On the Value of Virtual Currencies[1]

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[1] *Views expressed do not necessarily reflect official positions of DNB or BoC.*

Introduction

"You have to really stretch your imagination to infer what the intrinsic value of bitcoin is. I haven't been able to do it. Maybe somebody else can."

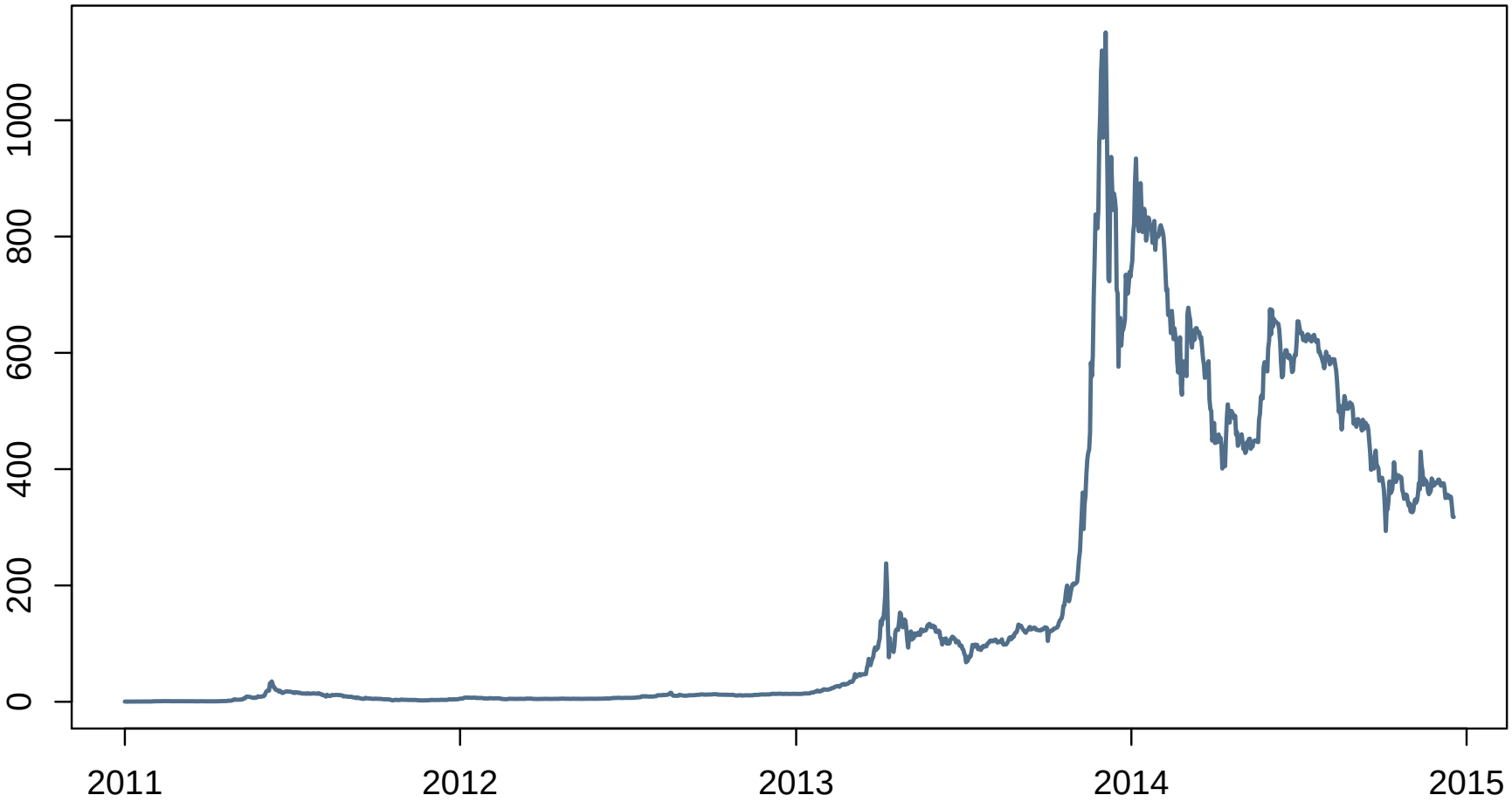
– Alan Greenspan, Bloomberg Interview, 4 Dec. 2013

Introduction

Characteristics of virtual currencies such as Bitcoin

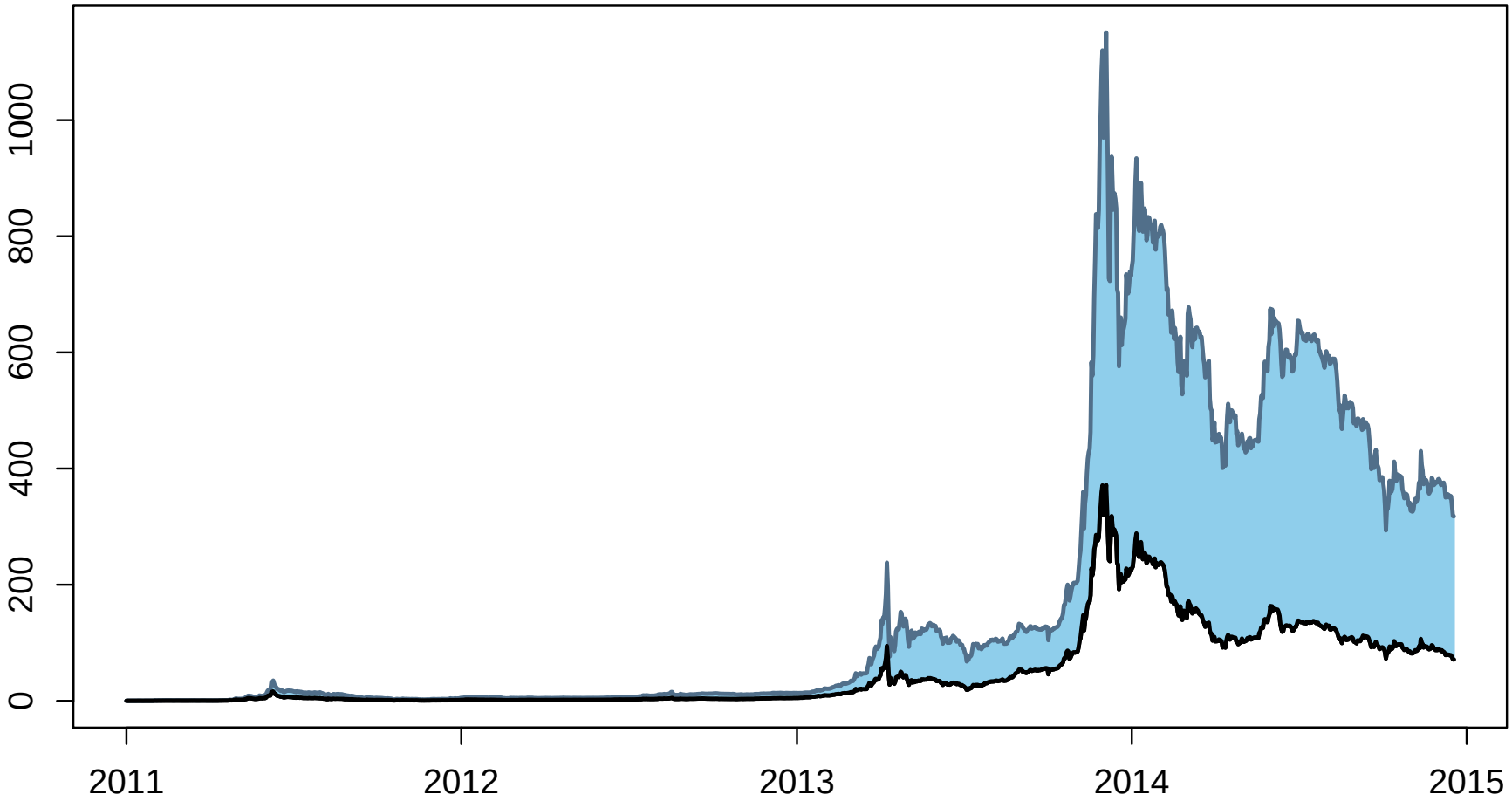
- *Predetermined money growth* path; commodity-like properties
- Peer-to-peer *payment system*
- Potential benefits for users (pseudonymity, cost efficiency, cross-border); benefits differ across users
- Prices quoted in bitcoin usually adjusted to the current exchange rate
- Speculation is an important motive for virtual currency holdings

Speculation and the USD/bitcoin exchange rate



Source: www.blockchain.info.

Speculation and the USD/bitcoin exchange rate



Source: www.blockchain.info and authors' calculations.

Preliminaries: Quantity equation

- Transaction version of quantity equation

$$P_t^B T_t^B = M_t^B V_t^B.$$

- Deviation from version popularized by Fisher (1911):
  - V_t^B is the average number of times a unit of the virtual currency is used to purchase *real* goods and services within period t;
  - T_t^B is the quantity of *real* goods and services purchased with virtual currency B.

Preliminaries: Quantity equation

- Electronic stores adjust prices in virtual currencies instantly to the latest available exchange rate: $P_t^B = P_t^{€} / S_t^{€/B}$.
- Some manipulation:

$$\underbrace{\frac{P_t^B}{P_t^{€}}}_{1/S_t^{€/B}} \underbrace{(P_t^{€} T_t^B)}_{T_t^{B*}} = M_t^B V_t^B.$$

- Note: star in T_t^{B*} signifies that value of transactions is now measured in terms of the "established" currency.
- This gives the exchange rate as

$$S_t^{€/B} = \frac{T_t^{B*}}{M_t^B V_t^B}.$$

Preliminaries: Quantity equation

- Suppose Z_t^B of the M_t^B units are not used for purchasing goods or services.
- Velocity, V_t^B, is the weighted average of the velocity of units used to settle payments for goods and services, V_t^{B*}, and those that are not

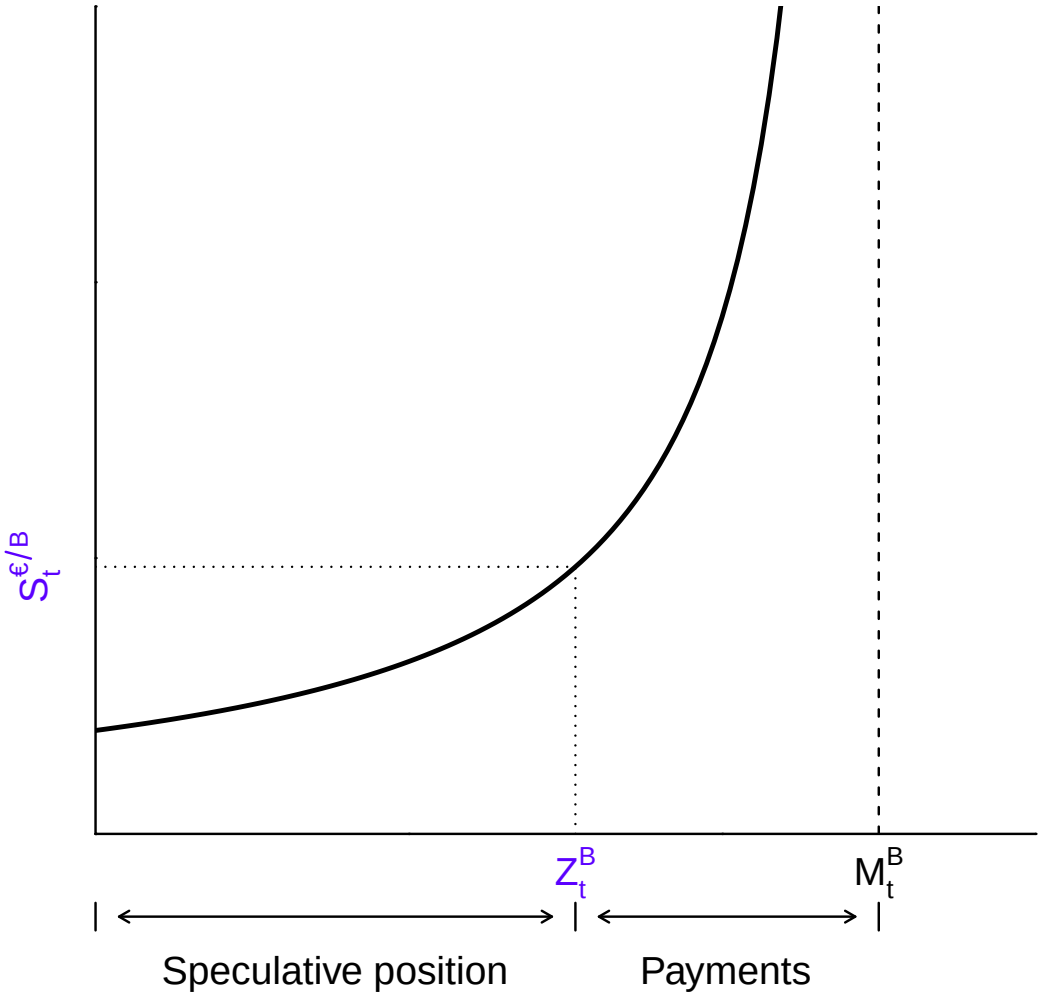
$$V_t^B = \frac{M_t^B - Z_t^B}{M_t^B} V_t^{B*} + \frac{Z_t^B}{M_t^B} 0.$$

- This gives the exchange rate as

$$S_t^{€/B} = \frac{T_t^{B*}/V_t^{B*}}{(M_t^B - Z_t^B)}.$$

  - Essentially, Z_t^B units are "stored-value". In the context of virtual currencies, we suggestively refer to those units as the *speculative position*.

Virtual currency value as a function of speculation



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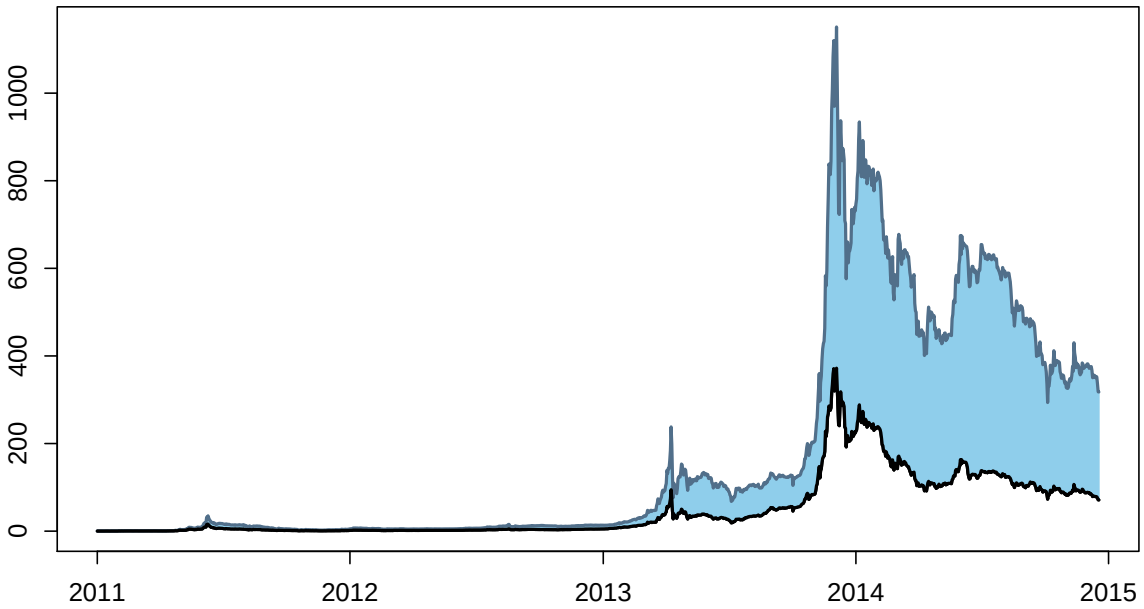
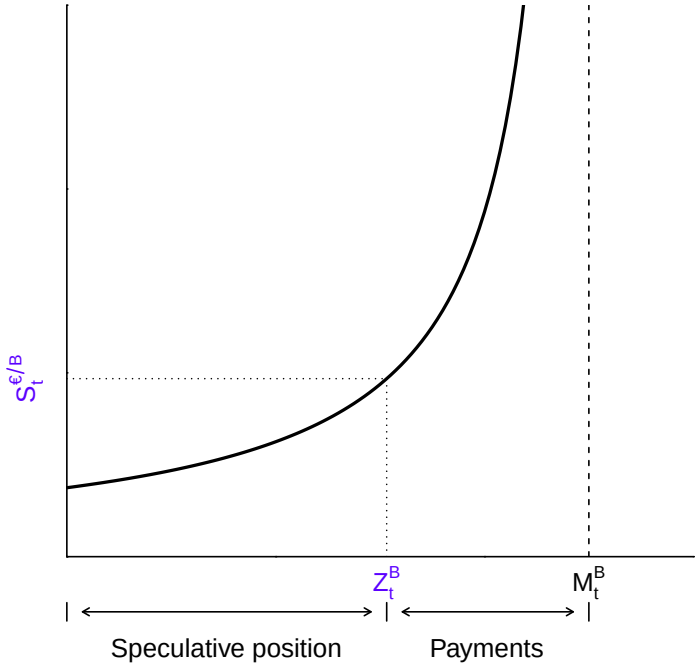
Virtual currency value as a function of speculation





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Model

Setup:

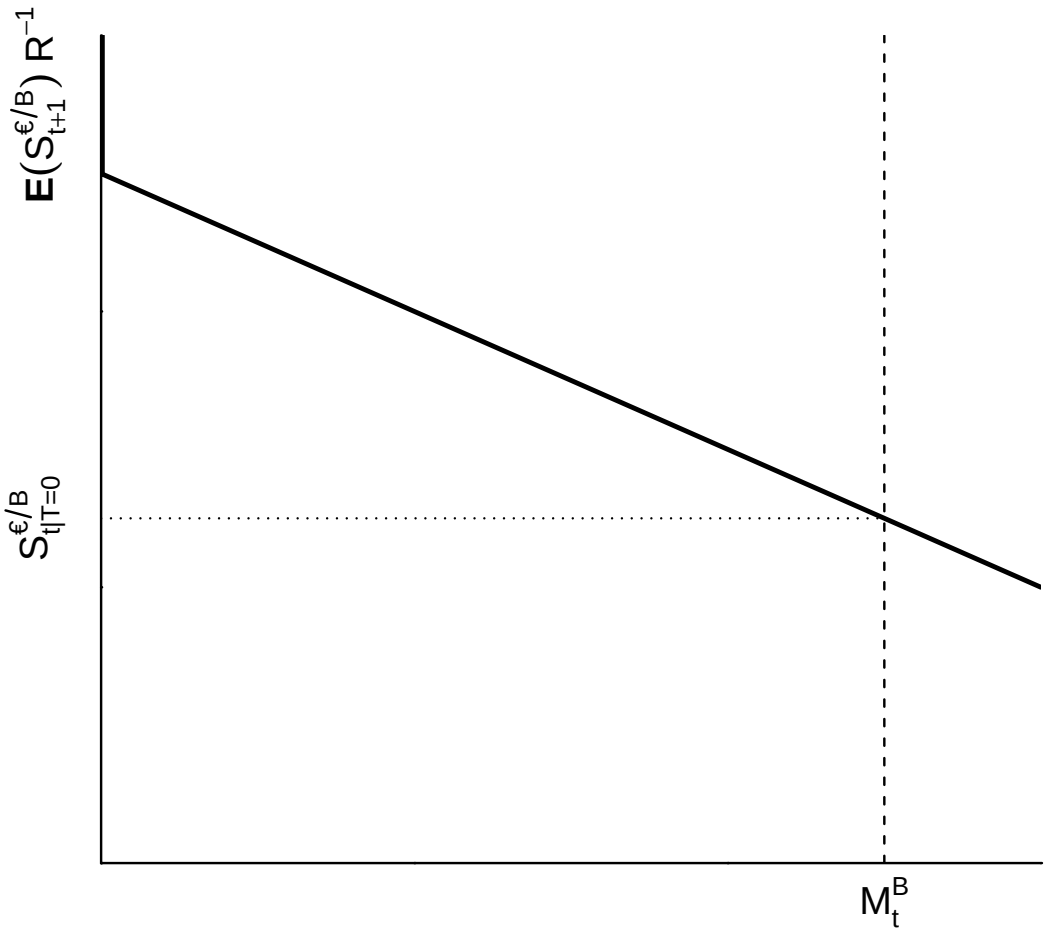
- One-shot model: period t refers to the initial state; period "$t+1$" refers to the moment at which use of the virtual currency network reaches its steady state.

- Two extremes:
  - With probability q, the virtual currency network reaches its full potential in the steady state;
  - With probability $1-q$, virtual currency is abandoned.

- The number of virtual currency units at $t+1$ that follows a predetermined growth rule $M^B_{t+1} = M^B_t \left(1 + m^B_{t+1}\right)$.

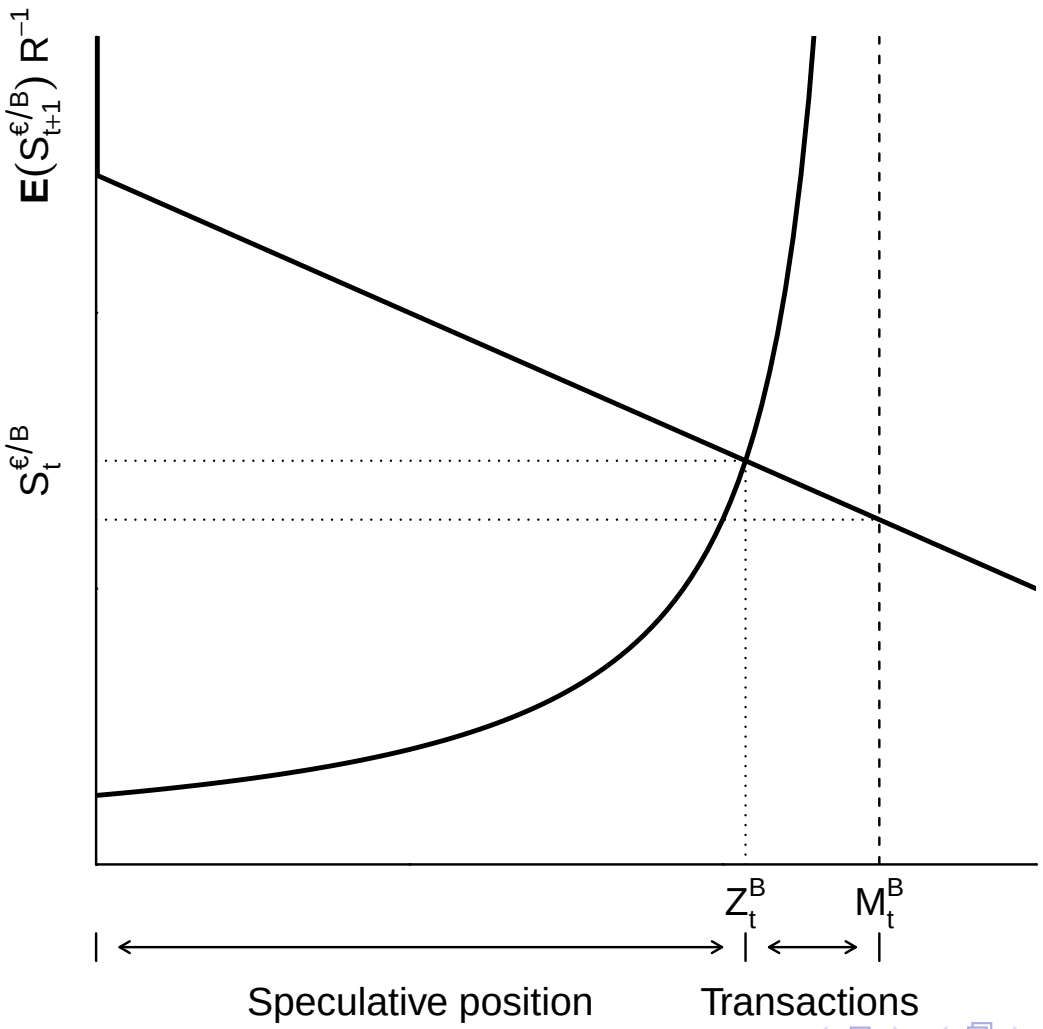
Speculative motive results in a demand schedule

Demand of $N_{s,t}$ speculators based on mean-variance approximation of preferences and risk aversion coefficient γ.



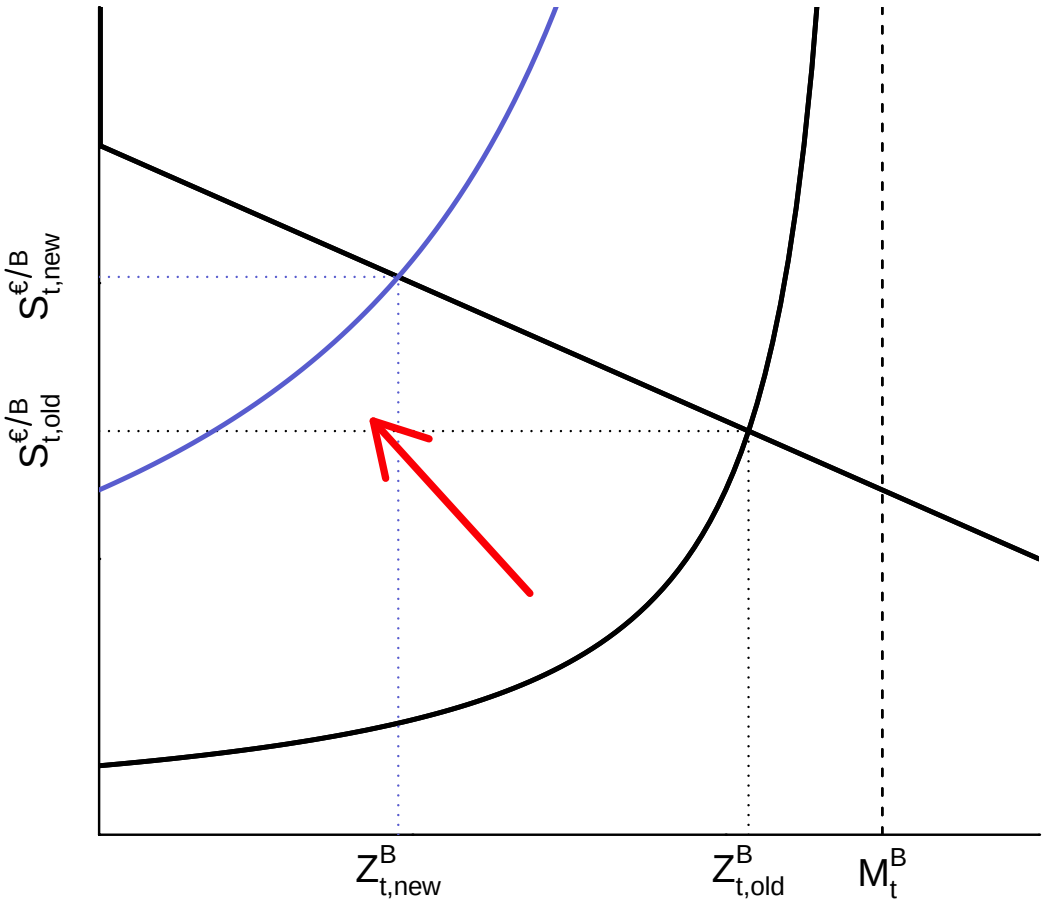
Two building blocks act as a demand and supply schedule

Providing the equilibrium exchange rate.



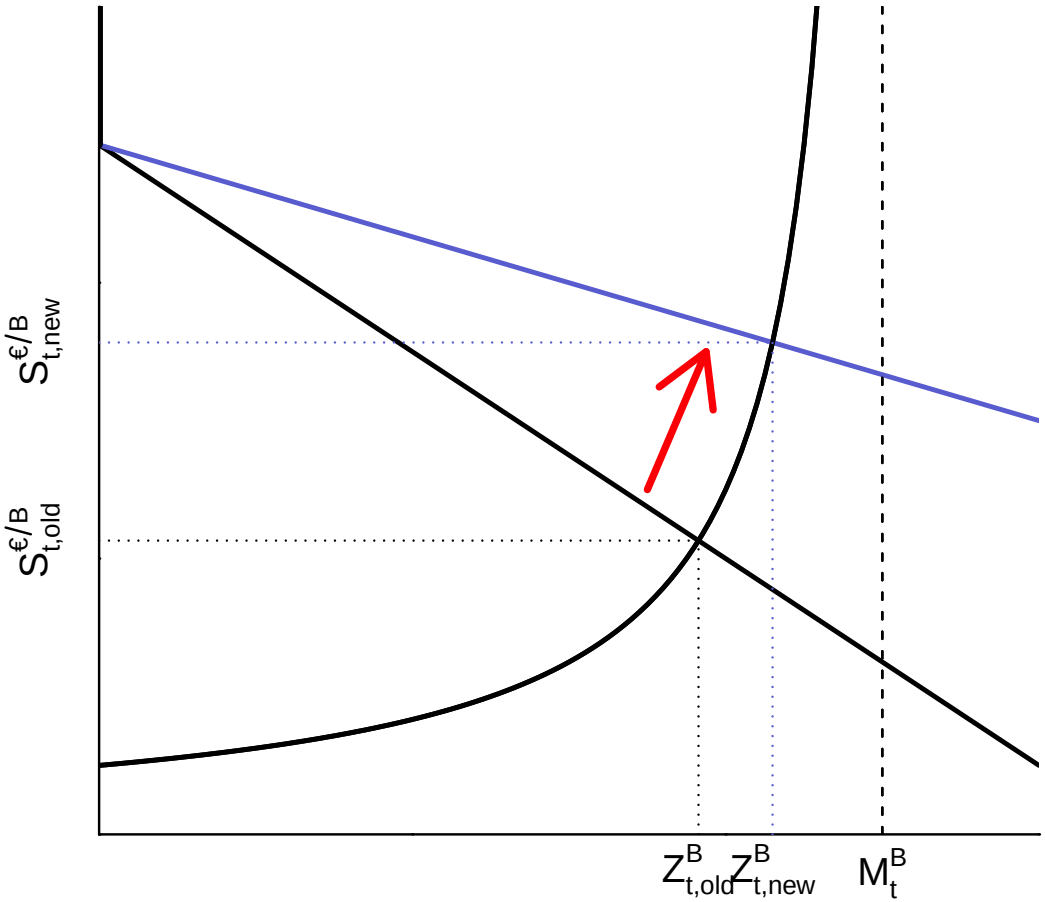
What moves the exchange rate of a virtual currency?

Increase in usage and value of real payments ($T_t^{B*} \uparrow$)



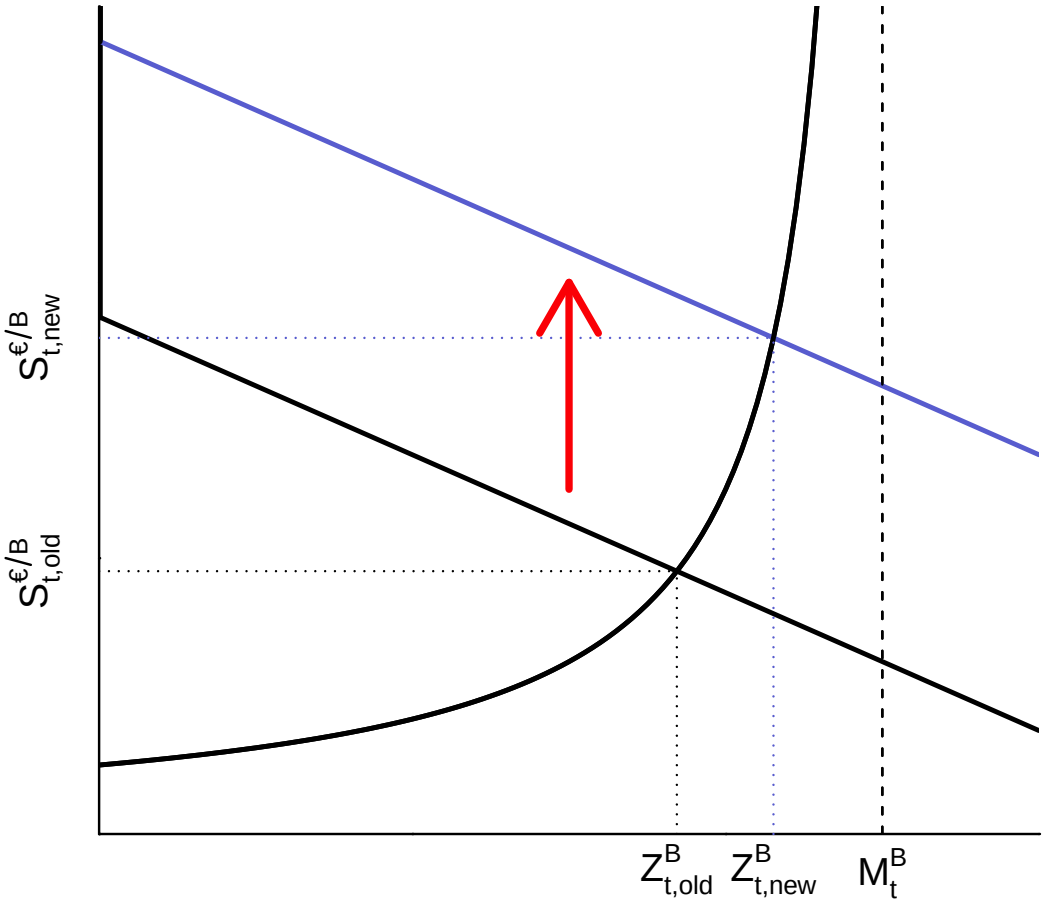
What moves the exchange rate of a virtual currency?

An influx of new speculators ($N_{s,t} \uparrow$)



What moves the exchange rate of a virtual currency?

More optimistic expectations of speculators ($\mathbb{E}(\tilde{S}^{€/B}_{t+1})\uparrow$)



Impact of speculative environment

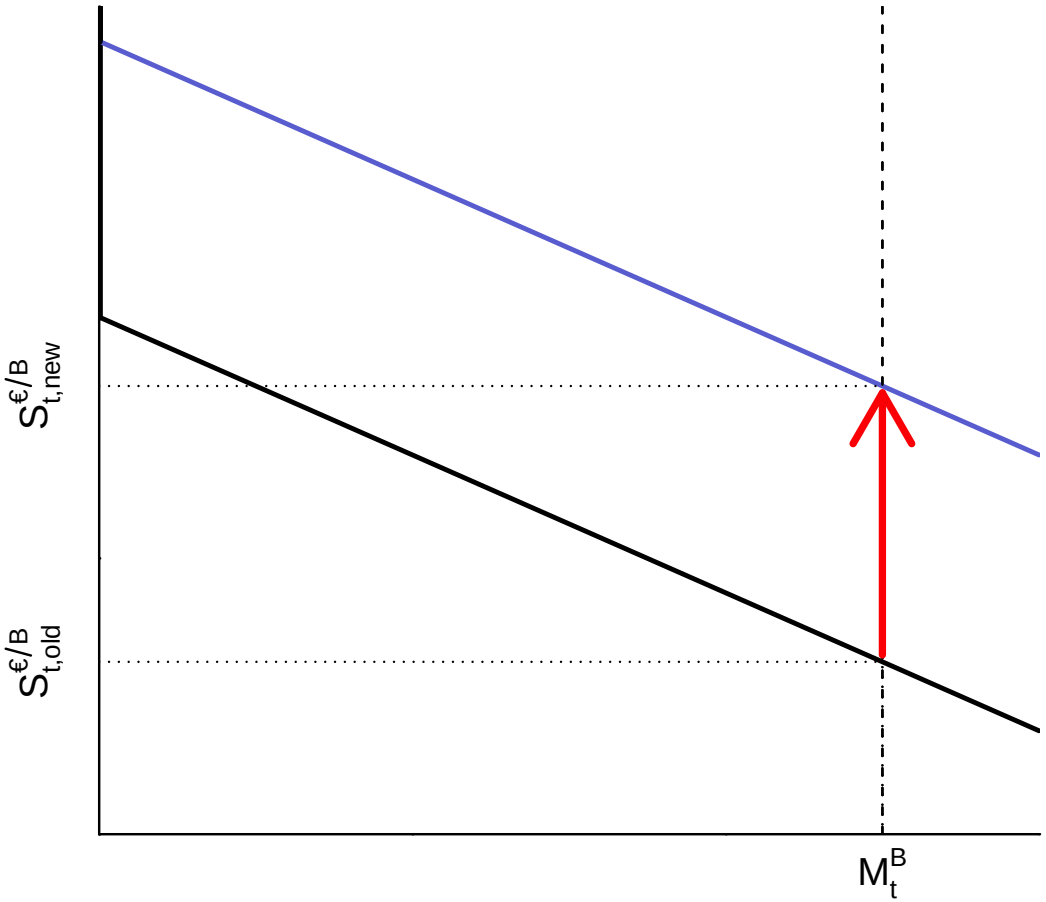
Virtual currencies have suffered from highly volatile exchange rates compared to the exchange rates of established currencies; see, e.g., Yermack (2015).

Theoretical prediction:
As the use of a virtual currency increases, its exchange rate becomes less sensitive to

- Shocks to speculators' expectations;
- Influx and outflow of speculators.

Impact of speculative environment

Impact of shocks in speculator's beliefs smaller with higher adoption



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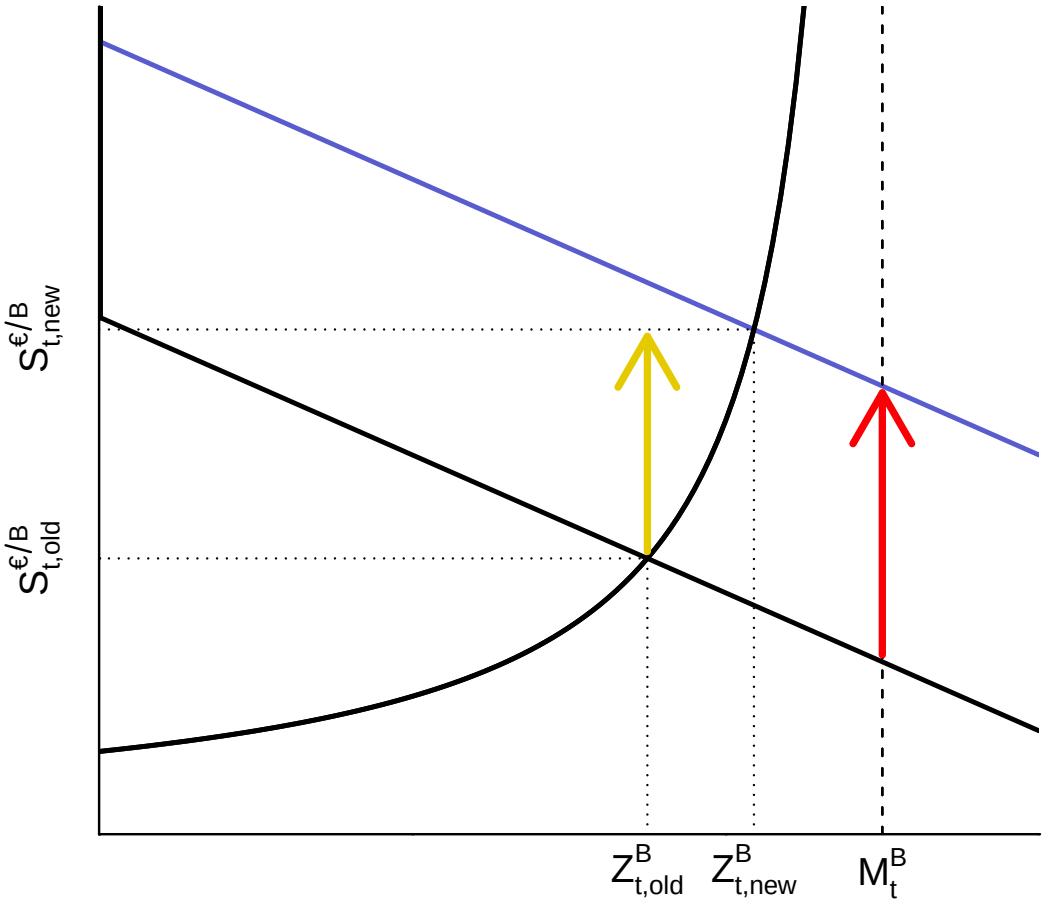

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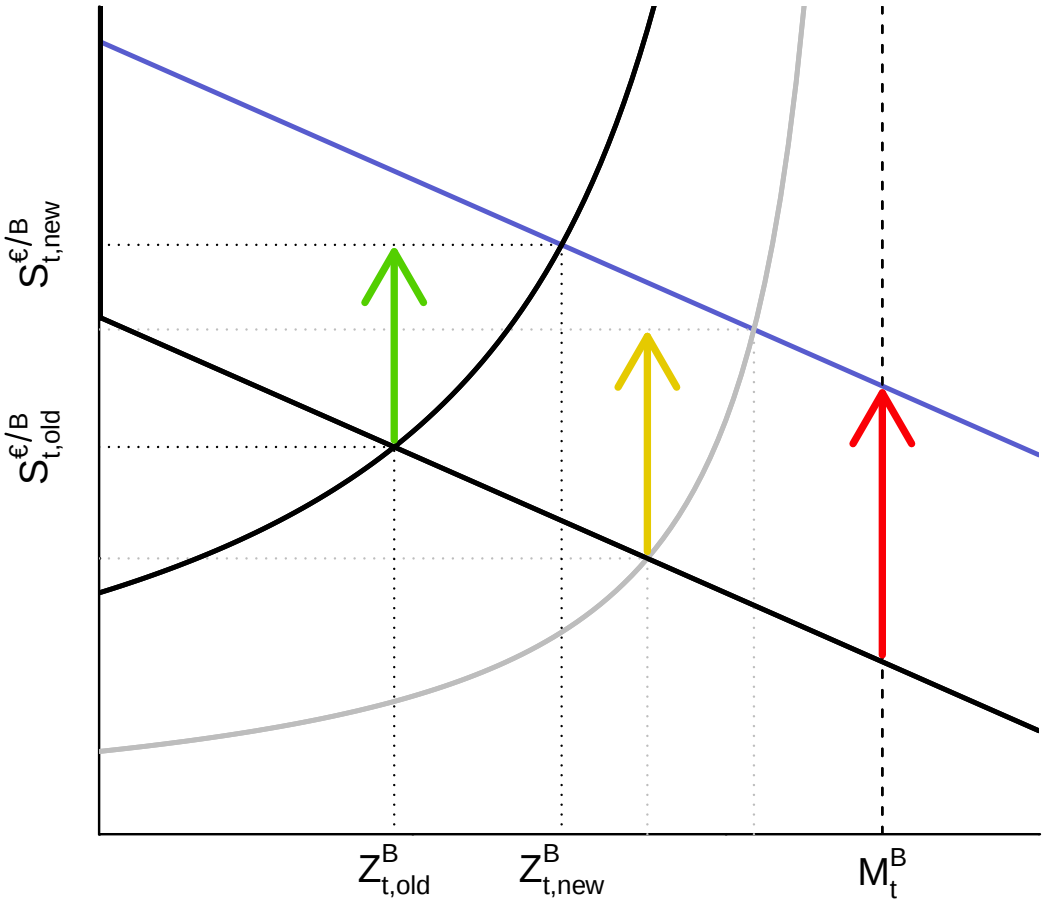
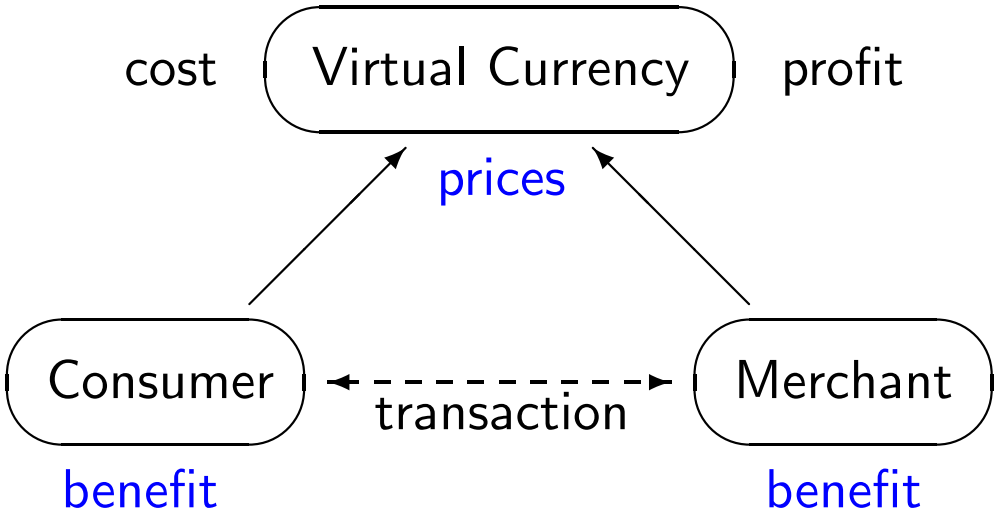


Model building block: Two-sided markets

What determines future usage of the virtual currency?



- Both sides need to be "on board".
- Indirect network effects are important for total usage.
- But not all consumers/merchants are the same.

Model building block: Two-sided markets

- Standard two-sided market theory with network effects provides solutions for the number of agents using the network once it reaches its full potential, i.e., N_c^* and N_m^*.
  The number of users increases in the
  - Cost efficiency of the network;
  - Magnitude of the benefits to (some) users of the network;
  - Strength of the network effects.

- The value of virtual currency units necessary to make payments increases in the number of users of the network, i.e.,

$$\frac{T_t^{B*}}{V_t^{B*}} = f\left(N_{c,t}, N_{m,t}\right) = \phi N_{c,t}.$$

Rational expectations equilibrium

Current exchange rate can be derived as

$$S_t^{€/B} = \underbrace{q\left(\frac{\phi N_c^*}{M_{t+1}^B}\right)}_{\mathbb{E}(\tilde{S}_{t+1}^{€/B})} \times \underbrace{\left(\frac{1}{2}\sqrt{\delta_t^2} + \frac{1}{2}\sqrt{\delta_t^2 + 4\gamma\phi\frac{N_{c,t}}{N_{s,t}}\frac{1-q}{q}R^{-1}}\right)}_{\text{discount factor}},$$

where δ_t represents the *hypothetical* discount factor in case of no real transactions using the virtual currency (i.e., if $N_{c,t} = 0$), which is calculated as

$$\delta_t = \left(1 - \frac{(1-q)}{1+m_{t+1}^B}\gamma\phi\frac{N_c^*}{N_{s,t}}\right)R^{-1}.$$

Current adoption $N_{c,t}$, results in a higher *actual* discount factor, and, therefore, in a higher current exchange rate $S_t^{€/B}$.

Conclusions

Take-aways:

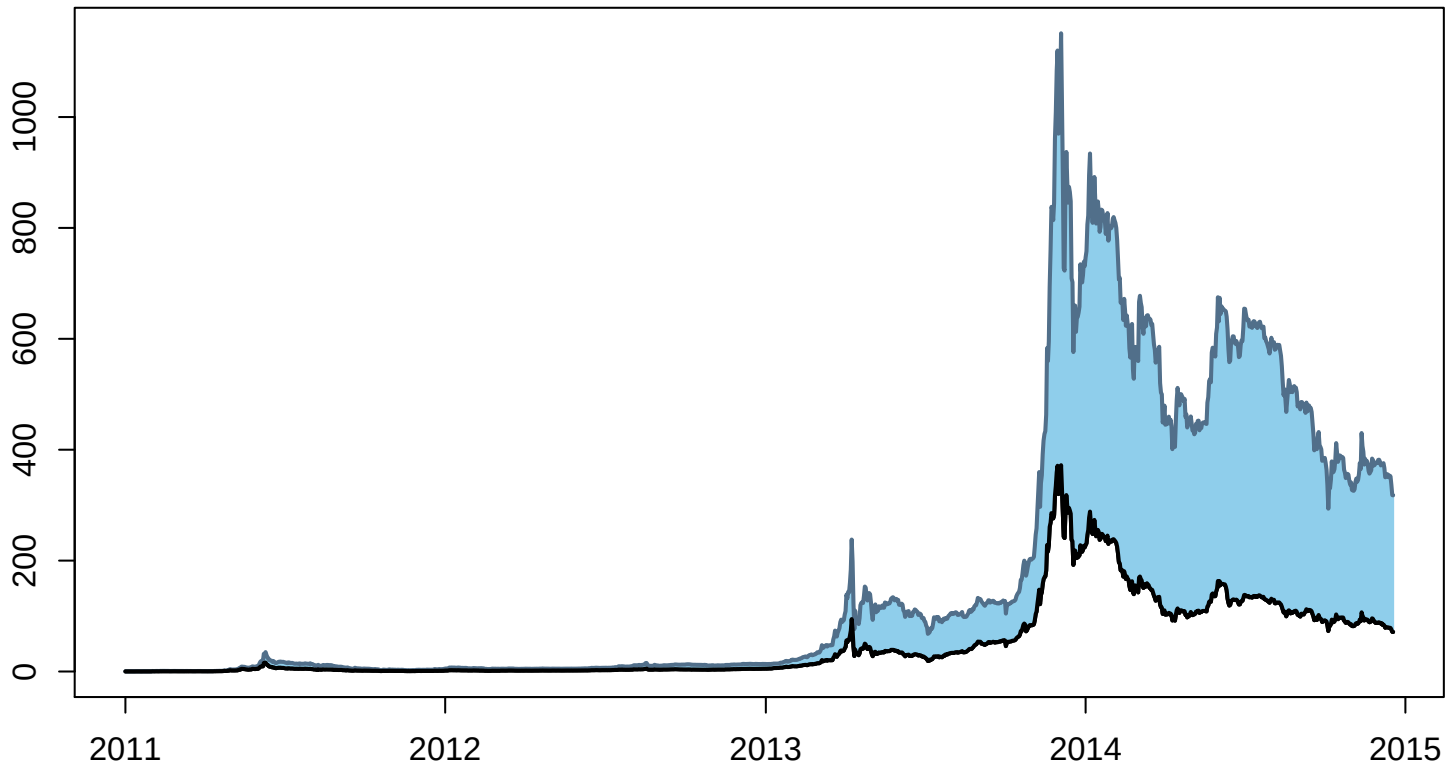
- A steep increase in the exchange rate due to speculative motives is exactly what you can expect at the introduction of a potentially successful virtual currency.

  "Some of them were withdrawn from circulation to be held for the rise. (...) Thus speculation acted as a regulator of the quantity of money."

  – Fisher, The Purchasing Power of Money, 1911.

- Current high level of volatility is a childhood disease: Theoretically, volatility should drop if the adoption by consumers and merchants increases.

Thank you!



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