Rock around the Clock: an explanation of flash crashes

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On May 6 2010, contemporaneously with the unprecedented price decrease of the E-Mini S&P500[5], many US equity indices, including the Dow Jones Industrial Average, nosedived by more than 5% in few minutes, before recovering much of the loss. During this "flash crash", most asset prices lost any informational role, as over 20,000 trades across more than 300 securities were executed at prices more than 60% away from their values just moments before. Many were executed at prices of a $0.01 or less, or as high as $100,000, before prices of those securities returned to their "pre-crash" levels (CFTC and SEC, 2010). Such a huge mispricing was associated with a sudden evaporation of market liquidity, swelled volatility and a prolonged crisis in market confidence (average daily volumes were down for several months after the crash). Furthermore, extreme asset misalignments could also be a source of systemic crises in light of mark-to-market financial accounting practices, according to which banks' and other financial institutions' assets are evaluated at current market prices.

The flash crash of May, 6 2010 widely reported in the press was not an isolated incident. Similar episodes have been observed since then in many financial markets. Moreover, because of their disruptive consequences on the orderly functioning of markets, flash crashes attracted the attention of regulators, politicians and academic researchers. In the last four years, many conjectures have been advanced to clarify the origins of the phenomenon and to propose regulatory measures able to prevent its emergence and/or to mitigate its effects. Most theories focused on the role of high-frequency trading (HFT). Indeed, as suggested by a SEC report, high-frequency (HF) traders may have had a fundamental role in fueling the crash by increasingly selling their positions. However, no convincing explanation has emerged yet and the debate on the benefits and costs of HFT, and its role in flash-crash events, is still unsettled. Some studies suggest that HFT can negatively affect market efficiency, exacerbating market volatility, reducing market liquidity and possibly fueling flash crashes. Others suggest that high-frequency traders are "modern" market makers, who provide an almost continuous flow of liquidity, thus reducing transaction costs and fostering price discovery and market efficiency.

The lack of a consensus on the net benefits of HFT is not surprising, as the ultra-fast algorithms adopted by high-frequency traders represent a genuine financial innovation, whose social impacts are difficult to assess given the legion of associated –often unintended– externalities and the underlying complexity of financial markets. In such a context, agent-based models (ABMs) may represent a powerful tool to study the impact of financial innovations such as HFT on market dynamics. Indeed, ABMs allow the researcher to build artificial markets where price fluctuations can emerge from direct interactions occurring among heterogenous traders, endowed with a repertoire of different trading strategies, ranging from simple to very sophisticated ones (as those employed by HF traders).

Following this intuition, in a OFCE Working Paper n°2014-03, we develop an ABM of a limit-order book (LOB) market, wherein heterogeneous HF traders interact with low-frequency (LF) ones. Our main goal is to study whether HFT is responsible for the emergence of flash crashes and more generally for periods of higher volatility in financial markets. Furthermore, we want to shed some light on which salient features of HFT are relevant in the generation of flash crashes and in the process of price-recovery after a crash.

The model portrays a market wherein LF agents trade a stock, switching between fundamentalist and chartist strategies according to their profitability. HF agents differ from LF ones not only in terms of speed, but also in terms of activation and trading rules. First, contrary to LF strategies, which are based on *chronological* time, the algorithmic trading required by HFT naturally leads HF agents to adopt trading rules which rest on event time. As a consequence, LF agents, who trade at exogenous and constant frequency, co-evolve with HF agents, whose participation in the market is endogenously triggered by price fluctuations. Second, HF agents adopt *directional* strategies that exploit the price and volume information released in the LOB by LF traders. Finally, HF traders keep their positions open for very short periods of time and they typically display high order cancellation rates. To study the model, we run extensive numerical simulations. Our results show that flash crashes together with high price volatility occur *only* when HF agents are present in the market. Why do flash crashes occur in our model in presence of HF traders? We clearly show that the emergence of flash crashes is not only related to the faster trading speed of HF agents, but more important to the use of specific trading strategies which enable them both to siphon liquidity off the market, leading to high bid-ask spreads[6], and to synchronize on the sell-side of the LOB, when the market crucially needs liquidity.

Finally, we explore the effects of HF agents' order cancellation rate on market dynamics. Order cancellation has received much attention in recent public debates, because HF traders can use it strategically to move prices in the desired directions by filling the LOB with fake orders within few microseconds only to cancel them just as quickly. We find that high rates of order cancellations have an ambiguous effect on price fluctuations. Indeed, a larger rate of order cancellations leads to higher volatility and more frequent flash crashes, but also to faster price recoveries, which in turn reduce the duration of flash crashes. We therefore suggest that order-cancellation strategies extensively employed by HF traders cast more complex effects than thought so far, and that regulatory policies aimed to curb these practices should take

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[5] A futures contract on the S&P 500 index.

[6] The difference between the highest price a buyer is willing to pay for an asset and the lowest price a seller is willing to sell this same asset.