

TOULOUSE ECONOMISTS ON **Finance and Macroeconomics**

10 YEARS OF PARTNERSHIP





PARTNERS IN EXCELLENCE



Since 2007, Banque de France has been able to draw on the skills, knowledge networks and cutting-edge tools of Toulouse economists to address urgent challenges facing the banking and financial sectors. The two institutions have now been working together for more than a decade to support and strengthen economic research in France, and to make key contributions to international economic debate and expertise. This long-term partnership focuses on issues such as monetary economics and finance, an arena in which TSE has a well-established reputation for scientific excellence.

Regular, in-depth and sustained exchanges allow Banque de France to enrich its analysis with rigorous theoretical elements but also robust and independent empirical studies. For TSE researchers, these interactions are invaluable as they ensure a much more accurate understanding of the mechanisms at work in banks and the financial markets.

Each year TSE students also benefit from this partnership through two channels. Banque de France representatives come to Toulouse to contribute to both basic and more applied courses. One or two PhD candidates also enjoy a scholarship grant funded by the Banque de France.

Finally, another central pillar of the partnership since 2012 is the Banque de France-TSE Prize in Monetary Economics and Finance.

In the following pages, we present evidence of this extraordinarily productive and mutually beneficial collaboration.

Enjoy reading!

Fany Declerck
Professor of Finance - TSE



RESEARCH TEAM



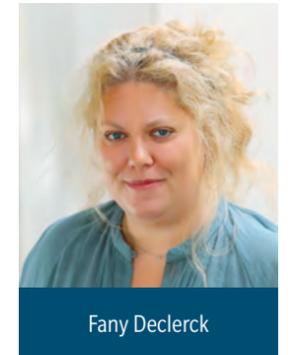
Marianne Andriès



Tiziana Assenza



Fabrice Collard



Fany Declerck



Martial Dupaigne



Patrick Fève



René Garcia



Christian Gollier



Alexander Guembel



Christian Hellwig



Jean-Charles Rochet



Jean Tirole

In 2012, Banque de France and TSE launched a series of prizes for academic researchers who have improved our understanding of monetary economics and finance. The aim of the awards is to foster conceptual progress toward the design and implementation of improved policies by central banks.

Presented by François Villeroy de Galhau, Governor of Banque de France, at a special event in Paris, the senior prize carries a cash award of €30,000. Laureates of the junior prize will spend time as visiting scientists at Banque de France. The junior prizes, presented by TSE's honorary chairman Jean Tirole, include a cash award of €15,000 plus travel and living expenses.

Prizes will be awarded at a conference on March 14, 2019 in Paris



SENIOR PRIZE 2018

Michael Woodford
Columbia University

Michael Woodford is the John Bates Clark Professor of Political Economy at Columbia University. He received his AB from the University of Chicago, his JD from Yale Law School, and his PhD in Economics from MIT. He has been a MacArthur Fellow and a Guggenheim Fellow, and is a Fellow of the American Academy of Arts and Sciences, as well as a Fellow of the Econometric Society, of the Society for the Advancement of Economic Theory, and of the Society for Economic Measurement, a Research Associate of the National Bureau of Economic Research (Cambridge, Mass.), a Research Fellow of the Centre for Economic Policy Research (London), and a Fellow of the CESifo Research Network (Munich). In 2007 he was awarded the Deutsche Bank Prize in Financial Economics.

His most important work is the treatise *"Interest and Prices: Foundations of a Theory of Monetary Policy"*, recipient of the 2003 Association of American Publishers Award for Best Professional/Scholarly Book in Economics. He is also co-author or co-editor of several other volumes, including a three-volume *Handbook of Macroeconomics* (with John B. Taylor), a two-volume *Handbook of Monetary Economics* (with Benjamin M. Friedman), and *The Inflation Targeting Debate* (with Ben S. Bernanke).

His current research focuses on implications of bounded rationality for economic analysis, drawing upon findings in cognitive psychology and neuroscience, with particular emphasis on the consequences of decisions based on imprecise mental representations. With Andrew Caplin of New York University, he co-directs NBER's working group on Behavioral Macroeconomics.



EUROPE JUNIOR PRIZE 2018

Victoria Vanasco

Centre de Recerca en Economia Internacional (CREI)

Her research focuses on topics related to information asymmetries and their impact on financial markets and the real economy. She is interested in factors that lead to information and belief heterogeneity, on how these factors may impact incentives of market players to screen and monitor assets, and on the study of regulatory policies to increase liquidity and discipline in markets.

Before joining CREI, she was an Assistant Professor of Finance at the Stanford Graduate School of Business. She earned her PhD in Economics from UC Berkeley and has a Masters in Finance and a BA in Economics from Universidad Torcuato Di Tella, in her native Argentina. Before her PhD, she spent two years as a Junior Professional Associate at the World Bank.

Previous winners:

- 2012 Klaus Adam (Mannheim University)
- 2013 Lasse Heje Pederse (Copenhagen Business School)
- 2014 Ralph Koijen (London Business School)
- 2016 Ricardo Reis (LSE)



WORLD JUNIOR PRIZE 2018

Yuriy Gorodnichenko

University of California, Berkeley

Yuriy Gorodnichenko is a professor in the economics department of University of California - Berkeley. He received his BA and MA at EERC/Kyiv-Mohyla Academy (Kyiv, Ukraine) and his PhD at the University of Michigan. He is broadly interested in macroeconomics and issues related to transition economies. His research focuses on monetary policy, fiscal policy, taxation, economic growth, pricing and economic cycles. Yuriy serves on many editorial boards, including *The Review of Economics and Statistics* and VoxUkraine.

Yuriy is a prolific researcher who has written more than 40 articles since his arrival at the University of Berkeley in 2007. His work has been published in economics journals and has been cited in political discussions and the media. Yuriy has received numerous awards for his research and advice.

Previous winners:

- 2012 Viral V. Acharya (NYU Stern School of Business)
- 2013 Emmanuel Farhi (Harvard University)
- 2014 Iván Werning (MIT)
- 2016 Amir Sufi (University of Chicago)



BANKS, FRICTION AND CRISIS

Jean-Charles Rochet
with Hans Gersbach and Martin Scheffel

What role do banks play in exacerbating or stabilizing economic downturns? By integrating financial intermediation into a model of capital accumulation with frictions, TSE's Jean-Charles Rochet and his co-researchers analyze the propagation of shocks through bank balance sheets and suggest policy responses to financial and banking crises.

Financial frictions affect the propagation of economic shocks and are an essential factor for understanding short-run dynamics and long-run macroeconomic performance. Typically, financial frictions can be traced back to either contract enforceability problems or asymmetric information and - on this ground - give rise to levered finance to align the interest of borrowers and lenders.

A tale of two channels

It is well understood that in an economy with financial frictions, even small temporary shocks can have large and persistent effects on economic activity by impacting the net worth of levered agents. In this literature, firms need net worth to credibly commit to the contractual obligations of the credit contract. Deteriorating conditions reduce firm profits, net worth and, thus, the capacity to obtain credit. The propagation of shocks through net worth and firm credit may have large and persistent impact on economic activity - a mechanism referred to as the credit channel.

Although Holmström and Tirole extended the analysis to financial intermediaries in *'Financial Intermediation, Loanable Funds, and the Real Sector'* (The Quarterly Journal of Economics, 1997), it was not until the 2007-2009 financial and banking crisis that macroeconomists took up their proposal. Financial intermediaries channel funds from investors to entrepreneurs, cope with the underlying financial friction and are, at the same time, subject to frictions themselves. Banks have to hold equity capital to credibly commit to the contractual obligations of the deposit contract.

Specifically, the level of bank equity is the skin in the game which determines the capacity to attract loanable funds. When financial conditions deteriorate, bank profits decline, which negatively affects future bank equity holdings and, thus,

“ We show that although the level of leverage is an amplification mechanism of shocks, the endogenous response of leverage to productivity and capital shocks is an automatic stabilizer that improves the resilience of the economy ”



the future capacity to attract loanable funds and to supply loans to entrepreneurs. The propagation of shocks through the bank balance sheets has real, large and persistent impact on economic activity - a mechanism referred to as the bank lending channel. In essence, the bank lending channel is a propagation mechanism similar to the credit channel, but it impacts different borrowers.

Modelling frictions

We develop a two-sector neoclassical growth model with frictions in the tradition of Holmström and Tirole (1997). The model has microfounded levered banks and allows for two forms of finance - bonds and loans. We adopt a medium to long-run perspective in the sense that output reacts smoothly to adverse shocks and economic dynamics are essentially driven by capital reallocation and accumulation instead of abrupt changes in prices.

Specifically, there are two production sectors. Firms in sector I (intermediary financed) are subject to severe financial frictions, which prevents them from obtaining financing directly through the financial market. As banks alleviate the moral hazard problems resulting from these financial frictions, firms in sector I obtain bank loans instead. However, bank lending itself is limited, as bankers can only pledge a fraction of their revenues to depositors and are thus subject to a different financial friction that gives rise to an endogenous leverage constraint which depends on equilibrium capital returns in sector I and the deposit rate. Firms in sector M (market financed) are not subject to financial frictions and issue corporate bonds.

The two financial frictions in our model are the need for bank lending - also called informed lending - and the lack of full revenue pledgeability. In the baseline model, there are three types of agents: investors, bankers and workers. The latter are immobile across production sectors as their skills are sector-specific. Workers do not save and consume their entire labor income. Investors and bankers have standard intertemporal preferences and decide in each period how much to save and to consume. Their utility maximization problems yield two accumulation rules for investor wealth and bank equity, respectively. These rules are coupled in the sense that the investor's saving and investment policies depend on how bankers fare and vice versa. Both types of lending - informed lending by banks and uninformed lending through capital markets - enable capital accumulation in the respective sectors.

Key contributions

First, we provide novel insights into the bank lending channel. We show that although the level of leverage is an amplification mechanism of shocks, the endogenous response of leverage to productivity and capital shocks is an automatic stabilizer that improves the resilience of the economy to adverse shocks. Specifically, suppose there is a shock that - directly or indirectly - leads to a decline in bank equity. Investors, ceteris paribus, reduce their deposits to restore the initial bank leverage, i.e. loan supply decreases. As a result, capital productivity in the loan financed sector increases and so do bank profits. The effective financial friction loosens such that investors can increase their deposits without incentivizing banks to defect. The ensuing increase in bank leverage partially neutralizes the initial decline in loan supply.

In particular, we show that financial market institutions (e.g. capital requirements) and labor market institutions (e.g. labor mobility and employment protection legislation) affect the elasticity of bank leverage with respect to productivity and capital shocks and, therefore, the resilience of the financial system. While the impact of financial market institutions on labor markets is well understood, we show that there is a non-negligible feedback effect from labor market institutions to credit market conditions and the resilience of the financial system - a result unique to the macro-banking and macro-labor literature.

Second, we derive macro-prudential policies comprising investor-financed recapitalization of banks, dividend payout restrictions, consumption taxes, and investment subsidies that are Pareto-improving and speed up the economic

recovery after a banking crisis, without encouraging banks to take excessive leverage in the expectation of future bailouts. In a similar vein, Acharya et al. (2017) show that bank equity capital has the characteristics of a public good which justifies dividend payout restrictions to internalize the impact of dividend payments on social welfare and output. In fact, bank-recapitalization and dividend payout restrictions have been used during recent financial and banking crises in the United States (2007-2009) and Europe (2007-2014).

Third, the model replicates typical patterns of financing over the business cycle: procyclical bank leverage, procyclical bank lending and countercyclical bond. This holds if downturns are associated with negative productivity, bank equity or trust shocks - or any combination thereof. Moreover, when recessions are accompanied by a sharp temporary decline in bank equity capital, they are deeper and more persistent than regular recessions - a result that is consistent with findings elsewhere.

Fourth, our model provides an analytically tractable macro-banking module that can easily be integrated into more complex economic environments to better take into account the special roles of banks in macroeconomic analysis.

Future research

Four simple extensions shed further light on the forces at work, the robustness, and interpretation of our findings. In particular, we discuss costs of financial intermediation, a variation with households acting as investors and workers, anticipated bank equity shocks, and stochastic productivity shocks. While these extensions produce essentially the same steady state properties as in the version of the main body of our paper, the transitional dynamics are more complex and - for some extensions - analytically not tractable.

Among numerous further generalizations and extensions of our framework, we highlight three promising avenues for future research. First, as the eurozone and a great part of Asia rely heavily on bank loans, while corporate bonds are much more dominant in the US, our framework can help to investigate which type of economic structure is more resilient to adverse shocks. Second, apart from monitoring firms, banks also perform risk sharing and maturity transformation. Including these functions into our banking model with capital accumulation is challenging but can provide further valuable insights. Third, introducing frictional labor markets with imperfect labor transition between production sectors can shed light on how labor market and financial frictions jointly affect amplification and persistence of adverse shocks.

Summing up

We have presented a simple model of capital accumulation in which financial intermediaries are essential for small and medium firms to invest. The model delivers a set of insights into the underlying shock propagation mechanism, is consistent with various stylized facts, and allows us to study policy responses to downturns associated with a decline of bank equity. The model presented in this paper is analytically tractable and it can be extended in many ways and, thus, is a convenient module that can be embedded in more complex models.

For more information, see Jean-Charles' 2018 paper 'Financial Intermediation, Capital Accumulation and Crisis Recovery'.

“ As the eurozone and a great part of Asia rely heavily on bank loans, while corporate bonds are much more dominant in the US, our framework can help to investigate which type of economic structure is more resilient to adverse shocks ”



FUNDING CONSTRAINTS AND MARKET ILLIQUIDITY

Sophie Moinas
with Minh Nguyen and Giorgio Valente

How do shocks to funding and market illiquidity interact? Using data on European Treasury bonds, TSE's Sophie Moinas and her co-researchers have found new empirical evidence about the complex dynamics that can lead to illiquidity spirals. Here she presents insights from a new paper which shows that individual bonds' responses to illiquidity shocks vary with bond maturity, the credit risk of the issuer, haircuts, and the number of bonds issued by country.

Financial markets routinely experience a variety of frictions impacting price formation that hinder their efficient functioning. These frictions are usually due to the organization of trading in a market, such as the design of a market structure or transaction costs, or to regulatory constraints, such as short-sale restrictions or market fragmentation.

Several studies have recently exposed another source of friction: trading capital. As securities can be used as collaterals to relax borrowing constraints, there is a natural interplay between the ease with which traders can obtain funds (funding liquidity) and the ease with which an asset is traded (market liquidity). Despite the mounting theoretical and empirical evidence documenting the impact of either funding and market illiquidity on asset prices, less is known about the empirical relationships linking the two dimensions of illiquidity.

European bonds

Our paper aims to fill this gap and proposes an empirical investigation of the dynamic relationships between funding and market illiquidity in the context of the European Treasury bond market. We focus on this market because of its large size, the wide use of traded Treasury securities in repo transactions, and its institutional features whereby trading occurs in a large supranational secondary market whose liquidity conditions respond to aggregate funding illiquidity shocks.

We take explicitly into account the endogeneity that naturally arises between the two dimensions of liquidity and adopt an empirical methodology that has been successfully used in other contexts: identification through heteroskedasticity. We then quantify economically the responses of market illiquidity to and from funding illiquidity shocks and exploit the heterogeneity in the cross-section of government bonds' characteristics, across European countries, to investigate the determinants of the liquidity responses.

“ The dual reinforcing relationship between funding and market illiquidity that we document is at the core of the existence of potential illiquidity spirals ”

The Mercato Telematico dei Titoli di Stato (MTS) is the most important electronic platform for euro-denominated government bonds and it consists of number of domestic markets and a centralized European marketplace. Using a dataset containing all European Treasury bonds traded on MTS platforms over the period October 1, 2004 - February 28, 2011, we carry out our estimation and find a host of interesting results.

Key results

• Feedback effect

We show that shocks to funding illiquidity significantly and positively affect the market illiquidity of the European Treasury market, after controlling for endogeneity. A one standard deviation shock to funding illiquidity, denoting increased funding constraints, increases market illiquidity by 0.15 standard deviation. This positive impact is consistent with most studies in this literature. Unlike previous literature, however, our econometric model uncovers evidence of a positive and significant feedback effect whereby one standard deviation shock to market illiquidity across European Treasury markets generates an increment of 0.08 standard deviation of funding illiquidity.

This latter result is crucial for two reasons. First, it shows the presence of a feedback effect from market illiquidity to funding illiquidity, which has been theoretically formalized but never formally tested in a joint setting. Second, it sheds further light on the direction of this impact, since theoretical models suggest that the impact of market on funding liquidity can either be stabilizing or destabilizing depending on the equilibrium or on model's parameters. The dual reinforcing relationship between funding and market illiquidity that we document is at the core of the existence of potential illiquidity spirals.

• Varied responses

After estimating the responses of market illiquidity to funding shocks for individual bonds in our sample, we find that these coefficients are on average positive, but with a different size across bonds. In other words, market illiquidity for individual bonds react differently to tightening funding constraints. This suggests that the role of intermediaries is on average destabilizing.

We also find that the responses to funding illiquidity shocks are higher for long-term bonds, which are more capital intensive than short-term bonds. Interestingly, they decrease with the number of sovereign bonds issued by the country. By contrast, the responses of funding illiquidity to individual bonds' market illiquidity shocks are lower for bonds with higher haircuts, that are used less frequently as collaterals in repo transaction.

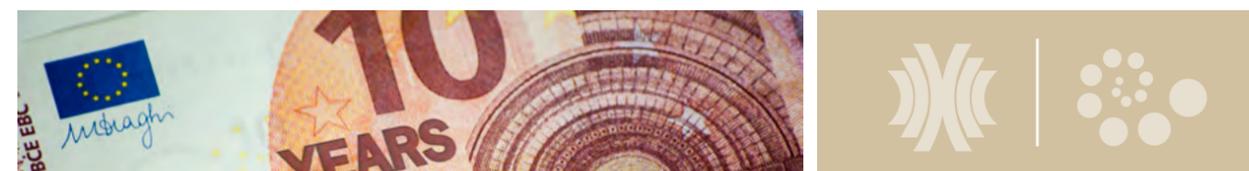
Our results are robust to alternative definitions of the volatility regimes, alternative samples of bonds, alternative sample periods, and alternative model specifications.

Policy implications

Taken together, our findings suggest the presence of destabilizing liquidity spirals. As shown by Brunnermeier and Pedersen in *'Market Liquidity and Funding Liquidity'* (The Review of Financial Studies, 2009), central banks can help mitigate market liquidity problems in such equilibria by boosting speculators' funding conditions during a liquidity crisis.

Our results have important implications for the new margin regulation for non-centrally cleared derivatives. In fact, shocks affecting initial and variation margins (hence impacting funding illiquidity) may not only have a first-order effect on trading capital, and overall credit risk, but also significantly affect market illiquidity.

“ Central banks can help mitigate destabilizing market liquidity problems by boosting speculators' funding conditions during a liquidity crisis ”



Future research

In addition, our results have important implications for the literature on the asset-pricing effects of liquidity. In light of the evidence reported in our study, it is important to consider both market and funding illiquidity shocks when assessing the effects of liquidity shocks on asset pricing. Moreover, it is also plausible to hypothesize that funding illiquidity shocks may exert even stronger effects on asset prices than due to their feedback effects on market illiquidity.

Summing up

Our study explores the dynamics between market and funding illiquidity by taking into account the multifaceted nature of illiquidity and the natural endogeneity occurring between the two aspects of illiquidity. Using an identification technique based on the heteroskedasticity of illiquidity measures, we corroborate existing evidence that shocks to funding constraints affect bond market illiquidity. We also document the existence of a positive and significant feedback effect between market and funding illiquidity shocks suggesting that market illiquidity shocks tighten funding constraints. We exploit the heterogeneity of our sample of bonds, characterized by different maturities and default risk, to investigate the determinants of the magnitude of these effects in the cross-section. We find that the market-to-funding illiquidity effect is stronger for short-term bonds and for bonds used as collaterals in repo transactions.

For more information, see Sophie's 2018 paper 'Funding Constraints and Market Illiquidity in the European Treasury Bond Market'.

REPO RESILIENCE

The European repo market differs substantially from the US repo market along various dimensions. This suggests that counterparty risk may play a different role compared to the evidence reported in previous studies. See, for example, *'The Euro Interbank Repo Market'* by Mancini, Ranaldo, and Wrampelmeyer (The Review of Financial Studies, 2016) for a discussion on differences between the US and the European repo markets, and their potential impact on the resiliency of the repo market.





FINANCIAL TRANSMISSION OF SHOCKS

Tiziana Assenza
and Domenico Delli Gatti

Tracking the chain of events generated by an aggregate shock in an Agent Based Model (ABM) appears at first glance to be impossible. But in a new paper, TSE's Tiziana Assenza and her co-author show that this can be straightforwardly done using a hybrid macro ABM consisting of an Investment-Saving (IS) curve, an Aggregate Supply (AS) curve and a Taylor Rule (TR) in which aggregate investment is a function of the moments of the distribution of firms' net worth.

In a macroeconomic ABM, an aggregate variable such as GDP is determined "from the bottom up" i.e., adding up the output of a large number of heterogeneous firms. In other words, GDP is a function of the entire distribution of agents' characteristics. The dynamic pattern of a macroeconomic variable such as GDP is an emergent property of the model that is determined by the complex microeconomic interactions of myriads of heterogeneous agents.

Emergent properties

Over the past decade, a fairly large literature has explored the emergent properties of aggregate variables in macro ABMs; see, for instance, Cincotti et al. (2010), (2012); Dawid et al. (2011), (2012); Delli Gatti et al. (2008), (2011); Dosi et al. (2006), (2012), (2013); and Gaffeo et al. (2008). For example, in Delli Gatti et al. (2005) and Assenza et al. (2015), in the presence of a financial friction, investment and output at the firm level are affected by individual net worth. Hence, at the aggregate level, GDP is a function of the distribution of the firms' net worth.

In an agent-based setting, thinking in macroeconomic terms - i.e., in terms of interrelated changes of aggregate variables - is *prima facie* impossible. When an aggregate shock occurs, it is extremely difficult to trace the transmission mechanism in a clear and uncontroversial way. To understand how a shock trickles down through the web of micro interactions and affects macro variables, it is necessary to rely on "narratives" that may or may not be convincing.

Hybrid macro ABM

In a 2013 paper, we dealt with this issue by building a *Hybrid Macroeconomic Agent-Based Model*, embedded in an optimizing IS-LM (liquidity preference-money supply) framework. In our new paper we follow the same methodology to build a model of an economy populated by households, firms and banks that is closer in spirit to the contemporary New Keynesian literature. The model consists of an IS curve, an AS curve (i.e., a Phillips curve) and a TR.



In principle, different types and degrees of heterogeneity could be taken into account. For simplicity, we assume there is a representative household and introduce heterogeneity only at the firm level. In particular, we assume that the corporate sector consists of a myriad of firms characterized by heterogeneous financial conditions (captured by net worth). In the spirit of Greenwald and Stiglitz (1993), each firm faces an idiosyncratic shock to revenues and decides investment in order to maximize expected profits. We assume that the cost of credit for the borrowing firm decreases with financial robustness. Hence the firm's optimal expenditure on capital goods is affected by its net worth.

Distribution moments

Adopting an appropriate aggregation procedure - *the Modified-Representative Agent* in our 2013 paper - we approximate the distribution of agents' net worth by means of the first and second moments of the distribution. Therefore, aggregate investment turns out to be a function of an average External Finance Premium (EFP), that in turn is affected by the moments of the distribution of firms' net worth. The moments of the distribution play the role of macroeconomic variables. We thus use this investment equation in the macroeconomic framework described by the IS-AS-TR model.

In each period, say t , given the moments of the distribution in period $t-1$, we determine the macroeconomic equilibrium, i.e., the triple consisting of the equilibrium levels of the employment rate, the inflation rate and the interest rate. Since the moments of the distribution change over time, the average EFP and therefore the macroeconomic equilibrium change as well. The role of heterogeneity (in the corporate sector) in influencing macroeconomic outcomes is captured by the fraction of change in the macroeconomic equilibrium, that can be traced back to the change in the cross-sectional variance of the distribution.

Two-way feedback

To assess the quantitative impact of changes in the moments of the distribution on macroeconomic outcomes, we develop a simple ABM of the corporate sector. For each firm, we define the law of motion of net worth, that is affected - among other variables - by the interest rate: the higher the interest rate, the lower realized profits and the lower individual net worth. The ABM boils down to a system of non-linear difference equations (one for each firm). From the artificial data obtained through simulations we trace the evolution over time of each and every element of the distribution of net worth. Hence we can retrieve the evolution over time of the cross-sectional mean and variance, that will impact future endogenous macro-variables.

In a nutshell, there is a two-way feedback between the macroeconomic and the agent-based submodels: the equilibrium interest rate in t , that is affected by the moments of the distribution in $t-1$, will impact on the moments of the distribution in t , that will reverberate on the equilibrium interest rate in $t+1$, and so on. Changes over time of the moments drive the evolution of the equilibrium interest rate, the employment rate and inflation.

Employment effects

What is the role of heterogeneity in the transmission mechanism of (fiscal, monetary and financial) shocks to the macroeconomy? For each shock, we provide a breakdown of the associated change of the employment rate.

“ In an agent-based setting, thinking in macroeconomic terms is *prima facie* impossible. When an aggregate shock occurs, it is extremely difficult to trace the transmission mechanism in a clear and uncontroversial way ”

The direct or *first-round* effect is the change in the employment rate generated by the shock assuming that the distribution of net worth does not change. There is also an indirect or *second-round* effect that captures the change of the employment rate due to the change in the distribution of net worth, that in turn is generated by the shock.

The indirect effect captures a *financial transmission mechanism*, because it is entirely due to the change of net worth, our measure of financial robustness. It can be broken down, in turn, into two components: a *Representative Agent (RA)* component and a *Heterogeneous Agents (HA)* component. The former is the indirect change in the employment rate that would occur if the individual EFP coincided with the average EFP (focusing therefore only on the first moment of the distribution) while the latter incorporates also the effect of changes in the variance of the distribution.

Given the chosen parameterization, we are able to quantify these effects. We consider three (permanent) shocks: *(i)* an expansionary fiscal shock (increase of government expenditure); *(ii)* a monetary shock (increase of the exogenous component of the interest rate); *(iii)* a financial shock (increase of the exogenous component of the individual EFP).

Key results

- In all the cases considered (fiscal shock, monetary shock, financial shock), the first round effect explains most of the actual change of the output gap.
- The second-round effect is unambiguously negative both in the case of an expansionary fiscal policy and in the case of a contractionary monetary policy. In both cases, in fact, the average EFP goes up.
- Both in the case of an expansionary fiscal policy and in the case of a contractionary monetary policy, after the shock the cross-sectional mean and variance of the distribution of net worth go down: the first and second moments of the distribution are positively correlated. This is due to the consequences of the increase of the interest rate on the distribution. The reduction of the cross-sectional mean pushes the average EFP up while the reduction of the variance pushes the average EFP down. The first effect prevails so that average EFP goes unambiguously up.
- The second-round effect is negative also in the case of a contractionary financial shock. In this case, the EFP goes up on impact because of the shock itself, and goes further up because of the second round effect. Also in this case, the cross-sectional mean and variance of the distribution of net worth go down, and the first effect prevails so that average EFP goes unambiguously up.
- The second-round effect amplifies the effect of the monetary shock and the financial shock and mitigates the effect of the fiscal shock. In the latter case, in fact, the financial transmission mechanism contributes to crowding out.
- In the case of the fiscal and monetary shock, the HA component has the same sign of the RA component and explains a sizable part of the second-round effect.

Of course, the size of these effects is due to our particular configuration of parameters and modelling choices. It is important to remember that there is only one source of heterogeneity in this model: the heterogeneity of firms' financial conditions.

“ What is the role of heterogeneity in the transmission mechanism of (fiscal, monetary and financial) shocks to the macroeconomy? For each shock, we provide a breakdown of the associated change of the employment rate ”



Summing up

Pursuing further a line of research on Hybrid Macroeconomic ABMs allows us to resume macroeconomic thinking in a multi-agent context. We consider a population of firms characterized by heterogeneous financial conditions. Each firm chooses the optimal level of investment in the presence of a financial friction. Hence individual investment depends on individual financial robustness captured by net worth.

We aggregate individual investment by means of a stochastic procedure that resorts to the first and second moments of the distribution of net worth. Aggregate investment, therefore, will be affected by the interest rate and by the first and second moments of the distribution. We use this behavioral aggregate equation in the context of an IS-AS-TR framework, where the IS curve is augmented by the moments of the distribution. Therefore, in equilibrium, the interest rate, inflation, and the employment rate (and output gap) will be functions of the moments mentioned above.

The evolution over time of individual net worth turns out to be a function of the cross-sectional mean and variance (through the equilibrium interest rate). We simulate the model to understand the statistical properties of the results. Thanks to our modelling strategy, we are able to disentangle the first-round effect of a shock (keeping the distribution unchanged) and the second-round effect and to distinguish the specific role played by heterogeneity in the latter.

In all the scenarios considered, the first-round effect explains most of the actual change of the output gap. The second-round effect is unambiguously negative. The HA component has the same sign of the RA component and explains a sizable fraction of the second-round effect. The benchmark model lends itself to a wide range of possible extensions, such as the explicit consideration of income and wealth inequality among households.

For more information, see Tiziana's paper 'The Financial Transmission of Shocks in a Simple Hybrid Macroeconomic Agent Based Model'.





DO BITCOIN RETURNS REFLECT FUNDAMENTAL VALUE?

Catherine Casamatta
with Bruno Biais, Christophe Bisière,
Matthieu Bouvard and Albert Menkveld

What is the fundamental value of cryptocurrencies, such as bitcoin? Could the rising price of bitcoin reflect an increase in its fundamental value, or does it only reflect speculation? Does the volatility of cryptocurrencies suggest investors are irrational? In a new paper on 'Equilibrium Bitcoin Pricing', TSE researchers Bruno Biais, Christophe Bisière and Catherine Casamatta examine these issues by testing an equilibrium model with new data on bitcoin's transactional costs and benefits.

Several recent empirical papers have offered econometric tests of bubbles in the cryptocurrency market. While these analyses use methods developed for stock markets, cryptocurrencies differ from stocks. This raises the need for a new theoretical and econometric framework, to analyze empirically the dynamics of cryptocurrency. The goal of our paper is to offer such a framework and confront it to the data.

Costs and benefits

We consider overlapping generations of agents with stochastic endowments who can trade central-bank money and a cryptocurrency. While both currencies can be used to purchase consumption goods in the future, the cryptocurrency can provide transactional benefits that the money issued by the central bank does not. For example, citizens of Venezuela or Zimbabwe can use bitcoins to conduct transactions although their national currencies and banking systems are in disarray, while Chinese investors can use bitcoins to transfer funds outside China. We also account for the costs of conducting transactions in cryptocurrencies: limited convertibility into other currencies, transactions costs on exchanges, lower rate of acceptance by merchants, or fees agents must

“ Cryptocurrency can provide transactional benefits, allowing citizens of countries like Venezuela or Zimbabwe to conduct transactions although their national currencies and banking systems are in disarray, or Chinese investors to transfer funds outside China ”



DO BITCOIN RETURNS REFLECT FUNDAMENTAL VALUE?

pay to have their transactions mined. Investors rationally choose their demand for the cryptocurrency based on their expectation of future prices and net transactional benefits.

What distinguishes cryptocurrencies from other assets (such as stocks, bonds) is the relationship between transactional benefits and prices. On the one hand, transactional benefits are akin to dividends for a stock, hence affect the price agents are willing to pay to hold the cryptocurrency. But unlike dividends, the magnitude of transactional benefits in turn depends on the price of the currency: the transactional advantages of holding one bitcoin are much larger if a bitcoin is worth \$15,000 than if it is worth \$100. This point, which applies to all currencies, not only cryptocurrencies, was already noted in Tirole (1985, p. 1515-1516):

"... the monetary market fundamental is not defined solely by the sequence of real interest rates. Its dividend depends on its price. [...] the market fundamental of money in general depends on the whole path of prices (to this extent money is a very special asset)."

Thus, the notion of "fundamental" means something very different for stocks (backed by dividends) and money (backed by transactional services). In particular, the feedback loop from prices to transactional benefits naturally leads to equilibrium multiplicity: agents who expect future prices to be high (resp. low) rationally anticipate high (resp. low) future transactional benefits, which in turn justifies a high (resp. low) price today.

A tale of two currencies

We depart from Tirole (1985) in ways we deem important for the dynamics of cryptocurrencies. First, our model features two currencies, traditional central-bank money and a cryptocurrency. We thus derive a pricing equation expressing the expected return on the cryptocurrency (say, bitcoin) in central-bank money (say, dollars), which we can confront to observed dollar returns of bitcoin. Second, in addition to transactional benefits we also consider transaction costs, reflecting frauds and hacks and the difficulty to conduct transactions in cryptocurrencies. Allowing for a rich structure of transactional benefits and costs is key to our empirical approach in which we construct measures of these fundamentals. Our econometric analysis sheds light on the relationship between these random variables.

The model delivers the following insights:

- The price of one unit of cryptocurrency at time t is equal to the expectation of its future price at time $t + 1$, discounted using a standard asset pricing kernel modified to take into account transactional benefits and costs. These benefits and costs reflect the evolution of variables from the real economy affecting the usefulness of cryptocurrencies, such as the development of e-commerce or illegal transactions.
- The structure of equilibrium gives rise to a large multiplicity of equilibria: we show in particular that when agents are risk neutral, if a price sequence forms an equilibrium, then that sequence multiplied by a noise term, with expectation equal to one, is also an equilibrium. Such extrinsic noise on the equilibrium path implies, in line with stylized facts, large volatility for cryptocurrency prices, even at times at which the fundamentals are not very volatile. This underscores that the Shiller (1981) critique does not apply to cryptocurrencies.
- When transaction costs are large, investors require large expected returns to hold bitcoins. In contrast, large transactional benefits reduce equilibrium required expected returns. Thus, large observed returns on bitcoin are consistent with the prediction of our model for currently large transactions costs and low transaction benefits. In this

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equilibrium, current bitcoin prices reflect the future stream of transactional benefits they will generate in the future. At that point in time, when the transactional services of bitcoin will have become large, bitcoin prices will have further increased, but equilibrium expected returns will be low.

Testing the model

Next, we confront these predictions of the model to the data. Using the Generalised Method of Moments (GMM), we estimate the parameters of the model and test the restrictions imposed by theory on the relation between the cryptocurrency returns, transaction costs and benefits. To do so, we construct a time series of bitcoin prices from July 2010 to July 2018 by compiling data from 17 major exchanges. We also construct three time series that proxy for the transactional costs and benefits of using bitcoin.

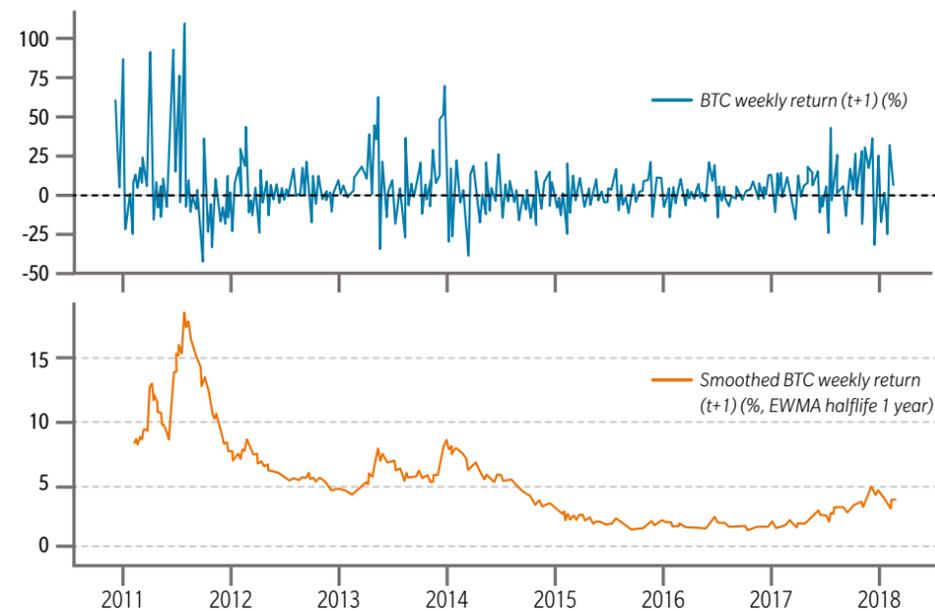
The first one captures the evolution of the transaction fees that bitcoin users attach to their transaction to induce miners to process them faster. For the other two, we collect information on events that likely affect the costs and benefits of transacting in bitcoin, and categorize them into two subsamples.

The first subsample captures transaction costs: it contains events indicative of the ease with which bitcoins can be exchanged against other currencies, such as a new currency becoming tradable against bitcoin or the shutdown of a large platform like Mt. Gox. The second subsample captures transactional benefits: it contains events affecting the ease with which bitcoin can be used to purchase goods and services, such as merchants starting or stopping to accept bitcoin as a means of payment.

From these subsamples we construct two indexes that proxy for the transactional benefits and transaction costs associated with bitcoin at every point in time. Finally, we collect data about thefts and losses on bitcoin to obtain a measure of the average monetary loss incurred when holding bitcoins.

Bitcoin returns

This figure plots weekly Bitcoin returns. The top graph plots raw returns. The bottom graph smooths these returns by plotting an exponentially weighted moving average of these returns with a half-life of one year.



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Key results

- Consistent with the model, GMM estimates show a negative and significant relation between expected return and transactional benefits and a positive and significant relation between expected returns and transactional costs.
- We also analyze how these different components affect the required return (implied by our model) over time. We estimate that the costs induced by the difficulty to trade bitcoins were large in 2011 and contributed at that time to fifteen percentage points of weekly required return. This decreased to five percentage points as investors could more easily trade bitcoins. On the other hand, transaction fees have a negligible impact on the required returns, except at the end of 2017, when they were particularly large.
- Furthermore, transactional benefits were initially low, reducing the required return by less than one percentage point. As more firms started accepting bitcoins to buy goods and services, transactional benefits became larger, inducing a reduction in the required return of around six percentage points since 2015.
- The estimation also shows that while fundamentals are significant factors, they only explain a relatively small share of return variations on bitcoin. In the context of our model, this suggests that observed bitcoin volatility in large part reflects extrinsic noise.

Summing up

We offer an overlapping generations equilibrium model of cryptocurrency pricing and confront it to new data on bitcoin transactional benefits and costs. The model emphasizes that the fundamental value of the cryptocurrency is the stream of net transactional benefits it will provide, which depend on its future prices. The link between future and present prices implies that returns can exhibit large volatility unrelated to fundamentals. We construct an index measuring the ease with which bitcoins can be used to purchase goods and services, and we measure costs incurred by bitcoin owners. Consistent with the model, estimated transactional net benefits explain a statistically significant fraction of bitcoin returns.



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