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Bitcoin Market Volatility Analysis Using Grand Canonical Minority Game: Open Review

Author: Matteo Ortisi*†

Reviewers: Reviewer A, Reviewer B, Reviewer C

Abstract. The final version of the paper "Bitcoin Market Volatility Analysis Using Grand Canonical Minority Game" can be found in Ledger Vol. 1 (2016) 111-118, DOI 10.5915/LEDGER.2016.61. There were three reviewers, none of whom have requested to waive their anonymity at present, and are thus listed as A, B, and C. After initial review (1A), the author submitted a revised submission and responses (1B). The revised submission and responses were reviewed by the assigned Ledger editor who, in consultation with other Ledger editors, determined that the author had adequately and substantively addressed the reviewers' concerns, thus completing the peer-review process. Author's responses in are in bullet form.

1A. Review, Initial Round

Reviewer A:

The use of the Minority Game makes sense in this context, and the difference between the agents with epsilon> or <0 is also important. Indeed, the MG is a game where the agents try to coordinate and learn a resource level collectively.

There are however fundamental issues with this submission. Indeed, the two choices of the game are not specified. In fact, I really believe that they should be to mine or not to mine, and then the agents would strive to reach the resource level. The fact that the price of bitcoins is fixed in an external market is an altogether other problem.

Nothing then prevents to consider a MG with a variable number of agents, that observe the game with interest from the outside. The cost epsilon to beat is then different for the two choices of the game.

This reference may be of some help:

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∗1Cr9PVH9dFz1KMxp3eMv6QN2MjPJWgVfQ9

Challet, Damien. "Minority mechanisms in models of agents learning collectively a resource level." Physica A: Statistical Mechanics and its Applications 344.1 (2004): 24-29.
In short, while there is indeed an intuitive connection between bitcoin mining and the MG, it is not explicit enough in this submission. Unless the authors can provide an alternate mapping, a major revision is needed.

Reviewer B:

The author has performed a market volatility analysis using the Grand Canonical Minority Game on the bitcoin market. I find the work relevant, the model appropriate and interesting, and the results relevant and interesting as well. I wish the analysis were more thorough, perhaps including more currencies and possibly precious metals. My comments are primarily editorial and I recommend the article for publication after taking into account the following comments. I hope the author will add more assets to his analysis, or possibly submit a new paper including more assets.

Could you add a few more words about the Grand Canonical model? I suppose it has a relationship to the Grand Canonical distributions in physics, but I didn't see any comment on the connection. Can you add one? Why is it a "minority" game? Who is the minority?

The comparison to USD is relevant but it's well known that the majority of miners are more exposed to China's RMB. Therefore I find myself interpreting your results through the lens of the correlation between RMB and USD. It would be more valuable to compare to multiple currencies, including RMB and EUR. It's my guess that the results would not change.

4th line: "evident characteristic"

I find the phrase "stylized facts" very awkward, used throughout the paper. Perhaps this is a translation difficulty. Some possible alternatives: indicators, observables, measurables

3rd paragraph: "The Minority Game has been introduced..."

page 2:

"new bitcoins, and validate transactions"

Figure 1: "vs" -> "relative to". Both figures should say "vs date" instead.

European dates DD/MM/YY are used in Fig.1, despite the currency being USD. ;-) Also the fonts are so small that they're unreadable.

Remove "Thinking at the stock market": I don't think bringing up stock markets is useful or informative here.

"of a public information" -> "of public information"

I don't understand the relationship between the uniform distribution on 1...P.
The variable P has not been previously introduced. Should it be N instead?

"not to play if the strategy is not good" -> (double negative) "to play if the strategy is good"

page 3:

"fat tails returns" -> "fat tailed returns"

"having agent that trades" -> "having agents that trade"

"But bitcoin market" -> "But the bitcoin market"

"trading only a pair currencies using cash, without any derivative" -> "trading only the currency pair and not any derivative"

"facts depends" -> "facts depend"

page 4:

Here you bring up that miners "spend USD for mining resources". Only a tiny fraction of mining is today in the USA, though your charts cover the period from 2011-2014 when there was much more. Some discussion of how mining has moved and the possible impact on price dynamics could be relevant. Could the sharp drop in Fig.1 (left) after 2015 be due to movement of mining out of the USA? Likewise some comment on the other dips and peaks in this figure would be informative.

"a speculator take" -> "a speculator makes"

"cost-opportunity base" -> "cost-opportunity basis"

page 5:

"it has been used" -> (remove)

$\epsilon=0$ is not clearly readable from Fig.2. I think there are open symbols overlapping with closed symbols in the bottom figure. This is not obvious. The vertical axis is pixelated and I cannot read the labels. What is the vertical axis label of the top half?

Here you bring up a "mining fee in USD" -- a notion that is practically impossible, and the suggestion is almost ridiculous. However I think we can improve this. Could you please elaborate on your thinking? Another means of achieving constant USD (or RMB or EUR) earnings would be a futures market, something which deserves mention here. What would be the impact on your model if miners could buy futures contracts? Would that achieve a risk-

free rate for miners?

In light of the above suggestions, the content of the conclusion will need revision as well.

Reviewer C:

Fundamentally, this is a solid paper. It is a bit sparse on important details, and with a bit of expansion in key passages, this could be a very valuable contribution to the literature.

p.1, ¶1

"Starting from 2013 bitcoin started to be really exchanged..."

The first bitcoin exchanges opened in 2010. How do you quantify "to be really exchanged"? What is the source of this assertion?

"...subsequent fall due to an external factor (bankruptcy of MtGox exchange)."

This needs documentary support, or hedging along the lines of "...subsequent fall at around the same time as the bankruptcy of MtGox..." Also, compare the long-term bitcoin price trend with the Hype Cycle. MtGox could have been a precipitating factor, and it might have been coincidental timing. Consider the relationship between the bitcoin price in its early years and the volatility of petroleum prices in the mid-1800s. This could be a consequence of market participants' trying to figure out what Bitcoin even is.

p.1, ¶2&3

The acronym GCMG should follow immediately after the first use of the phrase "Grand Canonical Minority Game", along with citations to the relevant literature, rather than lower down in the paragraph.

p.2, ¶1 (first full paragraph)

The assertion that a core group of miners constitutes ignores long-term bitcoin holders. If you mean to exclude these investors, state why, as many have substantial stakes in Bitcoin's success, although they are not active users.

With regard to miners "literally" mining, that term is a metaphor that appears only once in Nakamoto's white paper. At that, it is in passing. Bitcoins are released into the market in payment for services securing the network. This activity easily could have been called something else. Perhaps "popularly known as mining..."

Also, some reference to Fischer Black's (1986) "Noise" would fit well here. He makes the same point as you: Speculators create both noise and liquidity. If one wants to reduce noise,

one must reduce liquidity; if one wants to increase liquidity, one must increase noise.

§2

While the mathematical logic appears to be consistent, the explanation is not very accessible for a reader, who is not already familiar with the topic.

In particular, how is e like or unlike a regression error term? The form of Equation (1) looks very much like a time series autoregression. If this is the case, then what is the meaning of e --> -infinity ? If this is not the case, then expand on the description of what the equation represents.

§3

This section is very good and would benefit from the expansion of the first paragraph's discussion of the relationship between miners and speculators. Considering that ASICs have an economic half-life of approximately 18 months (see Andreas Antonopoulos's recent public comments concerning mining and Moore's Law), some might argue that all miners are speculators. Of course, others might argue differently. State your position here more clearly; or, alternatively, provide a balanced explanation of both positions.

p.4, final paragraph of §3

Explain more clearly how the reader would go about replicating your work. This topic is fascinating, and it could be very valuable for future readers to update your results, in order to see how your model evolves over time.

1B. Author's Response

Reviewer A:

I totally agree with the Reviewer that the most relevant question (for a miner) is to mine or not to mine and that the possibility of using Minority Games to study this problem could be exploited.

However the question that inspired this work is different and coming form an investor point of view: is bitcoin an asset class that could be used in constructing portfolios, together with more traditional asset classes like equity, fixed income, commodities,…?

Starting from this point of view I am considering bitcoin like a stock or a commodity with a value expressed in a currency (it could be USD, EUR, JPY,….).

The most striking empirical difference with respect to other asset classes is its high volatility. Since Minority Games have been proved to be able to reproduce stylized facts of other asset classes, it makes sense to use them in the same way to better understand the dynamic of bitcoin market. What we obtain is a relationship between volatility and lack of the equivalent of a risk free rate.

We are not trying to build a connection between bitcoin mining and minority game (that, as pointed out by the reviewer, intuitively exists), but we are applying minority game with decisions to buy or to sell bitcoin in exchange for other currencies in a market environment where, at the moment, a risk free rate is absent, arguing that the introduction of a free interest rate could deeply change the market structure.

To be more clear I have added previous considerations to the Introductory part of the paper (beginning of page 2).

Reviewer B:

Could you add a few more words about the Grand Canonical model? I suppose it has a relationship to the Grand Canonical distributions in physics, but I didn't see any comment on the connection. Can you add one? Why is it a "minority" game? Who is the minority?

- Better explained on page 3, 2nd and 3rd full paragraphs

The comparison to USD is relevant but it's well known that the majority of miners are more exposed to China's RMB. Therefore I find myself interpreting your results through the lens of the correlation between RMB and USD. It would be more valuable to compare to multiple currencies, including RMB and EUR. It's my guess that the results would not change.

- Explained at the end of page 1 why the choice of another base currency is irrelevant in our volatility analysis. Chart left in fig1 would the same with EUR, JPY or CNY as base currency instead of USD

4th line: "evident characteristic"

- Done

I find the phrase "stylized facts" very awkward, used throughout the paper. Perhaps this is a translation difficulty. Some possible alternatives: indicators, observables, measurable

- Done

3rd paragraph: "The Minority Game has been introduced..."

- done

page 2:
"new bitcoins, and validate transactions"

- done

Figure 1: "vs" -> "relative to". Both figures should say "vs date" instead.

- done

European dates DD/MM/YY are used in Fig.1, despite the currency being USD. ;-) Also the fonts are so small that they're unreadable.

- I improved readability of figure 1. If still to small we could separate the two figures.

Remove "Thinking at the stock market": I don't think bringing up stock markets is useful or informative here.

- Done

"of a public information" -> "of public information"

- done

I don't understand the relationship between the uniform distribution on 1...P. The variable P has not been previously introduced. Should it be N instead? I better explained it (end of page 3 and page 4) including a table (Table 1) as an example of strategy "not to play if the strategy is not good" -> (double negative) "to play if the strategy is good"

- done

page 3:
"fat tails returns" -> "fat tailed returns"

- done

"having agent that trades" -> "having agents that trade"

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"But bitcoin market" -> "But the bitcoin market"

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"trading only a pair currencies using cash, without any derivative" -> "trading only the currency pair and not any derivative"

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"facts depends" -> "facts depend"

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page 4:
Here you bring up that miners "spend USD for mining resources". Only a tiny fraction of mining is today in the USA, though your charts cover the period from 2011-2014 when there was much more. Some discussion of how mining has moved and the possible impact on price dynamics could be relevant. Could the sharp drop in Fig.1 (left) after 2015 be due to movement of mining out of the USA? Likewise some comment on the other dips and peaks in this figure would be informative.

- page 1: I added comments on figure 1

"a speculator take" -> "a speculator makes"

- done

"cost-opportunity base" -> "cost-opportunity basis"

- done

page 5:
"it has been used" -> (remove)

- done

$\epsilon=0$ is not clearly readable from Fig.2. I think there are open symbols overlapping with closed symbols in the bottom figure. This is not obvious. The vertical axis is pixelated and I cannot read the labels. What is the vertical axis label of the top half?

- I better explained on page 6 the interpretation of figure 2. IO improved description in figure caption

Here you bring up a "mining fee in USD" -- a notion that is practically impossible, and the suggestion is almost ridiculous. However I think we can improve this. Could you please elaborate on your thinking? Another means of achieving constant USD (or RMB or EUR) earnings would be a futures market, something which deserves mention here. What would be the impact on your model if miners could buy futures contracts? Would that achieve a risk-free rate for miners?

- This observation is of fundamental importance: the introduction of future contracts is exactly the answer I was looking for. I added it to the abstract and to the analysis on page 6

Answers to Reviewer C

p.1, ¶1

"Starting from 2013 bitcoin started to be really exchanged..."

The first bitcoin exchanges opened in 2010. How do you quantify "to be really exchanged"? What is the source of this assertion?

- I made a mistake looking at exchange vs EUR instead of USD. I amended accordingly (pag1)

"...subsequent fall due to an external factor (bankruptcy of MtGox exchange)."

This needs documentary support, or hedging along the lines of "...subsequent fall at around the same time as the bankruptcy of MtGox..." Also, compare the long-term bitcoin price trend with the Hype Cycle. MtGox could have been a precipitating factor, and it might have been coincidental timing. Consider the relationship between the bitcoin price in its early years and the volatility of petroleum prices in the mid-1800s. This could be a consequence of market participants' trying to figure out what Bitcoin even is.

- I modified the beginning of introduction

p.1, ¶2&3

The acronym GCMG should follow immediately after the first use of the phrase "Grand Canonical Minority Game", along with citations to the relevant literature, rather than lower down in the paragraph.

- done

p.2, ¶1 (first full paragraph)

The assertion that a core group of miners constitutes ignores long-term bitcoin holders. If you mean to exclude these investors, state why, as many have substantial stakes in Bitcoin's success, although they are not active users.

- I added long-term bitcoin holders at the end of page 2. From the model point of you , they are like producers.

With regard to miners "literally" mining, that term is a metaphor that appears only once in Nakamoto's white paper. At that, it is in passing. Bitcoins are released into the market in payment for services securing the network. This activity easily could have been called something else. Perhaps "popularly known as mining..."

- modified (beginning of section 3)

Also, some reference to Fischer Black's (1986) "Noise" would fit well here. He makes the same point as you: Speculators create both noise and liquidity. If one wants to reduce noise, one must reduce liquidity; if one wants to increase liquidity, one must increase noise.

- I added the reference at the end of page 2

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While the mathematical logic appears to be consistent, the explanation is not very accessible for a reader, who is not already familiar with the topic.
In particular, how is e like or unlike a regression error term? The form of Equation (1) looks very much like a time series autoregression. If this is the case, then what is the meaning of e --> -infinity ? If this is not the case, then expand on the description of what the equation represents.

- I better explained this part, adding table 1 to give a practical example of a strategy (end of page 3 and page 4).

§3

This section is very good and would benefit from the expansion of the first paragraph's discussion of the relationship between miners and speculators. Considering that ASICs have an economic half-life of approximately 18 months (see Andreas Antonopoulos's recent public comments concerning mining and Moore's Law), some might argue that all miners are speculators. Of course, others might argue differently. State your position here more clearly; or, alternatively, provide a balanced explanation of both positions.

- I expanded this section better explaining the roles played by long term bitcoin holders and "core miners" as producers and speculators (both miners and financial). I introduced the effect of the use of future contracts on bitcoin, that would have the effect of exposing agents to interest rates

p.4, final paragraph of §3

Explain more clearly how the reader would go about replicating your work. This topic is fascinating, and it could be very valuable for future readers to update your results, in order to see how your model evolves over time.

- In the conclusive section I am mentioning possible future investigations.

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