Digital Currencies", Journal of Financial Stability, 2015
  - "Bits and Pieces: The Digital World of Bitcoin Currency", with Norbert Michel, Heritage Foundation Backgrounder
  - Blog, www.jerrydwyer.com/blog