Dear Editor,

We thank the referees for their helpful comments on our manuscript “Foreign exchange markets: price response and spread impact” by Juan C. Henao-Londono and Thomas Guhr. We followed all of the referees’ suggestions and revised the paper accordingly.

In the sequel, we respond in detail to the points that the referees made:

- the passage "In a spot market, as the currency transactions are carried in the OTC markets, information concerning open interest and volume is unavailable. The transactions in this market represent up to the 40% of the total market transactions in the foreign exchange market. " not clear to me if all currency spot trades are done OTC and if the volumes are not known, how the number of 40% occurs? Or are 40% traded over OTC?

  We add the following to the paragraph to give more clarity about the spot market:

  “Currency markets are divided into spot market, forward market, future market, currency swaps market and currency options market [41, 42, 43]. The spot and forward exchange markets are OTC markets [40]. In our work we particularly focus on the spot market, where as his name suggest, the trades are settled on the spot [40, 42]. In a spot market, as the currency transactions are carried in the OTC markets, information concerning open interest and volume is unavailable. The transactions in this market represent up to the 40% of the total market transactions in the foreign exchange market. This estimations are made by the Bank for International Settlements (BIS) based on a central bank survey of foreign exchange and derivatives market activities in major financial centers [44].”

- "There are fewer rules, there are no clearing houses and central bodies that oversee the market. The investors will not have to pay fees or commissions as on another markets. It is possible to trade at any time of day and regarding the risk and reward, it is possible to get in and out whenever the investor want. In the foreign exchange market, the bid-ask spread is the only transaction cost [35]. " Do all participants pay no fees? E.g. if you travel abroad and want to exchange your cash (to get the foreign cash) at a Bank abroad, you will certainly pay a fee on top of their bid ask spreads. Not every market participant of the spot fx market can avoid fees (on top of the bid ask spreads). Or can you specify which traders produced the data you analysed?

  The travel abroad is the perfect example to show that in some cases, it is necessary to pay fees or commissions. We rewrite the idea in the paragraph as follows:

  “There are fewer rules, there are no clearing houses and central bodies that oversee the market. Some investors do not have to pay fees or commissions as on other markets. It is possible to trade at any time of day and regarding the risk and reward, it is possible to get in, and out whenever the investor wants. In the foreign exchange market, the providers use a bid-ask spread as a measure for the transaction cost [41]. "

- Eqs. (2) and (3): S(t) has not been defined. Please add a short description.

  In the manuscript are Eqs. (3) and (4) the ones that use S(t). We improve the text below Eq. (3) to add the description of S(t):

  “where \delta is a positive time increment and S(t) is the price.”

- "The main objective of this work is to analyze the price response functions. In general we define the price response functions in a foreign exchange market as ". On this stage is not clear to me what/which information regarding trading, risk, etc. the response functions contain. I would appreciate to have it in an order: "Generally, a price response functions measures …. and are defined as follows: …. The main objective of this work is to analyze the price response functions for the spot fx markets". We rewrite the paragraph following your advice as:

  “Generally, price response functions measure price changes implied by execution of market orders. Here, different time scales have to be distinguished. The superscript scale refers to the time scale used, whether physical time scale (scale = p) or trade time scale (scale = t). The price response functions are defined as follows

  $mathematical expression$ + definition of the variables

  The main objective of this work is to analyze the price response functions for the spot foreign exchange markets.”

- I suggest dropping the (scale) here, as you have it in Eq. (8). There the two time scales are also defined (in contrast to Eq, (5) where reader didn't see the different times yet).

  We consider that the superscript “(scale)” is important to better show to the reader which parameters we are considering to compute the price response functions. However, we reordered the paragraph of the previous point and add a sentence to point the importance of the different time scales in the computation of the responses.

- "Finally, The subscript"… A typo, change to "Finally, the subscript"

  The typo was corrected.

- "… the price response function increases to a maximum and then slowly decreases." … You may add here "with increasing \tau"

  We added the sentence as follows:

  “… the price response function increases to a maximum and then slowly decreases with increasing \tau”

- "Due to the nature of the data, they are several" A typo, change to "Due to the nature of the data, there are several"

  The typo was corrected.

- "Moreover, tick-by-tick data available on financial markets all over the world is time stamped up to the millisecond, but the order of magnitude of the guaranteed precision is much larger, usually one second or a few hundreds of milliseconds". Wonders me, e.g. Xetra in Frankfurt stamps tick-by-tick data with accuracy of nano seconds (see here https://www.xetra.com/resource/blob/1741884/e4a1e8329d20a0b2a052492956eb9beb/data/T7_EOBI_Manual_v.8.0.4.pdf, page 24)

  We want to thank the referee to bring our attention to this fact. We rewrite the sentence as follows:

  “"Moreover, tick-by-tick data available on financial markets all over the world is time stamped up to the nanosecond [66], but the order of magnitude of the guaranteed precision is much larger, usually one second or a few hundreds of milliseconds".

- "Their use directly depend on the application." A typo, change to "Their use directly depends on the application."

  The typo was corrected.

- What is the role of t in the trade time scale ? Can you add one sentence on it?

  We add the following sentence to clarify the role of t in the trade time scale:

  “Here, t distinguish each second where one or more trades can happen. \epsilon (t) (t,n) = + 1 implies ...”

- Under Eq. (7): "where N(t) is the number of trades in an interval of one second." Do you mean the time interval of 1 second prior t?

  In fact is the time interval of 1 second following t. For more clarity, we add the following to improve the sentence:

  “where N(t) is the number of trades in an interval of one second following t”

- "implies that the majority of trades". The word "majority" is maybe misleading: assuming N(t)=1000, with 501 buy-trades and 499 sell-trades. Then epsilon^(p) (t)=sign(501-499)=+1. But would you say in this case there was a "majority" of buy-trades? Especially as we don't know the volumes of trades, even with epsilon^(p) (t)=+1, the price might have dropped within the underlying second.

  We modify the word “majority” to a word that better describes the situation:

  “implies that the imbalance of trades in the second t are triggered by a market order to buy, and (…) indicates an imbalance of sell market orders.”

- "This behavior is different to the one presented in correlated financial markets, where the results differ about a factor of two depending on the time scale." Can you add a reference here?

  We added the corresponding reference.

- "we can see that the liquid pairs have a smaller price response compared with nonliquid pairs." Can you mention which pairs are liquid?

  We mentioned the liquid pairs as follows:

  “we can see that the liquid pairs have a smaller price response compared with non-liquid pairs. The liquidity of the pairs vary regarding the analyzed year. For the years 2008 and 2014, the most liquid pairs are the EUR/USD and the GBP/USD. For 2019 the most liquid pairs are EUR/USD and USD/CAD”

- "Also, the older the response, the stronger the signal." Can you add one two words that "older" means the year. Generally, any estimation on "average physical time between two trades" for each year would be an interesting observable, as a clear drop in this time may be a sign of high trading activity (like more participants send orders) or a sign of trading algos.

  We rewrite the sentence to clarify the meaning of the word “older”:

  “Also, the former year responses have stronger signals”

- As there can be multiple "spreads" on financial instruments, I would suggest to explicitly use "bid-ask spread" instead of just "spread", as you do it e.g. over Eq. (10).

  We rewrite “spread” to “bid-ask spread” all over the manuscript to clarify the concept that we are using.

- "For each pair we compute the pip bid-ask spread in every trade along the market time" Can you explain what do you mean here? As the bid-ask spread is a property of the order book at time t, a trade has no a priori bid-ask spread. Do you mean the bid-ask spread of the order book at each time a trade accrued?

  We rewrite the sentence as you suggested for more clarity in their meaning:

  “For each pair we compute the bid-ask spread of the order book at each time a trade accrued.”

- "With this value we group the foreign exchange pairs." Can you add a comment on the grouping: how did you come up with the number of groups for each year?

  We improve the explanation as follows:

  “With this value we group the foreign exchange pairs in several groups considering different interval values. We start to reduce the number of groups and find out that for the years 2011 and 2015 two clusters and for 2019 three clusters are clearly distinguishable.”

- "With the groups of the stocks defined," I think you mean "currency pairs" instead of "stock".

  We changed the word “stock” to “currency pairs”.

- "we used 46 foreign exchange pairs" but in Appendix A you write "We analyze the spread impact in the price response functions for 47 foreign exchange pairs" is there a reason for the difference 46 vs 47?

  We had to remove one foreign exchange pair of the analysis, but did not update all the places in the document with the amount of pairs used. We used 46 foreign exchange pairs and is now fixed in all the manuscript.

- Throughout the paper in the Figures you have a double index in the label of the y-axis: R_{ii} … I think you mean R_{i}.

  We update all the figures to have the label R_{i}.

- the authors state "a tremendous amount ot data is available [1]"; however [1] is a ref from 1999 which cannot contain all the material of years used by authors in years 2008-2019. In fact the authors use data from HistData.com as they state a bit later; it is better to be clear from the beginning and state in the Introduction where the data comes from

  In this case, [1] is a reference from a paper that describes how the amount of data in financial markets in general grew in the last years. Our objective with this reference was to give an overview of the large amount of data available in finance. As the referee state, a better description of the data that we used in the paper is made in Sect. 3. Thus, to give more clarity to the text we rewrite it in the following way and add more references to support our claim:

  “Here, we carry out such a study for finance, because a tremendous amount of data is available in general [1,2,3,4,5], and in particular in foreign exchange markets [6,7,8], to cite some examples.”

- can be results of fig.3 be interpreted in a more physical terms of correlation functions? may be rescaling by a average value of correlations will show some type of universality between different curves of fig.3?

  This is a very interesting point. However, we are not dealing with correlation functions in the sense where the same quantities are compared. We rather use response functions as in Eq. (5) comparing trade signs with returns. Nevertheless, it would be interesting to study the universality of response functions, but this is beyond the scope of the present study, as a considerably larger data analysis would be required to quantitatively asses the similarities that are qualitatively seen in Fig. (3).

We hope that we answered the referees’ questions and the revised version of our manuscript meets the criteria for publication in the journal Physica A: Statistical Mechanics and its Applications.

Yours Sincerely,

Juan Camilo Henao Londono, also on behalf of Thomas Guhr