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Impact of value-at-risk models on market stability

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ABSTRACT

Financial institutions around the world use value-at-risk (VaR) models to manage their market risk and calculate their capital requirements under Basel Accords. VaR models, as any other risk management system, are meant to keep financial institutions out of trouble by, among other things, guiding investment decisions within established risk limits so that the viability of a business is not put unduly at risk in a sharp market downturn. However, some researchers have warned that the widespread use of VaR models creates negative externalities in financial markets, as it can feed market instability and result in what has been called endogenous risk, that is, risk caused and amplified by the system itself, rather than being the result of an exogenous shock. This paper aims at analyzing the potential of VaR systems to amplify market disturbances with an agent-based model of fundamentalist and technical traders which manage their risk with a simple VaR model and must reduce their positions when the risk of their portfolio goes above a given threshold. We analyse the impact of the widespread use of VaR systems on different financial instability indicators and confirm that VaR models may induce a particular price dynamics that rises market volatility. These dynamics, which we have called 'VaR cycles', take place when a sufficient number of traders reach their VaR limit and are forced to simultaneously reduce their portfolio; the reductions cause a sudden price movement, raise volatility and force even more traders to liquidate part of their positions. The model shows that market is more prone to suffer VaR cycles when investors use a short-term horizon to calculate asset volatility or a not-too-extreme value for their risk threshold.

1. Introduction

Financial institutions around the world use value-at-risk (VaR) models to measure their market risk (Feridun, 2005). This type of models were first used in Wall Street in the late 80 s, and after the launch in 1994 of the RiskMetrics VaR methodology by JP Morgan, they have become the mainstream methodology for financial risk management (IMF, 2007; McNeil et al., 2005), as well as a fundamental part of the Basel Capital Accords since the 1996 Amendment on market risks (Shin, 2010).

VaR measures the maximum loss that an asset portfolio may suffer over a specific horizon and with a given level of confidence (Choudhry, 2006). For example, if the daily VaR of a portfolio is €1 million at 95% confidence, this means that the probability that daily losses are higher than €1 million is 5%. VaR constitutes an intuitive measure that was initially used

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to communicate financial risks to managers in an easy, understandable way; however, over time it has also been universally adopted to set position limits to traders, to allocate capital among different trading units, or to calculate the regulatory capital required under Basel Accords (Jorion, 2001).

VaR models, as any other risk management system, are meant to keep financial institutions out of trouble by, among other things, guiding investment decisions within established risk limits so that the viability of a business is not put unduly at risk in a sharp market downturn. However, some researchers have warned that the widespread use of VaR models creates negative externalities in financial markets, as it can feed market instability and result in what has been called *endogenous risk*, that is, risk caused and amplified by the system itself, rather than being the result of an exogenous shock (Danielsson and Shin, 2002). Financial institutions usually set VaR limits to their traders or units, which are forced to reduce their positions when the risk exceeds these limits; when volatility increases, the VaR of trading portfolios also goes up and so traders can be forced to reduce their positions, but their sales can cause a price drop and so a new volatility upsurge, triggering further portfolio reductions. When many investors hold similar positions and also use the same type of risk management models, they may be forced to simultaneously sell the same assets, leading to an instabilising spiral (Danielsson et al., 2001; Persaud, 2000).

A paradigmatic example of this type of process is the turmoil that hit mature financial markets in Summer 1998 and which in the end led to the downfall of LTCM, one of the most successful hedge funds at the time (Davis, 1999; Perold, 1999). The Russian default on 17 August 1998 forced the investors with exposure to the ruble debt market to liquidate positions to purchase safer, more liquid assets. This flight-to-quality raised the price of most liquid assets and plunged the price of illiquid ones (MacKenzie, 2003). The spread widening caused significant losses to LTCM and to the numerous investors that in previous years had imitated LTCM's strategies dazzled by their impressive returns (BIS, 1999; MacKenzie, 2003). Some of these investors were forced to further reduce their portfolios, resulting in a self-feeding spread widening. The mounting losses brought LTCM to the brink of collapse, and only a rescue organised *in extremis* by the Fed was able to avoid its failure and the subsequent systemic crisis that it would certainly have caused (IMF, 2007).

In a report on the events of 1998 (BIS, 1999), the Committee on the Global Financial System of the Bank for International Settlements provides a telling account of the deficiencies in current risk management methodologies, which were perceived by market participants to have played a major role in the 1998 crisis. According to the BIS findings, the ubiquitous use of VaR-based risk management tools might have contributed to no small extent to the propagation of initially localised disturbances. This concern was shared by all interviewed market participants, who described how the increase in VaR due the higher volatility forced many investors to reduce simultaneously their exposure, thereby draining liquidity from the markets and raising the upward pressure on volatility.

So risk management control such as that proposed by the Basel Accords can, paradoxically, facilitate the contagious spread of instabilities, because they contribute to synchronise the behaviour of market participants, which may be forced to liquidate part of their positions simultaneously (IMF, 2007; Whitehead, 2013). The impact of these liquidations would be negligible if investors had very different portfolios, as the selloffs by some agents would have no effect on those with different positions. Nevertheless, there is empirical evidence that financial institutions such as hedge funds and big banks accumulate similar positions (Pericoli & Sbracia, 2010; Haldane and May, 2011), and diverse regulators have warned of the risk this may pose to the liquidity of those markets where they invest (Bank of England, 2004; ECB, 2007). In particular, this concern was raised during the hearing held by the U.S. House of Representatives in September 2009 to elucidate the role that risk-management systems and specially VaR played in credit crunch of 2007–08:

> *"[A]sset-pricing and risk management tools are developed from an individualistic perspective, taking as given (ceteris paribus) the behavior of all other market participants. However, popular models might be used by a large number or even the majority of market participants. Similarly, a market participant (e.g., the notorious Long-Term Capital Management) might become so dominant in certain markets that the ceteris paribus assumption becomes unrealistic. The simultaneous pursuit of identical micro strategies leads to synchronous behavior and mechanic contagion. This simultaneous application might generate an unexpected macro outcome that actually jeopardizes the success of the underlying micro strategies."* (Colander, 2009, p. 10)

This paper aims at analysing the potential of VaR systems to amplify market disturbances with an agent-based model where traders set position limits and must reduce their positions when the VaR of their portfolio is above the limit.[1] As seen above, we are not the first to warn on the detrimental effects that the widespread use of risk management systems can have in market stability, but we are able to analyse their impact on different instability indicators and to study under which conditions the market is more prone to show turmoil episodes.

In recent years, a few equilibrium-based models have already been developed to study the link between risk constraints and heightened volatility. Danielsson et al. (2004) consider a continuum of risk-averse traders that determine their portfolio to maximise their next-period utility. A risk contraint is incorporated in the model through traders' beliefs, which are

[1] This process has similarities with the loss spirals identified by Brunnermeier and Pedersen (2009), which affect market liquidity: when investors are leveraged and their assets lose value, their losses mount and leverage goes up. In order to continue getting access to credit it is necessary to have a minimum margin, and thus there is a limit on their leverage level. To keep a constant level of leverage and avoid surpassing this limit, investors are forced to reduce their portfolio, what may move prices in an unfavourable direction (the more illiquid the market, the greater the impact in prices) and cause new lossses. This dynamics gives rise to a loss spiral.