

High-frequency trading and regulatory policies. A tale of market stability vs. market resilience

by Sandrine Jacob Leal and [Mauro Napoletano](#)

Over the past decades, high-frequency trading (HFT) has sharply increased in [US](#) and [European](#) markets. HFT represents a major challenge for regulatory authorities, partly because it encompasses a wide array of trading strategies ([AFM \(2010\)](#); [SEC, 2010](#)), and partly because of the big uncertainty yet surrounding the net benefits it has for financial markets (Lattemann *and al.* (2012); [ESMA \(2014\)](#); [Aguilar, 2015](#)). Furthermore, although HFT has been indicated as [one potential cause of extreme events like flash crashes](#), no consensus has yet emerged about the [fundamental causes of these extreme events](#). Some countries' [regulations have already accounted for HFT, \[1\]](#) but, so far, this has led to divergent approaches across markets and regions.

Overall, the above-mentioned open issues call for a [careful design of regulatory policies](#) that could be effective in mitigating the negative effects of HFT and in hindering flash crashes and/or dampening their impact on markets. On these grounds, in a [new research paper](#) published in the *Journal of Economic Behavior and Organization* we contribute to the debate about the regulatory responses to flash crashes and to the potential negative externalities of HFT by studying the impact of a set of policy measures in an agent-based model (ABM) where flash crashes emerge endogenously. To this end, we extend the ABM developed in [Jacob Leal et al. \(2016\)](#) to allow for endogenous orders' cancellation by high-frequency (HF) traders, and we then use the model as a test-bed for a number

of policy interventions directed towards HFT. This model is particularly well-suited and relevant in this case because, differently from existing works (e.g., Brewer et al, 2013), it is able to endogenously generate flash crashes as the result of the interactions between low- and high-frequency traders. Moreover, compared to the existing literature, we consider a broader set of policies, also of various natures. The list includes market design policies (circuit breakers) as well as command-and-control (minimum-resting times) and market-based (cancellation fees, financial transaction tax) measures.

After checking the ability of the model to reproduce the main stylized facts of financial markets, we run extensive Monte-Carlo experiments to test the effectiveness of the above set of policies which have been proposed and implemented both in Europe and in the US to curb HFT and to prevent flash crashes.

Computer simulations show that slowing down high-frequency traders, by preventing them from frequently and rapidly cancelling their orders, with the introduction of either minimum resting times or cancellation fees, has beneficial effects on market volatility and on the occurrence of flash crashes. Also discouraging HFT via the introduction of a financial transaction tax produces similar outcomes (although the magnitude of the effects is smaller). All these policies impose a speed limit on trading and are valid tools to cope with volatility and the occurrence of flash crashes. This finding confirms the conjectures in [Haldane \(2011\)](#) about the need of tackling the “race to zero” of HF traders in order to improve financial stability. At the same time, we find that all these policies imply a longer duration of flash crashes, and thus a slower price recovery to normal levels. Furthermore, the results regarding the implementation of circuit breakers are mixed. On the one hand, the introduction of an ex-ante circuit breaker markedly reduces price volatility and completely removes flash crashes. This is merely explained by the fact that this type of regulatory

design precludes the huge price drop, source of the flash crash. On the other hand, ex-post circuit breakers do not have any particular effect on market volatility, nor on the number of flash crashes. Moreover, they increase the duration of flash crashes.

To sum up, our results indicate the presence of a fundamental trade-off characterizing HFT-targeted policies, namely one between market stability and market resilience. Policies that improve market stability – in terms of lower volatility and incidence of flash crashes – also imply a deterioration of market resilience – in terms of lower ability of the market price to quickly recover after a crash. This trade-off is explained by the dual role that HFT plays in the flash crash dynamics of our model. On the one hand, HFT is the source of flash crashes by occasionally creating large bid-ask spreads and concentrating orders on the sell side of the book. On the other hand, HFT plays a positive role in the recovery from the crash by contributing to quickly restore liquidity.

[1] Some unprecedented actions and investigations by local regulators were widely reported in the press ([Le Figaro, 2011](#); [Les Echos, 2011](#); [2014](#); [Le Monde, 2013](#); [Le Point, 2015](#)).

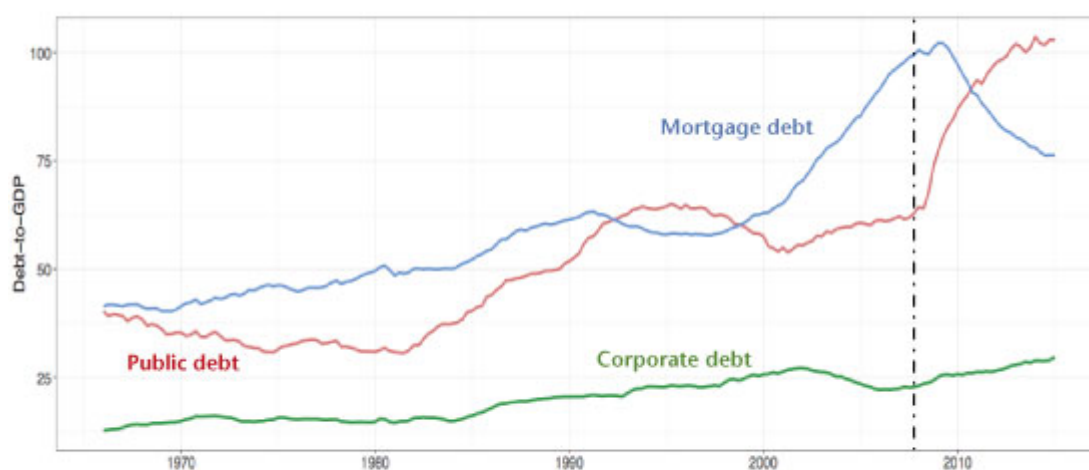
The Janus-Faced Nature of Debt

by Mattia Guerini, Alessio Moneta, [Mauro Napoletano](#), Andrea Roventini

The financial and economic crises of 2008 have been intimately intertwined with the dynamics of debt. As a matter of fact, a research by [Ng and Wright \(2013\)](#) reports that in the last thirty years all the U.S. recessions had financial origins.

[Figure 1](#) shows that both U.S. corporate (green line) and mortgage (blue line) debts have been growing steadily from the sixties to the end of the century. In the 2000s, however, mortgage debt increased from around 60% to 100% of GDP in less than a decade. The situation became unsustainable in 2008 with the outburst of the subprime real asset bubble. The trend in debt changed since then. Mortgage debt declined substantially, while the U.S. public debt-to-GDP ratio (red line) skyrocketed from 60% to a level slightly above than 100% in less than 5 years, as a consequence of the Great Recession.

Figure 1. Private and public debt-to-GDP series



The vertical dashed line represents 2007 (Q4).
Source: authors.

This surge in public debt has been raising concerns about the

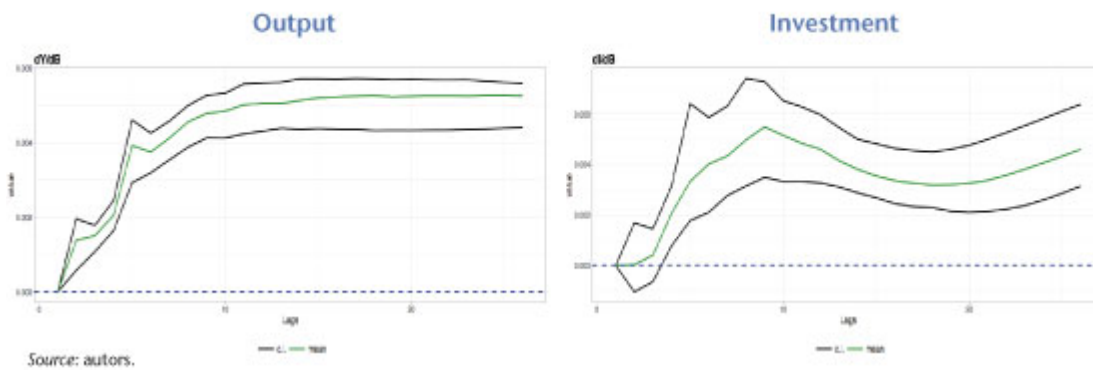
sustainability of public finances, and more generally, about the possible detrimental effects of public debt on economic growth. Some economists argued indeed that there exist a 90% threshold after which public debt harms GDP growth (see [Reinhart and Rogoff, 2010](#)). Notwithstanding a large number of empirical studies contradicting this hypothesis (see [Herdon et al., 2013](#) and [Égert, 2015](#) as recent prominent examples), the debate is still open (see [Ash et al., 2017](#) and [Chudik et al., 2017](#)).

We have contributed to this debate with a new empirical analysis that jointly investigates the impact of public and private debt on U.S. GDP dynamics and that will appear on “*Macroeconomic Dynamics*” (see [Guerini et al., 2017](#)). Our analysis keeps the *a priori* theoretical assumptions as minimal as possible by exploiting new statistical techniques that identify causal structures from the data under quite general conditions. In particular, we employ a causal search algorithm based on the Independent Component Analysis (ICA) to identify the structural form of the cointegrated VAR and to solve the double causality issue.^[1] This has allowed us to keep an “agnostic” perspective in the econometric analysis, avoiding restrictions on the model, thus “letting the data speak”.

The results obtained suggest that public debt shocks *positively* and *persistently* affect output (see [Figure 2](#), left panel).^[2] In particular, our results provide evidence against the hypothesis that upsurges in public debt hamper GDP growth in the U.S. In fact, increases in public debt—possibly channeled through an increase in public spending in investments—crowd-in private investments, (see [Figure 2](#), right panel) confirming some results already brought to the fore by [Stiglitz \(2012\)](#). This implies that government spending and, more generally, expansionary fiscal policy spur output both in the short- and in the medium-run. In that, austerity policies do not seem to be the appropriate policy answer to overcome a

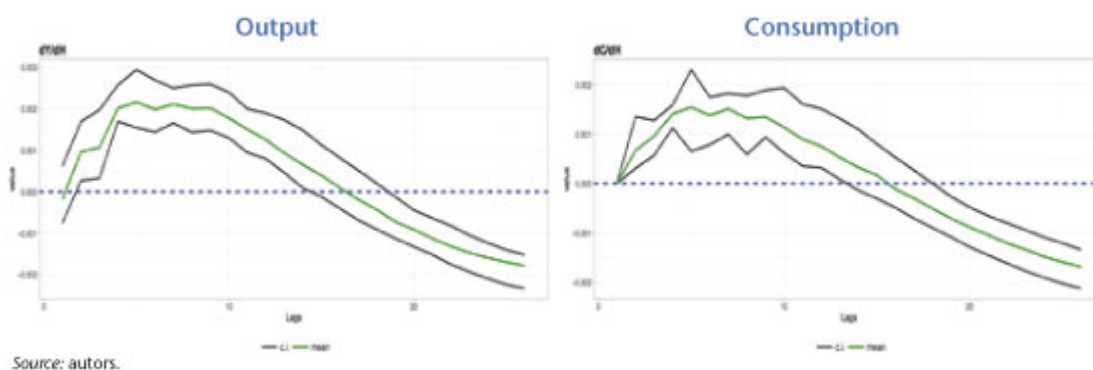
crisis.

Figure 2. Effects of public debt on output and investment



On the contrary, these positive effects are not fully observed when we look at the effects of private debt and in particular when we focus on mortgage debt. More specifically, we find that the positive effects of private debt shocks are milder than public debt's ones, and they fade out over time. Furthermore, increasing the levels of mortgage debt have a negative impact on output and consumption dynamics in the medium-run (see [Figure 3](#)), while their positive effects are only temporary and relatively mild. Such a result appears to be fully consistent with the results of [Mian and Sufi \(2009\)](#) and [Jordà et al. \(2014\)](#): mortgage debt fuels real asset bubbles, but when these bubbles burst, they trigger a financial crises that visibly transmit their negative effects to the real economic system for longer periods of time.

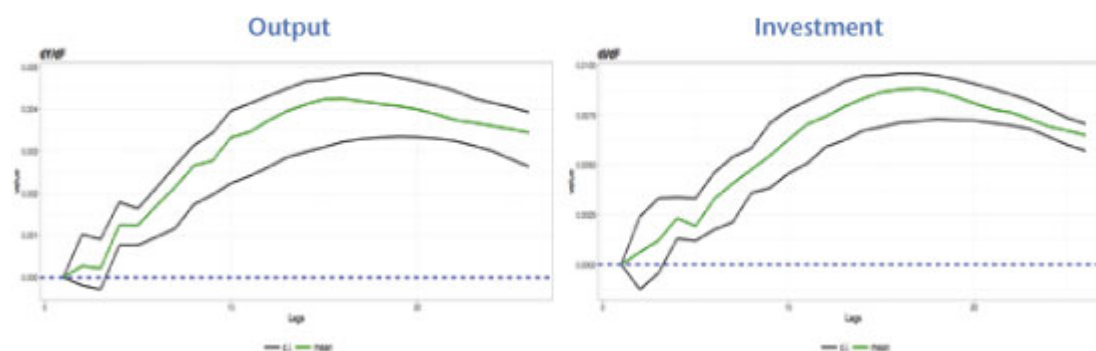
Figure 3. Effects of mortgage debt on output and consumption



Another interesting fact that emerges from our research, is that the other most important form of private debt—*i.e.* non-

financial corporations (NFCs) debt—does not generate negative medium-run impacts. As a matter of fact (as it is possible to see in [Figure 4](#)) surges in the level of NFCs debt seems to have a positive effect both on GDP and on gross fixed capital formation, hence directly increasing the level of investments.

Figure 4. Effects of corporate debt on output and investment



Source: authors.

To conclude, our results suggest that debt has a *Janus-faced* nature: different types of debts impact differently on aggregate macroeconomic dynamics. In particular, possible threats to medium- and long-run output growth do not come from government debt (which might well be a consequence of a crisis), but rather from increasing too much the level of private one. More specifically, surges in the level of mortgage debt appear to be much more dangerous than the building up of corporate debt.

^[1] For details about the ICA algorithm see [Moneta et al. \(2013\)](#); for details about its statistical properties see [Gourieroux et al. \(2017\)](#).

^[2] When computing the Impulse Response Functions, we apply a 1 standard deviation (SD) shock to the relevant debt variable. Hence, for example, on the y-axis of Figure 2, left panel, we can read that a 1 SD shock to public debt has a 0.5% positive effect on GDP in the medium run.

Rock around the Clock: an explanation of flash crashes

Sandrine Jacob Leal, [\[1\]](#) Mauro Napoletano, [\[2\]](#) Andrea Roventini, [\[3\]](#) Giorgio Fagiolo [\[4\]](#)

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 heterogeneous 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.

Economic policy-making tools for pre- and post-crisis periods

by [Zakaria Babutsidze](#) and [Mauro Napoletano](#)

The worldwide financial crisis has questioned the relevance of economic models that are currently used by central bankers and macro analysts. In contrast, the recent economic events seem to be better described by models featuring boundedly rational heterogeneous agents and wherein markets do not necessarily clear at all times. Agent Based Models (ABMs) are a new class of models that embed all the above features, and therefore qualify as a promising alternative to conventional models.

An economic crisis, such as the current one, is a clear divide between processes before and after it. For instance, economic policies can be split into two groups: pre-crisis and post-crisis policies. While the latter aim at helping the economy to move out of the crisis to a more favourable state, the former policies concentrate on averting it.

Currently popular economic models can (to an extent) discuss post crisis policies. These models view economies as closed systems that move along one of (few) balanced equilibria. A modeller can introduce a large external shock in the system that can be interpreted as the crisis and further discuss policies to help the system move back to the previous (or even better) equilibrium. However, there is a problem with these policies. The main assumption of modern mainstream economics is hyper-rational agents, which assumes that economic agents (including households) possess complete information about the future of the economy and by acting rationally on this information the future that was foreseen is actually realized.

Modellers argue that this is reasonable even if we know that

people do not optimize. The argument is that due to market selection only the best performing agents will survive. As optimization guarantees the best response to the current situation every agent that is present at the equilibrium has to be behaving "as if" she is optimizing. Notice that this argument rests on the notion of equilibrium and says nothing about how this equilibrium will be reached. Now recall that modellers had to assume a large shock knocking the system out of the equilibrium in order to discuss the crisis. Then the approximation with hyper-rationality cannot properly describe the agent behaviour after crisis.

Concerning pre-crisis policies the problems are even greater. Current mainstream models exclude the possibility of generating the crises endogenously. While, it is a known fact that modern economic crises are rarely related to external shocks. They are generated endogenously by the system. They emerge from the factors (like non-price interactions, localized learning processes, outrageous banking and investment practices etc.) that are directly assumed away from the mainstream modelling. Therefore, these models are inherently inadequate to discuss policies directed to prevention of crises.

We believe that an economic tool that is to be successful in designing economic policy to avert the economic crises requires three characteristics. Firstly, it has to take account of the individual behaviour. Secondly, it has to model the behaviour in a way that is consistent not only with equilibrium, but also with non-equilibrium states. Finally, it has to allow for the possibility of endogenously generating crises.

Currently popular policy making tools fail in at least one of these three respects. Take for example Dynamic Stochastic General Equilibrium (DSGE) models. They represent the workhorse of modern monetary policy. This modelling strategy conforms to the first requirement listed above: DSGE is a

micro-founded modelling strategy that replaced previous techniques that were abstracting from individual agent behaviour and thus were prone to Lucas (1976) critique.[\[1\]](#)

Alas, DSGE fails in two other respects. Microeconomic behaviour is based on perfect foresight that requires hyper-rational agents that were mentioned above, and therefore, as argued above, does not describe well agent behaviour during the out-of-equilibrium dynamics. In addition to this, stochasticity of the system allows only for small perturbations and large shocks (such as crises) have to be exogenously injected in the system. Perhaps, these failures are the cause of difficulties that DSGE modelers are having in predicting and managing current crises, as acknowledged by some central bankers ([Trichet, 2010](#); [Kocherlakota 2010](#)).

It is true that DSGE models take into account micro-behaviour as well as institutions (see for example Smets and Wouters 2003), which is the model widely used by European Central Bank). However, what they fail to take into account is the possibility of endogenous (co-)evolution of these structures, the heterogeneity and non-price interactions among economic agents that can lead the system to breakdown without external interference.

One promising tool for economic policy design goes under the name of Agent Based Modelling (ABM). The characteristics of this approach are discussed at greater length in a recent OFCE [briefing paper by Napoletano, Gaffard and Babutsidze 2012](#). In contrast to mainstream economics (such as DSGE), ABM is more flexible to model relevant processes as dynamical systems of heterogeneous agents who interact through price and non-price channels. The approach treats time as the key variable. This is in contrast to orthodox models. Take the crises again. In mainstream modelling at the moment of crisis new equilibrium becomes known to everyone instantaneously and perfectly rational individuals adjust their choices accordingly. This drives the system to the new equilibrium. In ABM individuals

do not get information about new equilibrium to which the system is supposed to converge to and each individual has to navigate in its own way. This feature allows for the plethora of learning processes (which, according to Howitt 2012 are extremely scarce in modern Macroeconomic theory) to be also taken on board.

ABM concentrates on open-ended dynamics and allows for an equilibrium (defined as an ergodic state of the system) as an emergent and optional outcome ([Leijonhufvud 2011](#)). While current mainstream modelling is based on the centralized information processing structure that is fed with all the available information in the system, ABM takes a bottom-up approach that starts modelling realistic micro-foundations (in contrast to DSGE) and analyses the resulting behaviour of the model at upper levels. The dynamics of aggregate variables are the result of complex, continuously (and endogenously) changing micro-structure. This yields substantial advantages in modelling policy on macro (LeBaron and Tesfatsion 2008), as well as on industry (Chang 2009) and market (Duffy and Unver 2008) levels.

Using Agent Based tools a modeller can specify the agent's micro behaviour and understand how the dynamics of the system leads to the critical state and a subsequent breakdown (endogenously generated crisis). This is a common occurrence in physical systems and Agent Based approaches are routinely used for their analysis. Using such a model the policies to direct the path of the economy away from the critical state can be discussed. From this prospective ABM has clear advantage in discussing pre-crisis policies over orthodox approaches.

Another substantial advantage of the methodology is its easiness to be implemented in a computational environment. Behavioural rules can be passed to the agents in computer simulations and respective outcomes can be observed. This is important for two reasons. Firstly, this makes models easily

understandable for policy-makers that are not necessarily proficient in mathematics that current orthodox methods heavily rely on ([Uri Wilenski](#), the developer of the most popular computational environment for ABM – NetLogo, is repeatedly making this point). Secondly, behavioural rules (and other settings) can be easily adjusted to fit the problem at hand. Due to their concern with the equilibrium, mainstream models are less flexible and consequently less appropriate for policy-making.

However, there are disadvantages to the approach. Detailed discussion of approach's shortcomings is presented in the above-mentioned [OFCE briefing paper](#). Here we concentrate on the one that is shared by all non-equilibrium approaches. It is that ABM does not (cannot) provide a comprehensive analysis of all the paths the model allows for. Once you leave the equilibrium, the number of paths an economic system can take become infinite. Therefore, in most of the cases, comprehensive analysis is not feasible.

While this criticism is relevant in face of commonly accepted practice in economic science, it is irrelevant to the ABM's powers as a policy-making tool. Policy makers are not concerned with all the possible scenarios in all the possible types of economies. They have a very specific problem at hand. They operate in a specific country/region, they are given a very specific initial condition (currently existent in the economy) and they want to achieve a certain well-defined goal with a specific policy tool. Agent Based Modelling gives them the opportunity to fine-tune the model to their specific situation and then analyse the effects of a specific policy instrument. The policy instrument controls one (or very few) parameters of the model. Given a specific market/economy and specific initial conditions exhaustive analysis of these policy tool can be performed and welfare improving (if not optimal) policy can be designed.

Merits of every modelling approach can be debated. But

allowing diversity in approaches is bound to make policy discussions more stimulating and is likely to help the discipline avert the crises that are now seen as the crises of the discipline itself (Kirman 2010).

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[\[1\]](#) However, DSGE models downplay the possibility of multiple equilibria. Thus, their ability to overcome the Lucas critique by introducing micro-foundations presents only a limited advantage.