When complexity meets finance: A contribution to the study of the macroeconomic effects of complex financial systems

Alberto Botta[1], Eugenio Caverzasi[2,4], and Alberto Russo*[3,4]

[1]University of Greenwich (UK)
[2]Università degli Studi dell'Insubria (Italy)
[3]Universitat Jaume I (Spain)
[4]Università Politecnica delle Marche (Italy)

March 10, 2020

Abstract

In the last decade, complexity economics has emerged as a powerful approach to the understanding of the most relevant factors influencing economic development. The concept of economic complexity has been applied to the study of different economic issues such as economic growth, technological change and inequality. This work represents a first step towards the application of this concept to the study of the financial side of the economy, and particularly of the macroeconomic effects of rising financial complexity. In this paper, we present an agent-based macroeconomic model including an increasingly complex financial sector, characterized by the presence of Collateralized Debt Obligations with different seniorities next to more standard assets, like bonds and commercial papers. Simulations results suggest that financial complexity exerts major economic effects: while financial engineering makes securitized loans very attractive and opaque assets, the disperse interaction among different agents and financial institutions generated by these complex financial instruments shapes the behavior of the economies and allows for the diffusion of financial distress.

Keywords: Financial complexity, securitization, agent-based model, stock-flow consistency, inequality, financial crisis.

*Corresponding address: Department of Economics, Universitat Jaume I, Av. Vicent Sos Baynat (Campus del Riu Sec), 12071 Castellòn de la Plana (Spain). E-mail: russo@uji.es; alberto.russo@univpm.it

1 Introduction

The concept of complexity has been around in the economic literature for the last 40 years. At the origin of the story, complexity came to economics as an alternative methodology with respect to the equilibrium- and calculus-centered mainstream approach. In this sense, complexity was mainly conceived as *system* complexity, i.e., a vision of the economy as a complex set of interactions among heterogeneous agents, which *endogenously* determine the environment they live in and to which they constantly react by changing, revising and adapting their actions (Arthur et al., 1997; Arthur, 2014).

Since mid 2000s, thanks to the contributions by Hausmann et al. (2007), Hidalgo and Hausmann (2009), and Felipe et al. (2012) among others, complexity has been increasingly adopted with the meaning of *product*, *production* or, more broadly, *economic* complexity. In this context, complexity stands for the set of technological knowledge and capabilities, as well as organization and managerial competencies, through which different countries may develop different productive systems and, as a consequence, give rise to different development trajectories.

After the outbreak of the 2007-2008 worldwide financial crisis, the above two concepts have been also applied to the study of modern financial systems in order to better understand the origin and development of the financial crisis itself. On the one hand, economists have started to analyze financial systems through the lenses of complexity theory in order to stress how boom-and bust cycles, tipping points, and contagion phenomena may emanate from the interaction between heterogeneous agents in complex financial networks, (Battiston et al., 2016). On the other hand, an expanding body of literature has put emphasis on the increasing complexity of some financial products, namely securitized assets such as asset-backed securities and Collateralized Debt Obligations (CDOs henceforth), as relevant sources of rising riskiness, both at the level of the single (underlying) asset, as well as of the system as a whole (Furfine, 2012; Ghent et al., 2017).

In this paper, we connect these three strands of literature by analyzing the macroeconomic implications of increasing financial complexity. We first run a parallelism between complexity in the financial system and the more standard notion of product or economic complexity. We do this by describing the intrinsic complexity characterizing the production of some financial assets, namely CDOs, which massively spread through financial markets before the last financial crisis. We aim at analyzing how the complex financial alchemy at the basis of such “opaque” financial products - which was originally meant to create highly remunerative and (apparently) safe investment opportunities - may have caused deep changes in the functioning of the economy by affecting its growth performance, its macroeconomic stability, and the level of inequality characterizing income and wealth distribution. Secondly, we carry out our analysis through a complex agent-based (AB) stock-flow-consitent (SFC) model featuring multiple financial sectors and heterogenous households. Consistently with Arthur (2014), a central feature of our model is the existence of *positive feedbacks* in the continuous interactions between heterogeneous households, the productive non-financial sector, and financial institutions giving rise to endogenous boom-and-bust credit cycles.

The results of our computational model suggest that when complexity meets finance, it may bear rather different macroeconomic effects with respect to those ascribed to the more standard phenomenon of product or economic complexity. The existing literature about economic complexity usually identifies it as a relevant positive source of economic progress (Hausmann et al., 2007; Hidalgo and Hausmann, 2009; Felipe et al., 2012). Our simulations suggest that the macro implications of financial complexity are much more nuanced, to say the least. On the one hand, we find that financial complexity might somehow stimulate faster economic growth by allowing financial institutions to extend more resources to both households and real economy firms, which are then enabled to increase both consumption and investment expenditures. On the other hand, modestly higher growth records are matched with heightened macroeconomic volatility and, perhaps more relevantly, with a considerably higher tendency to the endogenous generation of large financial shocks. Even further, the introduction in financial markets of complex financial products tends to give rise to worsening income and wealth distributions, which in turn seems to stimulate even further the production of such opaque financial commodities in the context of what might be labelled as a rentier-friendly economy. Actually, this finding is completely at odds with the empirical evidence put forward by Hartmann et al. (2017) according to which higher degrees of economic complexity (rather than financial complexity) contribute to reduce income inequality.

Financial complexity has a twofold nature. On the one hand, financial engineering made complex (but obscure) financial assets highly attractive, favoring a high demand for CDOs even with a decreasing quality of the underlying assets (i.e., riskier borrowers) and ultimately allowing banks to securitize existing loans and increase credit issuance. On the other hand, the complex network of disperse interactions on which these instruments are based turned to be crucial in determining the income and wealth structure, and therefore the behavior, of the agents, causing financial distress to spread through the economy. These features of modern financialized economies are captured in our model and are at the core of the results of our simulations, in which complex financial instruments might ease economic growth at the cost of making the financial system more unstable and income and wealth more unequally distributed.

The paper is organized as follows. Section 2 presents a short review of the existing literature on financial innovation, financial complexity, and its relations with the real-side of the economy. In this section, we explain how the concept of product complexity may be applied to the financial world and, in particular, to the description of the financial products at the roots of the last financial crisis. Sections 3 and 4 illustrate the main features and the rationale of our AB-SFC macro model. Section 5 presents the simulation results. Section 6 draws conclusions on the peculiar macroeconomic effects of financial complexity.

2 Literature review

The relationship between finance and economic development dates back to Schumpeter's description of the dynamics of capitalist economies. On the one hand, Schumpeter (as well as other evolutionary economists such as Carlota Perez later in his tradition - see Kregel (2009)) attributes to innovations in the real sector of the economy, in manufacturing in particular, the primacy as leading forces behind economic progress. On the other hand, Schumpeter himself recognizes the fundamental importance of bankers as the economic actors that effectively enable entrepreneurs to carry out "new combinations" (of goods and processes) by extending to them the required financial resources (see Schumpeter 1934). In a way, whilst innovation in the real sector of the economy is the "king" of economic dynamics, finance "is the ephor of the exchange economy" (Schumpeter, 1934, p.74).[1]

In a series of more recent contributions, Levine (1997) and Levine (2005) tend to emphasize the role of *financial development* as independent and autonomous source of economic dynamics regardless of possible first moves in the real side of the economy. According to this view, a more developed financial system, i.e., a financial system capable of efficiently intermediating a larger amount of resources between savers and investors via bank-centered and market-centered mechanisms, may boost growth. A similar reshuffling of the balance between finance and the real economy, even though in a completely different theoretical framework and with different systemic and policy implications, comes from Minsky. Indeed, from Minsky's own words, "those who finance a Schumpeterian innovator always have novel problems in structuring the financing [so that] two sets of new combinations, in production and in finance, drive the evolution of the economy" (Minsky, 1988, p.3). And Kregel (2009) puts this point even more bluntly by stating that "it is financial innovation in the financial sector that provides the increased financing that allows for the exploration and installation of the new technological paradigm" (Kregel, 2009, p.205).

There is not precise one-to-one matching from Levine-type financial development to Minskyan financial innovation and, ultimately, to financial complexity. Yet, the process of financial development as Levine describes seems to be associated with a change in the structure of finance from a bank-based to a more market-based financial system (Demirguc-Kunt and Levine, 1999). Such a change in turn implies institutional innovations (the emergence of institutional investors, pension and hedge funds, money market mutual funds and broaker-and-dealers), as well as the production of new market-based increasingly complex financial products such as CDOs.

There seems to be a certain similarity between the concept of product complexity as elaborated by Hidalgo and Hausmann (2009) and Felipe et al. (2012) among others and the complexity characterizing the above-mentioned structured financial products. Felipe et al. (2012) define "the complexity of a product [as] a function of the capabilities it requires", which in turn refer to "(i) the set of human and

[1]The "ephor was an elected magistrate of Sparta who exercised supervisory powers over the kings" (see Minsky, 1988, p.8).

physical capital, the legal system, institutions that are needed to produce a product [...]; (ii) the "know-how" or working practices held collectively by the group of individuals comprising a firm; and (iii) the organizational abilities that provide the capacity to form, manage, and operate activities that involves large numbers of people" (Felipe et al., 2012, p.37). The complex capabilities and technological knowledge at the basis of the production of complex products in turn explain why only few (prevalently developed) countries produce and export sophisticated goods (Hausmann et al., 2007; Hidalgo and Hausmann, 2009; Felipe et al., 2012). Advanced know-how is unevenly distributed among regions, does not spread easily, and it is hard to be replicated by lagging-behind economies (Balland and Rigby, 2017).

When we move the attention to the financial world, there is increasing evidence that the production of complex financial assets may share (at least) some of the above properties. First, Greenwood and Scharfstein (2013) document the considerable increase of the financial sector's share over US GDP since the 1980s. They identify in the security and credit intermediation sub-sectors that gave rise to securitization and the production of CDOs as the major contributors to such an expansion. More relevantly for our analysis, they stress how the production needs of booming and increasingly complex (securitization-related) financial practices and products diverted an increasing amount of high-skilled graduates from top universities (i.e., high-skill human capital), mathematicians, physicists and engineers, into the finance industry. Cecchetti and Kharroubi (2012), Philippon and Reshef (2012), Marin and Vona (2017), and the US National Commission on the Causes of the Economic and Financial Crisis (2011) (NCCEFC henceforth) all provide further support for this evidence. The NCCEFC notes that Wall Street companies started to hire so-called "quants" back in the 1970s, but that "securitization increased the importance of this expertise [and that] major players in these complex markets relied increasingly on quantitative analysts" (NCCEFC, 2011, p.44). [2]

Second, securitization and the production of CDOs have considerably increased the degree of complexity of the network of specialized actors, hence competencies, involved in financial activities. Following Douglas et al. (2007) and the NCCEFC (2011), the production of CDOs involves at least 5 different players absolving specific functions and endowed with specific capabilities (i.e., CDOs issuers, asset (collateral) managers, rating agencies, insurance providers and trustees). This fact is in turn consistent with the steep rise, since the beginning of the 1990s, in the credit intermediation index computed by Greenwood and Scharfstein (2013), which is meant to capture the degree of complexity characterizing the financial relationships somehow embedded into financial products.

Third, in line with Balland and Rigby (2017), the complex set of capabilities and the intricate network required for the production of structured financial products may explain why just a few big players monopolized this business, and why it did not spread to many other financial systems in the world. Indeed, according to the NCCEFC (2011), from 2004 to 2007, three big companies, namely Merill Lynch, Goldman Sachs and Citigroup accounted for more than 30 percent of CDOs issuances taking place in that period. And rival non-US companies were Deutsche Bank and UBS also located in developed economies. In our view, these three aspects constitute clear signs of the complex organizational, managerial, institutional and technological capabilities needed for the production of complex structured *financial* products on top of "standard" manufactured goods.

Given the similarity between the concept of economic/product complexity and financial (product) complexity, it is worth wondering whether analogies persist even in their economy-wide implications. More specifically, a higher degree of economic and product complexity is usually seen as indicator of more advanced economic development and predictor of brighter economic opportunities. Does increasing financial product complexity bring with it the same positive implications in terms of macroeconomic dynamics? The mainstream literature on financial development a là Levine (1997) would likely provide a positive answer. Indeed, complex structured financial products were originally meant as useful financial instruments enhancing financial intermediation and, hence, supporting economic growth. The creation of large secondary market for mortgage-backed securities, for instance, was considered a powerful vehicle for

[2]Following Awrey (2012), it is worth stressing that the expanding production of structured financial products has been possible only by combining high-skill experts in quantitative methods with advances in information technology and computer-based computations allowing for the simultaneous estimation of the variance, co-variance and market value of myriad assets underlying the performance of CDOs (see more on this below). Other way around, the joint accumulation of high quality more advanced human and physical capital is a central part of the story behind the expansion of the securitization industry.

allowing mortgage originators to extend mortgages even to credit-constrained households, traditionally cut off from credit circuits. This would have in turn fostered (US) home ownership and the expansion of the housing sector. By the same vein, massive issuance of securities backed by a variety of loans such as home-equity loans, car loans, student loans and credit card receivables[3] would have helped to boost consumption and allow for the emergence of a finance-led consumption-centered growth regime (Boyer, 2010).[4]

The outbreak of the last financial crisis has severely shaken the above belief in the virtues of complex structured financial products. At a micro level, economists questioned the alleged high degree of safety characterizing CDOs. Structured financial products turned out to be much more exposed to systemic risks than thought initially (Coval et al., 2009; Gorton, 2010). And their high degree of complexity and opaqueness actually turned out to be voluntary outcomes of CDOs producers aimed at exploiting asymmetric information and hidden mismatch between (effective) returns and risk in search for higher mark-ups (Furfine, 2012; Celerier and Vallee, 2017; Ghent et al., 2017).

From a macroeconomic perspective, i.e., the focus of this paper, the financial crisis sparked concerns about the fragility of the macroeconomic regime that the above financial products and the connected financial complexity gave rise to. Such a regime which was mainly based on high consumption expenditures carried out by increasingly indebted households in the context of increasingly unequal economies (Boyer, 2010; Russo et al., 2016; Botta et al., 2020; Caverzasi et al., 2019). On the one hand, the crisis confirmed the original Minsky's conviction that financial innovations play a fundamental destabilizing role and can lead to boom-and-bust dynamics out of period of relative tranquility, so that "explosive business cycles rather than steady growth is likely to be the normal result of the financing process" (Minsky, 1988, p.11). On the other hand, it also casted doubts on the long-run "dynamic efficiency" of a modern economy dominated by "money managers", i.e., large institutional investors, hedge and pension funds, money market mutual funds, whose demand for maximum returns at minimum risk structured financial products were meant to cater.

As said before, in this paper we do not focus on potentially non-linear long-run relationship between recent financial developments, financial complexity and economic growth, which has been recently pointed by a series of complementary contributions (see Cecchetti and Kharroubi (2012); Law and Singh (2014); Arcand et al. (2015)). We rather put our attention on the pure macroeconomic regime that, in a demand-driven economy, can emerge from the production of complex structured financial products. In sections 3 and 4 below, we provide a detailed description of the main features of our model.

3 The macroeconomics of complex financial products: A formal model

Collateralized debt obligations have been around in financial markets since the end of the 1980s. Nevertheless, their production and diffusion, together with their level of complexity, exploded in the 2000s up to the outbreak of the financial crisis. In this period, they became "standard" investment options to institutional investors, hedge funds, and almost all type of asset managers. [5]

The astonishing increase in the production of CDOs was due to two fundamental advantages, strictly connected to their intrinsic complexity, that CDOs are supposed to give to final investors with respect to other investment opportunities. First, CDOs are financial derivatives whose return depends on interest payments coming from a large pool of underlying assets. The set of assets backing CDOs could be literally composed by myriads of different financial products such as mortgages (of different quality), home equity loans, car loans, student and commercial loans, or even other CDOs or Credit Default Swaps (CDS) in

[3]According to Awrey (2012), between 1985 and 2011, the stock of non mortgage-related asset-backed securities astonishingly increased by 1800 percent.

[4]Consistently with this logic, Hoffmann and Nitschka (2012) note that the international commercialization of mortgage asset-backed securities positively contributed to smooth domestic credit cycles and consumption volatility associated to shocks.

[5]According to the NCCEFC (2011), in the US economy the production of CDOs jumped from 30 billion dollars in 2003 to 225 billion dollars in 2006. In 2005, almost all non-prime mortgage-backed securities rated BBB were purchased by financial institutions producing CDOs.

the case of CDOs squared and synthetic CDOs, respectively. [6] Thanks to this intricate structure, CDOs can create new (apparently) safer investment opportunities by allowing investors to implicitly diversify risk over thousands of assets with respect to what would have happened should investor had to invest in just one of them.

Second, CDOs carry out a process of "*risk transformation*" thanks to the financial engineering through which the cash flow of interest payments from underlying assets is eventually distributed among CDOs holders. Indeed, the pool of underlying assets is packed and divided into different "*tranches*" with different degrees of priority or seniority on the expected flow of interests. On the one hand, "*junior*" or "*equity*" tranches, "*CDOs B*" in the jargon of our model (see more on this below), are those providing investors with higher potential returns but immediate losses as soon as a few of the underlying assets do not perform as expected. "*CDOs B*" are thus the assets where losses would concentrate and the first to default together with some of the financial items "in the back". On the other hand, "*senior*" tranches, what we label "*CDOs A*" in this paper, offer lower returns than CDOs B, but are still more remunerative than public bonds or commercial papers, and almost equally safe, since they suffer losses only in the event of the rate of non-performing underlying assets overcoming a certain threshold. It is precisely due to this kind of complex cash-flow distribution mechanism that the producers of CDOs managed to "transform risk" and to create apparently risk-free assets (rating agencies often recognized triple A standards to senior tranches) out of a pool of much riskier ones as in the case of sub-prime mortgages. [7]

There is an increasing evidence that the production of such complex financial products changed the "rules of the game" of financial markets and the behavior of financial institutions. Indeed, securitization and the connected production of CDOs may have caused the reduction of credit standards (Brunnermeier, 2009; C., 2010), the expansion of credit (Brunnermeier, 2009; C., 2010), and its redirection from business credit to households credit (Bertay et al., 2017). Despite this evidence, at the best of our knowledge, there are no previous attempts of investigating into a formal model how the intrinsic complexity of structured financial products may have affected the functioning of the financial system and of the economy as a whole. This paper aims at providing a first formal analysis of the macroeconomic effects of "*financial complexity*", here intended as the complex nature and structure of the financial assets at the roots of the last financial crisis. [8]

The present model builds upon a previous contribution by Botta et al. (2019). However, differently from the model presented in that paper, here we considerably enrich and expand the set of investment options available in the financial system. More specifically, we propose a sequential-step approach according to which we progressively expand the set of financial products existing in the economy up to the "most advanced" financial stage featuring securitization and the production of CDOs A and B. We do this is order to pur emphasis on and detect the peculiar macroeconomic implications of the creation of structured financial products with respect to other "more common" financial assets. Moreover, we modify the way institutional investors, investment funds in our jargon, allocate collected funds among different assets with different degrees of risk and complexity. In the present model, we first introduce the category of "risky" assets (as opposed to risk-free government bonds) including commercial papers and, in the most advanced stage of financial development, sophisticated CDOs. Second, we assume investment

[6] The evolution of CDOs from the end of the 1980s on, the change in their design and the constant attempt of creating new structured financial products with new increasingly complex "*combinations*" of underlying assets seem to resemble, to some extent, the description that Fleming and Sorenson (2001) provide of the evolution of technology. In a way, similar to what inventors are expected to do in, say, manufacturing, also "*financial engineers*" must find the proper "balance between increased mean outcome against decreased variability"(Fleming and Sorenson, 2001, p.1024). And not differently from what happens in the production of other manufactured goods, the invention of new manufactured CDOs pays attention to the degree of "*interdependence*" among their (financial) components.

[7] This process of financial engineering leading to "risk transformation" obviously implies that the production of "safe" CDOs A is possible only in conjunction with the production of riskier CDOs B. Indeed, this is why the two types of CDOs were created in a certain fixed proportion, with senior trances with "A rating" amounting, on average, to roughly 90 percent of all CDOs issuances (Douglas et al., 2007; NCCEFC, 2011).

[8] Following Awrey (2012), we could also measure financial complexity as a function of the costs one has to incur into in order to search, collect, process and understand all the information needed to evaluate the performance of a given financial product. In the case of structured financial products, "even the most (ostensibly) sophisticated counterparties failed to grasp their technical nuances, [and supposedly well-informed] market participants did not fully appreciate how the unique structure of sub-prime mortgages made the MBS and CDOs into which they were repackaged particularly sensitive to volatility in the underlying home prices" (Awrey, 2012, p.250).

funds to follow different behavioral rules in the formation of expectations about returns from CDOs A and CDOs B given their different degrees of riskiness.

We start with a closed economy composed of five sectors (*Stage 1*): a collection of N heterogeneous households, and four aggregate sectors, namely non-financial firms (NFFs), commercial banks (CBs), investment funds (i.e. non-bank financial intermediaries - IFs henceforth), and the government. This stage is characterized by a rather underdeveloped financial system. The only external source of funds for NFFs are CBs' loans, while government's bonds are the only financial asset available for investment funds, besides banks' deposits. In this system, commercial banks follow a "create-and-hold" approach, i.e., created assets – loans to NFFs and households – are kept on their balance sheet. securitization is not allowed and structured financial products do not exist.

In *Stage 2*, the financial market evolves. NFFs have direct access to the financial market and issue commercial papers, which represent a cheaper source of funds with respect to CBs' loans and allow them to circumvent possible banks' credit rationing.

Finally, *Stage 3* reproduces a developed financial system characterized by the existence of different types of CDOs. Securitization takes place and a new financial sector – Special Purpose Vehicles (SPV) – emerges allowing CBs to switch from a "create-and-hold" practice to a "create-and-distribute" practice by moving a portion of created loans out of their balance sheet. SPVs also perform risk transformation. They pool securitized loans and tranche them into CDOs A and CDOs B according to the fixed production proportion "90-10" (see footnote 7 on this). CDOs A and B are eventually sold on demand to IFs.

As briefly sketched above, we develop a hybrid AB-SFC model with all sectors at the aggregate level but the households sector. This methodology preserves the main advantages of both approaches (Caverzasi and Russo, 2018). On the one hand, the rigorous macro accounting structure inherited from SFC models (Godley and Lavoie, 2007; Caverzasi and Godin, 2014) ensures that all inter-sectoral flows and feedbacks are accounted for. On the other hand, the AB approach allows to analyze the emergence of macroeconomic phenomena from the interaction of heterogeneous agents at the micro level. This last aspect is of paramount importance in this study, since that it is connected to an additional factor of complexity inherently specific to structured financial products. In a developed financial system (*Stage 3* in our model), securitization of loans, and the production and diffusion of CDOs determine a tremendous increase in the degree of *disperse interaction* between a multitude of different borrowers and financial investors. In fact, returns on CDOs rely upon the performance of myriads of underlying assets. The financial behavior (i.e., the capacity to meet outstanding payment commitments) of a relatively restricted bunch of agents, say sub-prime borrowers, may thus affect the decisions and future actions of a much wider set of nodes, i.e., securitizing institutions and/or investors, involved in the newly developed "originate-and-distribute" network. The AB approach we adopt allows our model to capture this crucial aspect of financial complexity embedded into structured financial products. We decided to limit heterogeneity to the households sector to make the interpretation of the results much clearer than in full-fledge AB models whilst still capturing such network complexity ensuing from the production of CDOs.

Each of the various financial institutions has different characteristics and plays a different role in the economy (see Appendix A).

- The *CBs* create (credit-)money in the form of deposits by issuing loans to households and NFFs, and buys all the government bonds not purchased by IFs. CBs apply a specific interest rate to each individual household and to NFFs according to each borrower's creditworthiness. This, coupled with considerations on its own financial stability, may lead banks to ration credit. In Stage 3, CBs pass the interests collected on securitized loans (through SPVs) and profits in the form of dividends to IFs.

- *IFs* represent non-banking financial intermediaries which collect funds from households by issuing IFs' *shares*. IFs allocate collected funds among the financial assets available in each stage of financial development. In Stage 1, IFs make a portfolio choice between government bonds and banks' deposit only. In Stage 2, we introduce commercial papers, whilst in Stage 3 also CDOs are available as additional investment options. Returns on financial assets are entirely transferred to the owners of IFs' shares.

- *SPVs* come into play in Stage 3 of the model. They play the very specific role of performing the securitization process. SPVs buy loans from CBs and use them as financial inputs for manufacturing CDOs (Caverzasi and Russo, 2018). Through complex financial engineering, SPVs transform risks and give rise to the production of (apparently) relatively safe assets, i.e., CDOs A, out of riskier assets (underlying loans), with CDOs B as necessary complementary riskier assets. SPVs eventually sell all CDOs demanded by IFs. SPVs pass all cash flows from securitized loans to the holders of CDOs A and CDOs B, according to the cash flow distribution rule envisaged by the interconnected structure of the two types of CDOs (see more on this below).

To better capture the impacts of the evolution of the financial sector on the economy, the real side of our model is kept rather simple. NFFs produce a homogenous good used for both consumption and investment purposes. Investment in real capital and the desired level of deposits are financed primarily through retained profits and, whenever these are not enough, through external financing, i.e., banks' loans or issuance of commercial papers (in stages 2 and 3). In the event of banks' credit rationing, or insufficient demand for commercial papers, NFFs may need to diminish deposits in order to meet their financial or investment needs.

Households have two sources of income: (i) labor income (*i.e.,* wages); (ii) financial income, i.e., returns on IFs' shares. Moreover, they can meet their desired levels of consumption and accumulation of financial assets by applying for loans to CBs. If credit is rationed, households revise their decisions, starting from assets holding down to consumption.

Finally, the *government* issues bonds, bought by CBs and IFs, to finance outlays not covered by tax revenues.

3.1 The sequence of events

The timeline of events in each of the T simulation periods is the following:

1 *Households receive their labor income and pay taxes on wage.*

2.1 *Financial payments: returns on non-structured financial assets (i.e., interests on government bonds, interests on households' and NFFs' loans) are paid; CBs' profits are transferred to IFs.*

2.2 *Returns on commercial papers are paid by NFFs to IFs (in Stages 2 and 3).*

2.3 *Interests on securitized loans pass from CBs to IFs via SPVs in order to remunerate CDOs' holders (Stage 3).*

3 *IFs compute returns on their assets to remunerate holders of IFs' shares. Non performing loans diminish returns on CDOs B first, and, if above a certain threshold, on CDOs A*

4 *Households make consumption and savings decisions.*

5 *If needed, households apply for loans to CBs.*

6 *CBs decide whether to accomodate households' demand for loans.*

7 *In case of credit rationing, households revise their decisions.*

8 *The government implements spending decisions.*

9 *NFFs define investments in real capital and the desired level of deposits.*

10 *If retained profit do not fully cover their decisions, NFFs increase their liabilities by applying for loans to CBs or, in Stages 2 and 3, by issuing commercial papers.*

11 *CBs decide whether to fully accomodate NFFs' demand for loans.*

12 *In case of credit rationing, NFFs revise their decisions, scaling down their stock of deposits.*

13 *The government finances its deficit by issuing public bonds.*

14 *IFs perform their portfolio choice, allocating collected funds among government bonds, deposits, commercial papers (from Stage 2), and CDOs A and CDOs B (Stage 3).*

15 *CBs buy all bonds not purchased by IFs.*

4 Behavioral equations

Due to space constraints, in this section we present the most relevant behavioral equations of the model only. We report the full list of equations in Appendix B. The suffices i and t define individual households and the simulation period, respectively.

4.1 Households

Households have two sources of income: wages $w_{i,t}$ and returns r^{sh} on holding of IFs' shares $SH_{i,t}$. Similarly, they have two different obligations: one fiscal (taxes on wage) and one financial (interests to be paid $r^h_{i,t-1}$ on their outstanding stock of debt $Lh_{i,t-1}$). These two components determine their disposable income (Equation (1)).

$$yd_{i,t} = w_{i,t} - tax^w_{i,t} + r^{sh}SH_{i,t} - \widetilde{r^h_{i,t-1}Lh_{i,t-1}} \tag{1}$$

All households are created equal in terms of wealth, as all assets are set equal to zero at the beginning of the simulation. However, wages differ as the total wage bill - set exogenously as a fix proportion λ of the capital stock - is distributed according to a stochastic process. At the beginning, individual wage quotas are drawn from a log-normal distribution (with log-standard deviation θ). The ranking in wage income is kept constant but differences among individual wages emerge due to the evolution of the aggregate wage bill.

The model includes a progressive taxation system as the tax rate tax^w on wages increases above a certain threshold, set equal to the median wage rate. The last component of disposable income $\widetilde{r^h_{i,t-1}Lh_{i,t-1}}$ represents 'effective' interest payment. Indeed, households may be unable to entirely meet their financial obligations, thus giving rise to non-performing interests (NPI).[9]

Once disposable income is computed, households decide their desired level of consumption and define their portfolio choices.

$$c^*_{i,t} = c_y yd_{i,t} + c_n\bar{c}_{t-1} \tag{2}$$

Desired consumption (Equation (2)) depends on the propensity to consume c_y out of disposable income plus a 'socially determined component' c_n, which depends on the previous period average consumption. This second component of Equation (2) has the double role of capturing the well-known fact that consumption propensity decreases with higher levels of income, as well as the influence of consumption norms (or external habit formation) on individual choices.

The stock of deposits that households decide to hold is defined as a fix share η of their individual wealth $WH_{i,t-1}$ (Equation (5) in Appendix B). An adaptive process based on the difference between the returns on IFs' shares ($rsh_{i,t-1}/Sh_{i,t-1}$) and public bonds ($i^B_{i,t-1}$) determines the desired stock of shares (Equation 3)

$$Sh^*_{i,t} = Sh_{i,t-1}[1 + \sigma(\frac{rsh_{i,t-1}}{Sh_{i,t-1}} - i^B_{i,t-1})] \tag{3}$$

[9] In Stage 3, households paying interests on past debt concur in determining the return of CDOs and, therefore, the return on shares, which is one of the sources of income they may use to cover their outlays, financial obligations included. This circular mechanism is solved through a recursive process, in which returns on shares are used to cover due interest payments, which in turn determine a further flow of returns for the holders of IFs' shares. This process ends whenever a further round of payments covers less than 10% of due interests.

The desired flows of deposits and shares simply result from accounting identities (Equations (6) and (8) in Appendix B). Whenever desired consumption and the desired acquisition of IFs' shares $Sh^*_{i,t}$ and deposits $Dh^*_{i,t}$ exceed desired savings $s^*_{i,t}$, households may apply for a loan from CBs (Equations (4)). If rationed, households are forced to scale down their investment and, if needed, stock of shares. May this not be enough, the same is done with deposits. Finally, consumption can be reduced to a bottom subsistence level. Conversely, if the flow of savings exceeds the target flows of deposits and shares, the surplus is used to deleverage: the stock of loans is diminished. In the event a household succeeds in paying back his whole debt, the surplus will be accumulated in the form of deposits.

$$\Delta Lh^*_{i,t} = \Delta Dh^*_{i,t} + \Delta Sh^*_{i,t} - s^*_{i,t} \tag{4}$$

4.2 Non-financial Firms

The NFFs sector takes three decisions: (i) how much to invest in real capital; (ii) how to finance investment; (iii) the amount of deposit holding.

As to the investment in real capital (Equation (13) in Appendix B), it depends positively on the observed profitability of the aggregate sector – as captured by the profit share (Π_{t-1}/Y_{t-1}) – and on observed capital utilization ($u_{t-1} = Y_{t-1}/K_{t-1}$), with γ_1 and γ_2 being positive parameters. A stochastic element (Z_t, with $\gamma_3 > 0$) is included in the investment function to capture the influence of entrepreneurs' *animal spirits*. NFFs hold a stock of deposit equal to a fraction η of their capital stock for transaction and precautionary purposes (Equation (19) in Appendix B).

NFFs revert to external funds in order to fill the gap between available internal funds (*i.e.*, net retained profit Pf_t out of gross profits $\Pi_{F,t}$ once paid taxes and met interest payments $RL_{f,t}$ (Equation (20) in Appendix B)) and investment expenditures. In Stage 1, NFFs' external funding consists of CBs' loans only (Equation (5))

$$\Delta Lf_t = I + \Delta D_{f,t} - Pf_t \tag{5}$$

From Stage 2, NFFs can cover an exogenous share χ of their needs for external funds by issuing commercial papers, and revert to the banking sector for the rest.

$$\Delta CP_{f,t} = \chi(I + \Delta D_{f,t} - Pf_t) \tag{6}$$

$$\Delta Lf_t = I + \Delta D_{f,t} - Pf_t - \Delta CP_{f,t} \tag{7}$$

In the event that the demand for commercial papers falls short of the supply, or in the event of credit rationing by CBs, NFFs' deposits will act as buffer stock to accomodate NFFs' investment in real assets.

$$r^{cp} = (1-\mu) r^f_{t-1} + ø \frac{CP^S_{f,t-1} - CP^D_{if,t-1}}{CP^S_{f,t-1} + CP^D_{if,t-1}} \tag{8}$$

Equation (8) tell us that the return on commercial papers is set as a *mark-down* μ on the previous period interest rate on NFFs' loans, but it can increase (or decrease), at the speed set by the exogenous parameter ø in case of an excess supply (excess demand) of commercial papers in the previous period.

4.3 Government

We assume a very simple rule for public purchases. We model them a fixed proportion ξ of the previous-period aggregate consumption (Equation (27) in Appendix B). The government collects taxes from both firms and households. To cover its deficit, it issues public bonds, which are purchased by CBs and IFs in a recursive process that mimics the auction for public bonds in the US economy. The process (see Equation (9)) starts with the previous-period interest rate. IFs, whose role simulates that of *competitive bidders*, set their demand according to their behavioral rule. CBs, i.e., *non-competitive bidders*, are ready to buy all the remaining bonds issued. In the event the share of bonds that CBs will need to buy to clear the market is higher (lower) with respect to previous period, the interest rate will increase (decrease) of a small amount (ϕ). A new round begins. IFs and subsequently CBs update their demand. The process ends when a further increase of the interest rate leads to an increase in IFs' demand lower than α.

$$r_t^b = r_{t-1}^b[1 + \phi(\frac{B_{B,t}}{GD_t} - \frac{B_{B,t-1}}{GD_{t-1}})] \tag{9}$$

4.4 Commercial Banks

CBs make two key decisions. First, they set households' and NFFs-specific interest rates on conceded loans. Second, based on borrowers' creditworthiness, they decide whether to ration credit or not. These decisions can be conceived as a three-step process.

First, the expected specific interest rate for each individual household and for NFFs applying for loans is computed as a mark-up on the previous period bond rate i_{t-1}^B. Unlike individual households, the NFFs sector may be subjected to partial credit rationing only. We therefore assume the expected and actual interest rates to coincide for the NFFs sector. Equations (10) and (11) tell us that the higher the ratio of the '*notional*' (i.e. assuming the demand for new loans ΔL^* being accomodated) level of indebtedness over, respectively, net households' income $yn_{i,t}$ and NFFs' profits Pf_t, the higher the mark-up.

$$E[r_{i,t}^h] = i_{t-1}^B + i_{t-1}^B \frac{Lh_{i,t-1} + \Delta Lh_{i,t}^*}{yn_{i,t}} \tag{10}$$

$$E[r_t^f] = r_t^f = i_{t-1}^B + i_{t-1}^B \frac{Lf_{t-1} + \Delta Lf_t^*}{Pf_t} \tag{11}$$

Second, CBs compute *notional* borrowers' debt service ratios:

$$mh_{i,t}^* = E[r_{i,t}^h] \frac{Lh_{i,t-1} + \Delta Lh_{i,t}^*}{yd_{i,t}} \tag{12}$$

$$mf_{i,t}^* = E[r_t^f] \frac{Lf_{i,t-1} + \Delta Lf_{i,t}^*}{Pf_t} \tag{13}$$

Third, CBs compare notional debt service ratios with the endogenous threshold ψ_t, which is inversely related to CBs' financial soundness as measured by the distance of CBs' leverage from Basel-type capital requirements ($\bar{k}$). In Equation (14), ω is an exogenous parameter influencing CBs sensitivity to balance sheet's conditions, whilst $\bar{\psi}$ is the exogenous maximum acceptable level of the debt service ratio. The higher CBs financial fragility, the more CBs will be hesitant to securing new loans. Equation (15) represents our proxy for CBs leverage, here measured as risk-free assets (i.e., government bonds) over CBs' total assets in Stages 1 and 2. Equation (16) refers to Stage 3, in which securitization is introduced and z is the quota of securitized loans.

$$\psi_t = max\left(\bar{\psi}, \quad \bar{\psi} + \omega(k_{t-1} - \bar{k})\right) \tag{14}$$

$$k_{B,t} = \frac{B_{B,t}}{[L_t + B_{B,t}]} \tag{15}$$

$$k_{B,t} = \frac{B_{B,t}}{[(1 - z_t)L_t + B_{B,t}]} \tag{16}$$

It is self-evident how higher levels of z are associated with less prudent behaviors, and may therefore ease credit supply and the concession of riskier loans. Whenever m exceeds ψ, credit rationing takes place. In the case of individual households, this leads to a complete refusal of the loan. In the case of the NFFs sector, rationing is partial and the loan eventually granted (ΔLf) is diminished until $mf_{i,t}^*$ it is equal to $\bar{\psi}$.

Next to their role as credit providers for the private sector, CBs purchase government bonds not bought by IFs. They finally pass all their profits to IFs. Both these behaviors are better described in the next section.

4.5 Special Purpose Vehicles

Financial innovation as represented by the creation of structured financial products brings with it the creation of new financial institutions and a more complex network of financial intermediation. In our model, this happens at Stage 3 when SPVs are introduced. SPVs allow for the securitization of (part of) existing loans to take place in order to then produce structured financial products. Equation (17) first shows that the demand for CDOs by IFs drives the portion (z_t) of heterogenous households' and NFFs' debt SPVs will buy from CBs in order to produce CDOs.

$$z_t \sum_{i=1}^{N} Lh_{i,t} + z_t Lf_t = CDO_{if,t} \tag{17}$$

Differently from Botta et al. (2019), here we take a step further in the modeling of the financial sector by providing a much deeper description of the intrinsic complexity of structured financial products. We do this by modeling how SPVs transform risk associated to the pool of loans purchased from CBs by creating two different types of CDOs, i.e., CDOs A and CDOs B. First, Equation (18) defines the "notional" (assuming all borrowers being able to service their debt) flow of interest payments on the pool of securitized assets accruing to SPVs, and subsequently moved to holders of CDOs. The return on CDOs is given by a portion (z) of total interests paid on CBs' loans. Equations (19) and (20) then show how this cash flow is distributed among different CDOs tranches. Holders of CDOs A will be paid first. The notional return they will receive is obtained by applying a mark-down ν on the notional return from the bundle of securitized loans. Holders of CDOs B will receive all the remaining cash flow. [10] In this regards, in case of defaults, whenever the share of NPLs over total due interests does not exceed a certain threshold (θ), all losses are absorbed by CDOs B only. Losses above the threshold are spread among the two types of CDOs according to their fixed quotas (x^A and x^B).

$$r_t^{cdo} = \frac{z_t[(\sum_{i=1}^{N} r_{i,t-1}^{h} Lh_{i,t-1}) + r_{t-1}^{f} Lf_{t-1}]}{CDO_{if,t-1}} \tag{18}$$

$$r_t^{cdoa} = r^{cdo} * (1 - \nu) \tag{19}$$

$$r_t^{cdob} = \frac{r_t^{cdo} * CDO - r_t^{cdoa} * CDO_A}{CDO_B} \tag{20}$$

4.6 Investment Funds

IFs intermediate between households and financial markets. Their portfolio choices change significantly between the three different stages of financial development we consider, as the set of available investment options increase when moving from Stage 1 and Stage 3.

In Stage 1, IFs update the demand for government bonds following an adaptive rule based on the observed year-to-year difference in bonds' yields, allocating the remaining funds to deposits. In our model, government bonds represent completely risk-free assets. Bonds' yields thus stand as a premium for their lower liquidity with respect to CBs deposits. Liquidity is relevant to IFs insofar as it might protect them from the risk of a liquidity crisis may rentier households want to redeem a significant part of IFs' shares.

$$q_{if,t}^{b} = min\{0.1, q_{if,t-1}^{b}[1 - \beta(i_{t-1}^{B} - i_t^{B})]\} \tag{21}$$

$$D_{IF,t} = (1 - q_{if,t}^{b})SH \tag{22}$$

Equation (21) tells us that the higher the return on public bonds with respect to the previous period, the more IFs will increase their demand for bonds. Moreover, the share of collected funds allocated to government bonds cannot be less than 10% of total IFs' assets. This is to capture the effects of regulatory constraints about portfolio composition different types of financial intermediaries have to comply with.

[10] In our model, CDOs B stand for what is known in financial markets as *"equity-tranche"*.

Parameter β represents the sensitivity with respect to this inter-temporal spread. The remaining funds are allocated to deposits (Equation (23)).

In Stage 2, the introduction of commercial papers makes the set of IFs portfolio choices richer. In this stage, the stock of deposits is set as a fix proportion σ of collected funds (Equation (23)). The share of remaining funds invested in government bonds varies with the change in their relative remunerativeness. Equation (25) differs from Equation (21) as the year-to-year change in the return on bonds is now compared with the change in the return on commercial papers r_{cp}. Equation (26) defines the demand for commercial papers. If NFFs issue less commercial papers than IFs demand, IFs' deposits act as buffer stock.

$$D_{IF,t} = \sigma SH_t \tag{23}$$
$$B^D_{IF,t} = q^b_{if,t} SH_t (1 - \sigma) \tag{24}$$
$$q^b_{if,t} = min\{0.1, q^b_{if,t-1}[1 - \beta[(r_{cp} - i^B_t) - (r_{cp,t-1} - i^B_{t-1})]\} \tag{25}$$
$$CP^D_{IF,t} = SH_t - D_{IF,t} - B^D_{IF,t} \tag{26}$$

In Stage 3, a further step is added to IFs' portfolio choice by introducing structured financial products, i.e., CDOs. CDOs A and CDOs B now represent additional investment opportunities in the set of relatively riskier assets (compared to government bonds) next to commercial papers. Differently from Botta et al. (2019), here we describe the behavior of IFs through a more complex two-step mechanism. First, in order to define the amount of collected funds (out of deposit) to direct towards the purchase of government bonds (Equation (27)), IFs compare the return on government bonds with a weighted average (rr) of the returns on riskier assets. Equation (28) in turn gives the total demand for riskier assets. In a second step, IFs then decide the portion of different riskier assets to hold in their portfolio. Equations (29) and (30) jointly say that the quota of resources devoted to riskier assets (RA^D) and allocated to CDOs increases together with the expected relative remunerativeness of the "CDO bundle". Indeed, given the existence of two different types of CDOs, expected returns from investments on structured financial products $E[r^{cdo}]$ (see Equation (31)) now depend on the weighted average of expected returns on CDOs A and CDOs B, respectively, with weights captured by parameters x^A and x^B and equal to the fixed proportion (90-10) with which CDOs A and B must be produced.

$$q^b_{if,t} = min\{0.1, q^b_{if,t-1}[1 - \beta[(rr - i^B_t) - (rr - i^B_{t-1})]\} \tag{27}$$
$$RA^D_{IF,t} = SH_t - D_{IF,t} - B^D_{IF,t} \tag{28}$$

$$CDO^D_{IF,t} = RA^D_{IF,t} * \frac{E[r^{cdo}_t]}{[r^{cdo}_t] + r^{cp}_t} \tag{29}$$
$$CP^D_{IF,t} = RA^D_{IF,t} - CDO^D_{IF,t} \tag{30}$$

$$E[r^{cdo}] = x^A E[r^{cdoa}] * x^B E[r^{cdob}] \tag{31}$$
$$E[r^{cdoa}] = r^{cdoa}_t \tag{32}$$
$$E[r^{cdob}] = r^{cdob}_{t-1} \tag{33}$$
(34)

In the present paper, we explicitly model how IFs form their expectations about returns on risky assets. Equations (32) and (33), in particular, define the returns IFs expect to receive on the two different types of CDOs. The different status of seniority and safety between CDOs A and B obviously matters. We capture this point by assuming different expectations with which IFs estimate the remunerativeness of these two assets. CDOAs, which are considered safe assets, are expected to pay what SPVs announce (see Equation 32). In the case of CDOs B, given their status of "equity trances", we assume IFs to base their expectations on previous performances.

5 Simulations

The behavior of the model in its different stages is analyzed by means of computer simulations.[11] The values of the parameters are listed in Appendix C. To investigate the behavior of the economy in different scenarios, we run a battery of Monte Carlo experiments. Each is composed by 100 simulations with different seeds for the pseudo-random number generation process, which involves investment and wages. The three scenarios we consider correspond to the above mentioned stages of financial development:

- A first baseline scenario (*Stage 1* of financial development) with a simple bank-centered financial system with no commercial papers or CDOs;
- A second scenario (*Stage 2* of financial development) that involves the introduction of commercial papers;
- A third scenario (*Stage 3* of financial development) that includes CDOs A and CDOs B on top of commercial papers;

Our findings are reported in Table 1. We implemented a two-sample t-Test on simulated results in scenario 2 and 3 in order to to assess whether they are statistically different with respect to the baseline, and whether the introduction of structured financial products causes any structural change in the functioning of the economy with respect to the simple introduction of commercial papers.

As to the dynamics of the economy, nor the introduction of commercial papers nor of CDOs seems to have an appreciable effect on GDP growth. The increase in the GDP growth rate observed in scenarios 2 and 3 is marginal and not statistically different with respect the baseline. [12] In the specific case of scenario 3, our result does not support the idea of a finance-led growth pattern, in which debt-financed consumption may provide momentum to the dynamics of the economy, at least over a long time horizon.

When we move our attention from income generation to income (and wealth) distribution, results become more interesting. Indeed, both the introduction of commercial papers and CDOs tend to worsen income and wealth distribution (see also the top-right panel in Figure 1). It is worth noting that the creation of CDOs exacerbates, in a statistically significant way, the more unequal distribution of income and wealth already emerged in scenario 2 when commercial papers are first taken into account (see column 6 in Table 1).

The economic mechanisms behind such changes in distributive patterns are quite clear. On the one hand, income and wealth inequality increase in scenario 2 due to the fact that only wealthier households hold IFs' shares, whose remuneration rises in this stage thanks to the inclusion in IFs' portfolios (and hence, implicitly, in wealthy households' shares) of more lucrative assets, i.e., commercial papers, with respect to government bonds. In the end, the presence in the economy of commercial papers boosts the rentier-type source of income of the better offs, thus worsening inequality.

On the other hand, such a trend is further reinforced in scenario 3 given that CDOs A and B implicitly create an additional source of regressive income transfer from low-middle income increasingly indebted households to wealthy rentier households. To some extent, this further escalation in inequality is a direct consequence of the way the introduction of structured financial products affect the behavior of the economy, and of financial actors in particular. Indeed, thanks to the creation of CDOs, CBs can put a non negligible amount of originated loans out of their balance sheets. The securitized loans become implicit source of income for rentiers whilst they still remain pending liabilities for indebted households. On top of this, the securitization-led downsizing of CBs' balance sheets allows CBs themselves to extend more loans and to increase the debt of low-middle income households. In a securitized system featuring structured financial products, these new layers of indebtedness are nothing else that the creation of new underlying assets for the production of CDOs and the remuneration of rentiers.[13]

[11] In order to get rid of the possible effects of specific initial conditions regarding the balance sheets, we assume all starting stocks but one to be zero. The only exception, namely NFFs' capital stock, is set equal to 1 as this is required to put the economy in motion.

[12] Even small changes in the rate of growth of the economy may obviously produce some effects on the *level* of GDP over a long-term horizon. This is why the *final* level of GDP in the final period of simulations in scenario 2 and 3 is different with respect to the baseline despite non-statistically different values in the growth rate.

[13] One might reply to our argument that the regressive effects of CDOs over income and wealth distribution might

	STAGE1	***STAGE2***	***STAGE 3***	**T-Test**		
	No CDO	**No CDO**	**CDO**	**1vs2**	**1vs3**	**2vs3**
	No CP	**CP**	**CP**	***(p-values)***	***(p-values)***	***(p-values)***
GDP growth						
- Mean	0.0245	0.0247	0.0248	0*(0.2411)*	0*(0.0655)*	0*(0.5028)*
- Standard Deviation	0.0162	0.0160	0.0159	1*(0.0062)*	1*(3.36e-06)*	1*(0.0455)*
- Skewness	-0.0561	-0.0477	-0.0455	0*(0.4814)*	0*(0.3813)*	0*(0.8545)*
- Kurtosis	2.0965	2.1002	2.1075	0*(0.7981)*	0*(0.4228)*	0*(0.5702)*
GDP level*	1	1.2316	1.3769			
Public Debt over GDP	2.4870	2.1430	1.9565	1*(0.0033)*	1*(3.41e-06)*	0*(0.0713)*
Gini Indexes						
- Income	0.2796	0.2842	0.2870	1*(2.25e-06)*	1*(2.76e-13)*	1*(0.0032)*
- Wealth	0.7218	0.7297	0.7341	1*(3.21e-06)*	1*(1.81e-12)*	1*(0.0074)*
Loan Stock over GDP	1.7033	1.7056	1.7787	0*(0.8263)*	1*(6.52e-11)*	1*(1.00e-8)*
Spread (in bps) on NFF's financial costs**	1.4512	1.2731	1.4199	1*(2.84e-92)*	1*(4.78e-07)*	1*(9.23e-71)*
Debt to Income ratio	0.9563	0.9690	0.9820	1*(0.0097)*	1*(4.29e-02)*	1*(0.0075)*
Share Stock over GDP	0.9428	0.9480	0.9536	0*(0.6584)*	0*(0.3661)*	0*(0.6417)*
Comm. Papers over GDP	0	0.3827	0.1488			
Share of Securitized Loans	0	0	0.1372			
Crisis Probability****						
- unpaid interest > 2.5%	0.3320	0.5620	0.7940			
- unpaid interest > 5%	0.0440	0.0460	0.0440			
- unpaid interest > 7.5%	0.0100	0.0100	0.0120			
- unpaid interest > 10%	0.0000	0.0000	0.0040			
Return CDO	0	0	0.0390			
Return CDOA	0	0	0.0361			
Return CDOB	0	0	0.0643			
Volatility (CV) CDOA	0	0	0.1070			
Volatility (CV) CDOB	0	0	0.1373			

* GDP last period baseline = 1

** Difference between the average financial payments on both loans and comm. papers and the interest rate on bonds

*** Unpaid over due interests on loans

**** Number of cases for which unpaid over due interest on loans is above the four thresholds below.

Table 1: Descriptive statistics comparing the various scenarios (A Two-Sample t-Test for Equal Means has been implemented to statistically assess the differences among Monte Carlo averages).

In more general terms, this finding seems to suggest that increasing financial complexity, as measured by the production of complex structured financial products, may give rise to different, if not opposite, results with respect to the negative impact on income inequality that Hartmann et al. (2017) associate to the more standard concept of product and economic complexity, and Antonelli and Gehringer (2013) ascribe to technological change and innovation. It is beyond the scope of this paper to make a detailed comparison of such a stream of literature and the macroeconomic mechanisms described in our model. Nonetheless, with respect to Hartmann et al. (2017), we stress that the type of institutional changes that *financial* product complexity bring about are likely to be very different with respect to those associated with "standard" product complexity. They might tend to favor the concentration of economic and

equally take place in a traditional banking system in which CBs extend more loans to households and then distribute larger interest-related profits to shareholders (typically wealthy households) via equities. We stress that this would have not happened without securitization and CDOs (or it would have happened in a much lower extent). This is due to the fact that securitization and CDOs themselves are the practice and the products enabling CBs to reduce credit standards and expand credit provision even to low-middle income households usually excluded from formal credit channels.

political power rather than its more equal distribution (via increased organization of the workforce). With respect to Antonelli and Gehringer (2013), complex financial products tend to raise the financial sources of income (by increasing interest rates and debt burdens), and perhaps to reduce those related to increased labor productivity (i.e., rising wages), due to the diversion of funds from the financing of productive investment towards households debt. This is exactly the opposite than the virtuous redistributive mechanisms Antonelli and Gehringer (2013) attribute to technological change in the real sector of the economy.

Commercial papers and CDOs also bear relevant consequences for the costs of NFFs' external funding. Interestingly, the effect caused by the introduction of CDOs is opposite with respect to that brought about by commercial papers.

In scenario 2, financing cost, i.e., the spread between the interests rate NFFs need to pay on their liabilities and the interest rate paid by the government on public bonds, decreases significantly (17 base points) thanks to commercial papers. This can be neatly appreciated by looking at the bottom-right panel in Figure 1. [14] This result is perfectly in line with the goal of commercial papers, which is to provide NFFs a direct access to financial markets and to a cheaper source of external finance, and to decrease their indebtedness towards the traditional banking system.

Things radically change in scenario 3. Indeed, the introduction of CDOs leads the spread between NFFs' external source of funding and government bonds to increase and return closer to the baseline scenario. Other way around, the creation of CDOs leads to the loss of commercial papers-related advantages for NFFs. This phenomenon is due to the fact that CDOs, CDOs A in particular (i.e., more remunerative and supposedly equally safe assets than commercial papers), constitute alternative choices than commercial papers in IFs portfolio allocation. Accordingly, CDOs may divert IFs' capitals away from commercial papers, reduce its demand, and raise the connected spread. Indeed, when moving from scenario 2 (*Stage 2*) to scenario 3 (*Stage 3*), the value of commercial papers circulating in the economy over GDP falls from 38% to 15%. Interestingly, this result seems to somehow reproduce the empirical evidence put forward by Bertay et al. (2017), who document how securitization could have made NFFs' competition for external funding harder. According to them, whilst this fact might not bring visible effects in terms of aggregate GDP dynamics (because potentially lower investment demand might be compensated by higher debt-led consumption demand), it might certainly (negatively) affect the evolution of productivity by reducing capital accumulation.[15]

The previous point seems to be connected to a structural change in the banking business when commercial papers and CDOs are created. Commercial papers and CDOs both stand out as financial products that tend to move the financial system away from traditional bank-centered financial relations to more market-based relations. In turn, this can lead banks to re-orient their lending activity towards credit to households rather than business (Greenwood and Scharfstein, 2013). This is what data in Table 1 suggest. The overall stock of loans does not change (from a statistical point of view) when moving from the baseline to scenario 2 despite the introduction of commercial papers. This means that CBs replaced loans to commercial business with loans to households. This fact is reflected in the statistically significant increase in households' debt (over income) registered between scenario 2 and the baseline.

The introduction of CDOs in scenario 3, instead, leads to a statistically significant rise (with respect to scenario 2) in the overall stock of loans and household debt. The total stock of loans (over GDP) passes from 171 percent in scenario 2 to 178 percent in scenario 3. Once again, this is a specific outcome of how CDOs are constructed and designed. Following Douglas et al. (2007), one of the specific purposes of CDOs is to carry out a "balance sheet" effect: "selling the loans to a CDOs' [producers, i.e., SPVs in our model] removes them from the bank's balance sheet and therefore lowers the bank's capital requirement" (Douglas et al., 2007, p.6). In order to put originated loans out of balance sheets, financial institutions have to create appealing and popular financial products to investors. They can do this by pooling a complex variety of different loans together and then tranching them into different assets in order to create relatively remunerative but supposedly safe products institutional investors can purchase. This

[14] The numerous red crosses are outliers of the distribution that correspond to crisis events.

[15] For the sake of simplicity, in this model we do not explore any long-run dynamics related to the evolution of productivity. This represents an additional step further that we would like to take in future evolutions of the present analysis. Yet, our current finding may stand out as an indirect complementary add to Cecchetti and Kharroubi (2012) and Arcand et al. (2015), who stress how "too much finance" might eventually hurt productivity and long-run growth potential.

is precisely the case of CDOs, CDOs A in particular. And this is exactly what happened in the way leading to the last financial crisis, (and captured by our simulation results related to scenario 3), when the "popularity of securitized products ultimately led to a flood of cheap credit, and lending standard fell" (Brunnermeier, 2009, p.82).

The general move from a bank-centered financial system to a market-based financial system has a relevant impact on the vulnerability of the economy to financial shocks. We measure the probability of financial crises with the number of non performing loans (read unpaid interests) exceeding a certain percentage of total due interests. We consider four different thresholds: a low (somehow "physiological") non-performing loans threshold at 2.5% of total due interests; a medium threshold at 5%; two higher thresholds at 7.5% and, finally, 10%. From Table 1, it is easy to see that probability of crises increase when we move from the baseline to scenario 2, and then to scenario 3. More relevantly for our analysis, the probability of "extreme" crises with high levels of non-performing loans (above 7.5% or 10% of due interests) are higher in or exclusive related to scenario 3 featuring CDOs into the model.

The explanation for the increase in crisis probability from the baseline to the scenario with commercial papers lies in the behavior of households. Thanks to commercial papers, the higher remunerativeness of IFs' shares increases rentier households' disposable income and, hence, their consumption. This leads low-income households (which are those needing loans to meet their consumption and portfolio choices) to get more indebted to keep up with the increased average level of consumption. As described before, this causes an increase in the debt burden of low-middle income households, so that the risk of default on the accumulated debt rises.

The introduction of complex structured financial products in scenario 3 *exacerbates* the risk of tough financial crises with respect to both the baseline and scenario 2. This happens for two reasons. First, the "emulation" mechanisms in consumption behaviors described at the previous point is reinforced even further thanks to the contributions of CDOs to the remunerativeness of IFs' shares, hence to wealthy households' income and consumptions. Second, structured financial products "perversely" perform their expected function of allowing the economic system, low-middle income households in particular, to get more indebted, something that does not happen in scenario 2. Eventually, such a higher stock of private households debt comes with a higher probability of extreme financial crises.

An interesting point related to the sharpened financial fragility created by the introduction of structured financial products emerges from the bottom-left panel in Figure 1 in conjunction with data about crisis probability included in Table 1. Indeed, for middle values of non-performing loans between 5% and 7.5% of due interests, the probability of crisis is marginally lower in scenario 3 than in scenario 2. This is due to the fact that the creation of CDOs, and the connected rise in the overall debt stock, open more space for long-run unsustainable Ponzi games. Indebted households get even more indebted just to cover current interest payments and postpone the day of reckoning. This may work in some cases, but may eventually give rise to a more violent shock latter on. This fact emerges quite clearly in the bottom-left panel in Figure 1, where we show the ratio between due interest payments over net wages. Despite the general increase in such a measure of "debt service ratio" when moving from the baseline to scenario 2 and scenario 3, this ratio considerably exceeds 1 *only* when CDOs are created in scenario 3. It is thus the creation of CDOs, and the macroeconomic dynamics they give rise, that lie behind the build-up of long-run extremely vulnerable financial positions.

In scenario 3 of our analysis, the evolution of the financial system and of the economy as a whole is affected by the performance of structured financial products. Figure 5 shows how returns on CDOs A and CDOs B evolve through time. We also compare their returns with respect to those of government bonds, i.e., the risk-free financial asset in our model. We focus on the last 500 periods of simulation in order to get rid of the transient dynamics at the beginning of the simulation. Confirming the data reported in Table 1, CDOs B are generally more remunerative than CDOs A. Nevertheless, they are also more volatile and, when financial crises erupt, their returns decrease abruptly. More importantly, also CDOs A show a certain volatility when financial shocks take place. This fact tends to demonstrate that CDOs A may be quite far from being almost risk-less assets rated triple A as they were believed to be before the outbreak of the 2007-2008 financial crisis. It is also the recognition of such undesirable aspect of CDOs A leading IFs to sharply change the composition of their portfolio and quickly move to safe government bonds (a fact mirrored by the decrease in the interest rates over government bonds in Figure

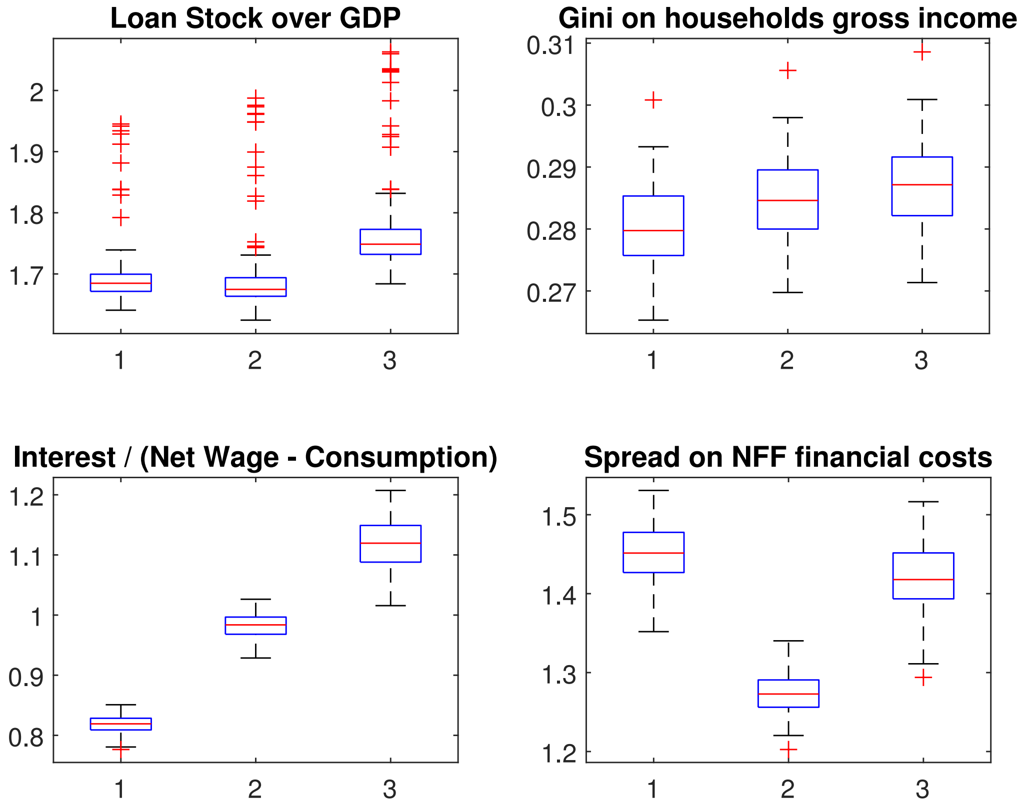

Figure 1: *Box plots for selected variables.* Top left: Total loan stock over GDP; top right: Gini index on gross households income; bottom left: Households' debt service ratio over net wage minus consumption; bottom right: Spread between interest rate on public bonds and weighted interest rate NFFs pay on their liabilities. Numbers from 1 to 3 on the horizontal axis stand for the three different stages (scenarios) of financial development.

5) when crises arrive.

Importantly, the above-mentioned fact that the production of CDOs tend to increase the probability of crises, together with the evidence that even (supposedly) rather safe assets such as CDOs A are hit by financial downturns, tell us that the somehow unexpected reduction in the returns over CDOs A during crises is not simply the outcome of mistakes in their pricing (and in the evaluation of the connected risk) by financial operators. Very frequently, economists have blamed mistakes in the measurement of correlation among, and exposure to system risks of, the myriads assets underlying CDOs as the major responsible for wrong evaluation of structured financial products themselves (Coval et al., 2009). In this context, exposure to systemic risk is usually interpreted in the narrow sense of correlation with some macro variables. However, what emerges from our analysis is that the intrinsic structure of CDOs brings a further element of complexity to the system not well captured by financial market practitioners: structured financial products, by influencing the in-depth functioning of the economy, are themselves an *endogenous* source of sharpened systemic risk. The systemic instability that the production and diffusion of CDOs give rise is certainly related to their contribution to the creation of a higher, eventually unsustainable, households' debt in the context of a more unequal economy. But it is also related to the "disperse interaction" embedded in the structure of CDOs, and which certainly contribute to spread the crisis throughout the system.[16]

[16] One the one hand, when households start defaulting, the remunerativeness of CDOs falls. This may in turn hamper the capability of other households to meet their financial obligations, as they see their financial income reduced. On the other hand, the demand for IFs' shares, and hence CDOs, declines, the securitization process comes to a halt and the financial

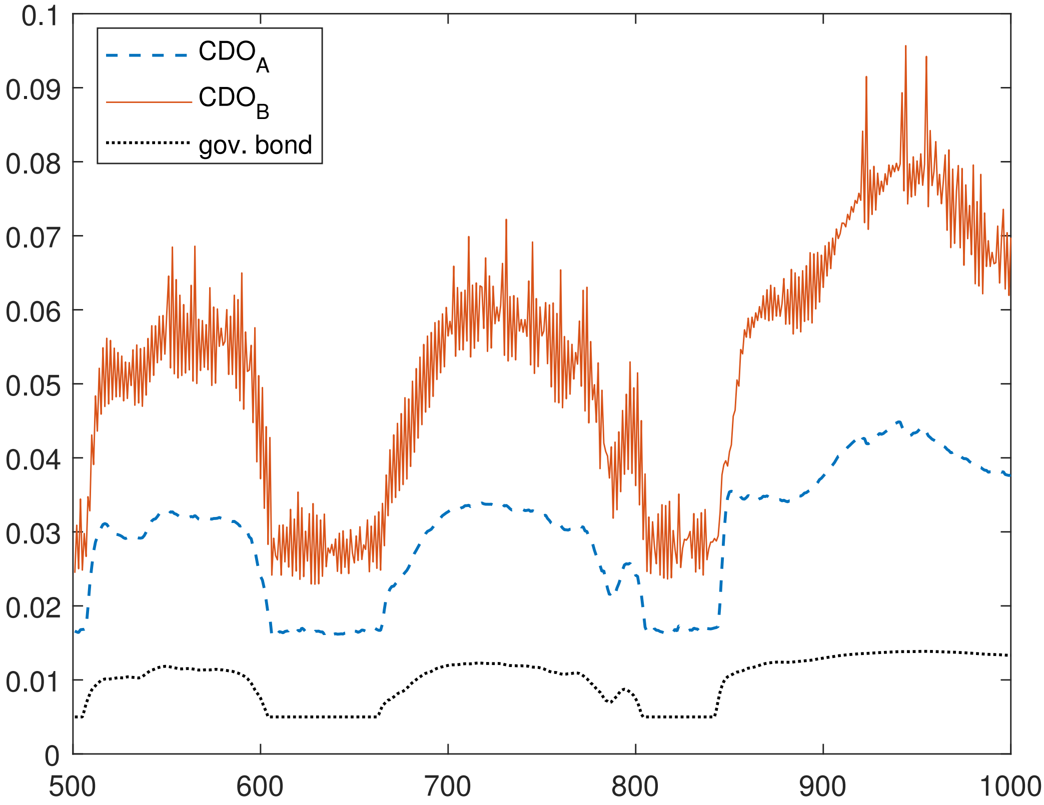

Figure 2: *Returns on CDOs A, CDOs B, and interest rate on government bonds. The simulation presented in this plot has been chosen among the 100 MC replies of Stage 3 with the aim of showing the behavior of the model when large financial crises emerge.*

6 Concluding remarks

Since the end of the 1970s, financial systems have gone through deep changes, shifting from traditional bank-centered systems to more market-based ones. The introduction of new financial products such as commercial papers was meant to favor this transition. The production of complex structured financial products such as CDOs represents a further step ahed in that direction. Indeed, CDOs are meant to transform into sellable and marketable financial products what was traditionally considered as "private" financial relations held on the balance sheets of CBs. In order to do so, the production of CDOs has implied an increasing degree of institutional and technological complexity, which is somehow consistent with the concept of economic and product complexity as generally understood by the connected literature.

In this paper, we present an AB-SFC macro model aimed at studying how increasing financial complexity, here intended as the production of complex financial products such as CDOs, may affect the macro performance of an economy. To the best of our knowledge, this is the first attempt of formalizing the production and peculiarities of structured financial products into a macro model. Our goal is to analyze whether financial complexity may have similar or different effects on economic dynamics with respect to the positive role for economic progress usually attributed to product (economic) complexity (Hausmann et al., 2007; Hidalgo and Hausmann, 2009; Felipe et al., 2012).

The results of our simulations show that financial product complexity does not seem to lead to better economic performances. First, the introduction of CDOs does not cause an appreciable and

positions of CBs deteriorates. This ultimately leads CBs to tighten credit, to reject the roll over of households' debt, and to effectively force them to default.

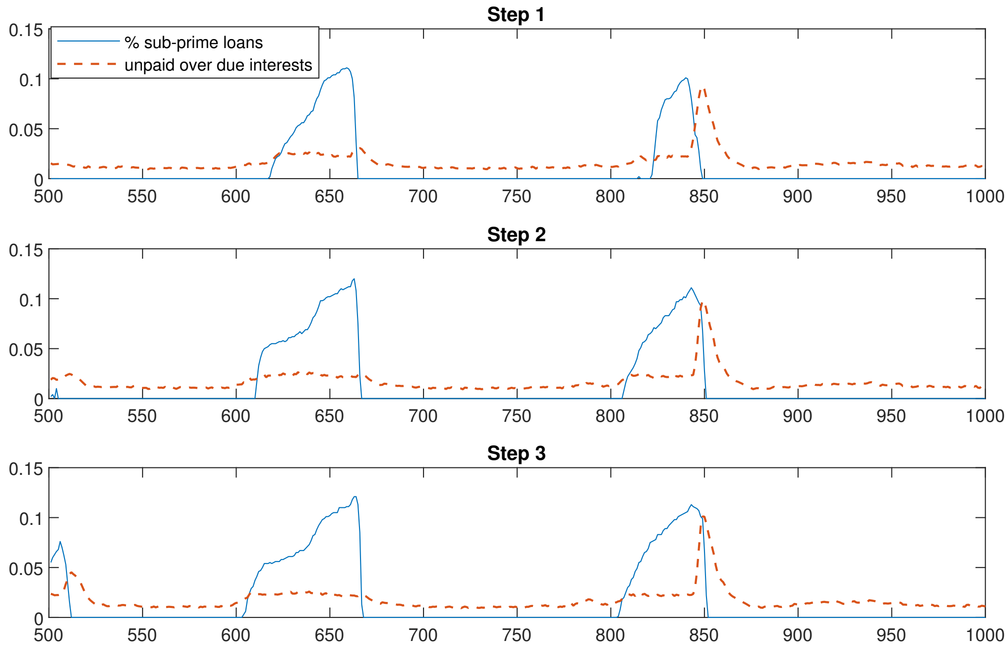

Figure 3: *Sub-prime vs. non-performing loans in Stage 3 of the model. Sub-prime loans are related to households with a loan stock-to-net wage ratio above 7.*

statistically relevant increase in GDP growth with respect to what observed in a "traditional" bank-centered financial system without securitization (the same applies to the scenario featuring commercial papers only). Moreover, while Hartmann et al. (2017) find that more economic complexity tends to reduce inequality, financial product complexity works the other way around. The creation of structured financial products actually *exacerbates* the rise in income and wealth inequality observed with the transition towards market-based financial systems. This result is not surprising since that growing inequality boosts the creation of bank (credit-)money through the loans provided to households and NFFs that, in turn, constitute the raw material used in the securitization process for the production of new structured financial products eventually sold to rentiers. Accordingly, financial payments on bank loans, typically coming from low-to-middle income households, feed rich households who invested in high-return financial products provided by financial intermediaries, resulting in higher income and wealth inequality.

More than this, financial product complexity tends to sharpen macroeconomic instability, and make the system more prone to financial shocks. On the one hand, our analysis shows that this seems to be a more general property of the structural transition towards more market-based financial systems (as modeled in this paper through the introduction of commercial papers in scenario 2). Figure 3 makes this point clear by portraying the co-evolution of non-performing loans and the stock of, say, "non-prime" loans (as measured by the number of households with a debt-net wage ratio higher than 7 – i.e., the highest value observed in our simulations). As one can easily see, "non-prime" loans tend to appear much more frequently in scenario 2 and 3 rather than in the baseline, and they anticipate the increase in non-performing loans that characterizes the beginning of the crisis. On the other hand, however, the production of structured financial products (scenario 3) makes this worrisome aspect of modern financial systems even more frequent and acute than in scenario 2.

In the end, whilst there is an increasingly solid evidence that more sophisticated (manufactured) products are good predictors of economic progress, the same cannot be said for complex financial products. They seem to add very little, if anything, to economic growth, whilst making the economy far more fragile and vulnerable to financial crises. In light of this evidence, it may be advisable for policy-makers and monetary institutions to think about a regulation of financial systems that discourages the production of "opaque" increasingly complex financial products, and to induce financial actors to re-discover their traditional role of institutions supporting the development of real-side economic activity and the introduction of more complex *manufactured* goods.

Appendix A: Matrices

In this appendix we include the balance sheet and the transaction matrix of the economy.

	Households	Banks	SPV (stage 3)	IF	Firms	Gov	Total
Deposits	$+D_H$	$-D$	$+D_{IF}$	$+D_{SPV}$	$+D_F$		0
Capital					$+K$		$+K$
Shares	$+Sh$			$-Sh$			0
Bonds		$+B_B$		$+B_{IF}$		$-B$	0
Loans	$-L_H$	$+(1-z)L$	$+zL$		$-L_F$		0
Stage 2: a new asset (commercial *papers*) is included; SPV is still not included in this scenario							
Papers				$+CP$	$-CP$		0
Stage 3: a further asset (Derivatives) and a new sector (SPV) add to the model							
Derivatives			$-CDO$	$+CDO$			0

Table 2: Aggregate Balance Sheet (Initial Situation)

	Households	Banks		SPV(Stage 3)		IF		Firms		Govt.	Σ
		CA	KA	CA	KA	CA	KA	CA	KA		
TRANSACTIONS											
Consumption	$-C$	0	0	0	0	0	0	$+C$	0	0	0
Publ. Exp.	0	0	0	0	0	0	0	$+G$	0	$-G$	0
Investment	0	0	0	0	0	0	0	$+I$	$-I$	0	0
Wages	$+W$	0	0	0	0	0	0	$-W$	0		0
Taxes	$-T_H$	0	0	0	0	0	0	$-T_F$	0	$+T$	0
Int. on Loans	$-r_h Lht-1$	$+r(1-z)L$	0	$+rzL$	0	0	0	$-r_f Lf_{t-1}$	0	0	0
Return on Shares	$+RSH$	0	0	0		$-RSH$	0	0	0	0	0
Int. on Bonds	0	$+RB_B$	0	0	0	$+RB_{IF}$	0	0	0	$-RB$	0
Dividends	0	$-Div_B$	0	0	0	$+Div_B$	0	0	0	0	0
Stage 2											
Return on papers	0	0	0		0	$+r_{cp}CP$	0	$-r_{cp}CP$	0	0	0
Stage 3											
Return on Deriv.	0	0	0	$-fCDO$	0	$+fCDO$	0	0	0	0	0
Saving and Profits	$+\Pi_H$	0	0	0	0	$-\Pi_{IF}$	$+\Pi_{IF}$	$-\Pi_F$	$+\Pi_F$	0	0
Δ STOCKS											
Deposits	$-\Delta D_H$	0	$+\Delta D$	0	0	0	$-\Delta D_{IF}$	0	$-\Delta D_F$	0	0
Loans	$+\Delta L_H$	0	$-\Delta(1-z)L$	0	$-\Delta zL$	0	0	0	$+\Delta L_F$	0	0
Shares	$-\Delta Sh$	0	0	0	0	0	$+\Delta Sh$	0	0	0	0
Bonds		0	$-\Delta B_B$	0	0	0	$-\Delta B_{IF}$	0	0	$+\Delta B$	0
Stage 2											
Papers	0	0	0	0	0	0	$-\Delta CP$	0	$-\Delta CP$	0	0
Stage 3											
Derivatives	0	0	0	0	$+\Delta CDO$	0	$-\Delta CDO$	0	0	0	0
Total	0	0	0	0	0	0	0	0	0	0	0

Table 3: Aggregate Transaction Flow Matrix

Appendix B: Equations

Hereafter, we present the list of equations.

Households

$$yd_{i,t} = w_{i,t} - tax^{w}_{i,t} + rsh_{i,t} - \widetilde{r^{h}_{i,t-1} Lh_{i,t-1}} \tag{1}$$

$$tax^{w}_{i,t} = \tau^{w}_{j} w_{i,t} \begin{cases} \text{if } w_{i,t} < \hat{w}_t & \Longrightarrow tax^{w} = \tau^{w}_{1} * w_{i,t} \\ \text{if } w_{i,t} \geq \hat{w}_t & \Longrightarrow tax^{w} = \tau^{w}_{1} * \hat{w} + \tau^{w}_{2} * (w_{i,t} - \hat{w}_t) \end{cases} \tag{2}$$

$$c^{*}_{i,t} = c_y yd_{i,t} + c_n \bar{c}_{t-1} \tag{3}$$

$$s^{*}_{i,t} = yd_{i,t} - c^{*}_{i,t} \tag{4}$$

$$Dh^{*}_{i,t} = \eta WH_{i,t-1} \tag{5}$$

$$\Delta Dh^{*}_{i,t} = Dh^{*} - Dh_{i,t-1} \tag{6}$$

$$Sh^{*}_{i,t} = Sh_{i,t-1}[1 + \sigma(\frac{rsh_{i,t-1}}{Sh_{i,t-1}} - i^{B}_{i,t-1})] \tag{7}$$

$$\Delta Sh^{*}_{i,t} = Sh^{*}_{i,t} - Sh_{i,t-1} \tag{8}$$

$$\Delta Lh^{*}_{i,t} = \Delta Dh^{*}_{i,t} + \Delta Sh^{*}_{i,t} - s^{*}_{i,t} \tag{9}$$

$$\text{if } m^{*}_{i,t} < \psi_t \Longrightarrow \begin{cases} \Delta Lh_{i,t} = & \Delta Lh^{*}_{i,t} \\ \Delta Sh_{i,t} = & \Delta Sh^{*}_{i,t} \\ \Delta Dh_{i,t} = & \Delta Dh^{*}_{i,t} \\ c_{i,t} = & c^{*}_{i,t} \end{cases} \tag{10}$$

$$\text{if } m^{*}_{i,t} > \psi_t \Rightarrow Lh_{i,t} = 0 \Rightarrow \begin{cases} \text{if } s^{*}_{i,t} > \Delta Dh^{*}_{i,t} \Rightarrow \begin{cases} \Delta Sh_{i,t} > 0 \\ \Delta Sh_{i,t} = s^{*}_{i,t} - \Delta Dh^{*}_{i,t} \\ \Delta Dh_{i,t} = \Delta Dh^{*}_{i,t} \\ c_{i,t} = c^{*}_{i,t} \end{cases} \\ \text{if } s^{*}_{i,t} < \Delta Dh^{*}_{i,t} \text{ and } s^{*}_{i,t} + Sh_{i,t-1} > \Delta Dh^{*}_{i,t} \Rightarrow \begin{cases} \Delta Sh_{i,t} < 0 \\ \Delta Sh_{i,t} = s^{*}_{i,t} - \Delta Dh^{*}_{i,t} \\ \Delta Dh_{i,t} = \Delta Dh^{*}_{i,t} \\ c_{i,t} = c^{*}_{i,t} \end{cases} \\ \text{if } s^{*}_{i,t} + Sh_{i,t-1} < \Delta Dh^{*}_{i,t} \text{ and } s^{*}_{i,t} + Sh_{i,t-1} > 0 \Rightarrow \begin{cases} Sh_{i,t} = 0 \\ \Delta Sh_{i,t} = -Sh_{i,t-1} \\ \Delta Dh_{i,t} > 0 \\ \Delta Dh_{i,t} = s^{*}_{i,t} + Sh_{i,t-1} \\ c_{i,t} = c^{*}_{i,t} \end{cases} \\ \text{if } s^{*}_{i,t} + Sh_{i,t-1} < 0 \text{ and } s^{*}_{i,t} + Sh_{i,t-1} + Dh_{i,t-1} > 0 \Rightarrow \begin{cases} Sh_{i,t} = 0 \\ \Delta Sh_{i,t} = -Sh_{i,t-1} \\ \Delta Dh_{i,t} < 0 \\ \Delta Dh_{i,t} = s^{*}_{i,t} + Sh_{i,t-1} \\ c_{i,t} = c^{*}_{i,t} \end{cases} \\ \text{if } s^{*}_{i,t} + Sh_{i,t-1} + Dh_{i,t-1} < 0 \Rightarrow \begin{cases} Sh_{i,t} = 0 \\ \Delta Sh_{i,t} = -Sh_{i,t-1} \\ Dh_{i,t} = 0 \\ \Delta Dh_{i,t} = -Dh_{i,t-1} \\ c_{i,t} \geq \tilde{c} \\ c_{i,t} = yd_{i,t} + Sh_{i,t-1} + Dh_{i,t-1} \end{cases} \end{cases} \tag{11}$$

Firms

$$C_t = \sum_{i=1}^{N} c_{i,t} \tag{12}$$

$$I_t = \gamma_1 \frac{\Pi_{t-1}}{Y_{t-1}} + \gamma_2 u_{t-1} + \gamma_3 Zt \tag{13}$$

$$Z_t = \gamma_4 Z_{t-1} + U(0, 0.1) \tag{14}$$

$$K_t = (1 - \delta) K_{t-1} + I \tag{15}$$

$$Y_t = C_t + I_t + G_t \tag{16}$$

$$\Pi_{F,t} = C_t + I_t + G_t - W_t \tag{17}$$

$$\pi_t = \frac{\Pi_{F,t}}{Y_t} \tag{18}$$

$$D_{f,t} = \eta K_t \tag{19}$$

$$Pf_t = (1 - \tau_3)\Pi_{F,t} - RL_{f,t} \tag{20}$$

$$\Delta Lf_t = I + \Delta D_{f,t} - Pf_t \tag{21}$$

$$\tag{22}$$

Stage 2 and 3

$$\Delta CP_{f,t} = \chi(I + \Delta D_{f,t} - Pf_t) \tag{23}$$

$$\Delta Lf_t = I + \Delta D_{f,t} - Pf_t - \Delta CP_{f,t} \tag{24}$$

$$r^{cp} = (1 - \mu) r^f_{t-1} + \o \frac{CP^S_{f,t-1} - CP^D_{if,t-1}}{CP^S_{f,t-1} + CP^D_{if,t-1}} \tag{25}$$

Government

$$T_t = \tau_3 \Pi_{F,t} + \sum_{i=1}^{N} \tau^w_j w_{i,t} \tag{26}$$

$$G_t = \xi C_{t-1} \tag{27}$$

$$GDS_t = r^b_{t-1} GD_{t-1} \tag{28}$$

$$\Delta GD_t = G_t - T_t + GDS_t \tag{29}$$

$$GD_t = GD_{t-1} + \Delta GD_t \tag{30}$$

$$r^b_t = r^b_{t-1}[1 + \alpha(\frac{B_{B,t}}{GD_t} - \frac{B_{B,t-1}}{GD_{t-1}})] \tag{31}$$

Commercial Banks

$$E[r^h_{i,t}] = i^B_{t-1} + \iota i^B_{t-1}\frac{Lh_{i,t-1} + \Delta Lh^*_{i,t}}{yn_{i,t}} \tag{32}$$

$$\text{if } m^*_{i,t} < \psi_t \text{ and } \Delta Lh_{i,t} = \Delta Lh^*_{i,t} \text{ then } r^h_{i,t} = E[r^h_{i,t}] \tag{33}$$

$$E[r^f_t] = r^f_t = i^B_{t-1} + \iota i^B_{t-1}\frac{Lf_{t-1} + \Delta Lf^*_t}{Pf_t} \tag{34}$$

$$mh^*_{i,t} = E[r^h_{i,t}]\frac{Lh_{i,t-1} + \Delta Lh^*_{i,t}}{yd_{i,t}} \tag{35}$$

$$mf^*_{i,t} = E[r^f_{i,t}]\frac{Lf_{i,t-1} + \Delta Lf^*_{i,t}}{Pf_t} \tag{36}$$

$$\psi_t = max\left(\bar{\psi}, \quad \bar{\psi} + \omega(k_{t-1} - \overline{k})\right) \tag{37}$$

$$k_{B,t} = \frac{B_{B,t}}{[L_t + B_{B,t}]} \tag{38}$$

$$k_{B,t,STAGE3} = \frac{B_{B,t}}{[(1-z_t)L_t + B_{B,t}]} \tag{39}$$

$$B_{B,t} = GD_t - B_{IF,t} \tag{40}$$

$$RL^h_{B,t}t = \sum_{i=1}^{N}(1 - z_{t-1})[\widetilde{r^h_{i,t-1}Lh_{i,t-1}}] \tag{41}$$

$$RL^f_{B,t} = (1 - z_{t-1})[r^f_{t-1}Lf_{t-1}] \tag{42}$$

$$RB_{B,t} = r^b_{t-1}B_{B,t-1} \tag{43}$$

$$\Pi_{B,t} = RL^h_{B,t} + RL^f_{B,t} + RB_{B,t} \tag{44}$$

Stage 3

$$CDO_{if,t} = z_t\sum_{i=1}^{N} Lh_{i,t} + z_tLf_t \tag{45}$$

$$z_t = min(1, \frac{CDO_{IF}}{L_t}) \tag{46}$$

$$r^{cdo}_t = \frac{z_t[(\sum_{i=1}^N \widetilde{r^h_{i,t-1}Lh_{i,t-1}}) + r^f_{t-1}Lf_{t-1}]}{CDO_{if,t-1}} \tag{47}$$

Special Purpose Vehicles

$$CDO_{if,t} = z_t\sum_{i=1}^{N} Lh_{i,t} + z_tLf_t \tag{48}$$

$$CDOA_{if,t} = x^A CDO_{if,t} \tag{49}$$

$$CDOB_{if,t} = x^B CDO_{if,t} \tag{50}$$

$$z_t = min(1, \frac{CDO_{IF}}{L_t}) \tag{51}$$

$$r^{cdo}_t = \frac{z_t[(\sum_{i=1}^N r^h_{i,t-1}Lh_{i,t-1}) + r^f_{t-1}Lf_{t-1}]}{CDO_{if,t-1}} r^{cdoa}_t \qquad = r^{*cdo} * (1 - \nu) \tag{52}$$

$$r^{cdob}_t = \frac{r^{cdo}_t * CDO - r^{cdoa}_t * CDO_A}{CDO_B} \tag{53}$$

$$\tag{54}$$

Investment Funds

$$D_{IF,t} = \sigma SH_t \tag{55}$$
$$q^b_{if,t} = q^b_{if,t-1}(1 - \beta[(r^{cdo}_t - i^B_t) - (r^{cdo}_{t-1} - i^B_{t-1})] \tag{56}$$
$$B^D_{IF,t} = q^b_{if,t} SH_t(1-\sigma) \tag{57}$$
$$CDO^D_{IF,t} = SH_t(1-\sigma) - B_{IF,t} \tag{58}$$
$$CDO_{IF,t} = min(z_t L_t, CDO^D_{IF,t}) \tag{59}$$
$$RCDO_{IF,t} = r^{cdo}_{t-1} CDO \tag{60}$$
$$RB_{IF,t} = r^b_{t-1} B_{IF,t-1} \tag{61}$$
$$RSH_t = RCDO_{IF,t} + RB_{IF,t} \tag{62}$$
$$rsh_{i,t} = RSH \frac{sh_{i,t-1}}{SH_{t-1}} \tag{63}$$
$$q^b_{if,t} = min\{0.1, q^b_{if,t-1}[1 - \beta(i^B_{t-1} - i^B_t)] \tag{64}$$
$$D_{IF,t} = (1 - q^b_{if,t})SH \tag{65}$$
$$D_{IF,t} = \sigma SH_t \tag{66}$$
$$B^D_{IF,t} = q^b_{if,t} SH_t(1-\sigma) \tag{67}$$

stage 2

$$q^b_{if,t} = min\{0.1, q^b_{if,t-1}[1 - \beta[(r_{cp} - i^B_t) - (r_{cp,t-1} - i^B_{t-1})]\} \tag{68}$$
$$CP^D_{IF,t} = SH_t - D_{IF,t} - B^D_{IF,t} \tag{69}$$

stage 3

$$q^b_{if,t} = min\{0.1, q^b_{if,t-1}[1 - \beta[(rr - i^B_t) - (rr - i^B_{t-1})]\} \tag{70}$$
$$RA^D_{IF,t} = SH_t - D_{IF,t} - B^D_{IF,t} \tag{71}$$
$$CDO^D_{IF,t} = RA^D_{IF,t} * \frac{E[r^{cdo}_t]}{[r^{cdo}_t] + r^{cp}_t} \tag{72}$$
$$CP^D_{IF,t} = RA^D_{IF,t} - CDO^D_{IF,t} \tag{73}$$
$$E[r^{cdoa}] = r^{cdoa}_t \tag{74}$$
$$E[r^{cdob}] = r^{cdob}_{t-1} \tag{75}$$
$$E[r^{cdo}] = x^A E[r^{cdoa}] * x^B E[r^{cdob}] \tag{76}$$

Appendix C: Parameters

Symbol	*Description*	*Baseline*
T	Number of periods	1000
N	Number of households	1000
τ_1	Lower tax rate on income	0.2
τ_2	Higher tax rate on income	0.4
τ_3	Tax rate on profit	0.5
γ_1	Profit share weight (investment function)	0.2
γ_2	Capacity utilization weight (investment function)	0.01
γ_3	Animal spirit weight (investment function)	0.1
γ_4	Weight of the autoregressive component (investment function)	0.9
η	Precautionary deposits	0.2
ϕ	Speed of adjustment in public bonds' bids and commercial papers' return	0.01
α	Tolerance in public bonds' interest rate setting	0.005
ω	Sensitivity to distance from desired share of bonds (banks credit rationing)	0.3
ϵ	Tolerance in recursive processes (bonds and return on share determination)	0.005
$\bar{k}$	Desired share of bonds in banks' portfolio	0.4
c_y	Propensity to consume out of income	0.8
δ	Capital depreciation rate	0.03
λ_1	Wage bill's determination out of capital	0.15
ξ	Public purchases' determination out of capital	0.6
θ	Log-standard deviation (wage distribution)	0.5
c_{sub}	Subsistence consumption	0.25
c_n	'Socially determined' consumption	0.2
ν	Mark down on CDO return	0.1
θ	Threshold default absorbed by CDOb	0.05
ν	Quota of senior tranches (CDOA)	0.9
θ	Quota of non-senior tranches (CDOB)	0.1

Table 4: Parameter setting

References

Antonelli, C. and Gehringer, A. (2013), Innovation and income inequality, Department of Economics Working Paper Series 24/13, University of Turin.

Arcand, J. L., Berkes, E. and Panizza, U. (2015), 'Too much finance?', *Journal of Economic Growth* **20**(2), 105–148.

Arthur, B. W. (2014), *Complexity and the economy*, Oxford University Press.

Arthur, B. W., Durlauf, S. N. and Lane, D. A. (1997), Introduction, *in* B. W. Arthur, S. N. Durlauf and D. A. Lane, eds, 'The economy as a complex evolving system volume II', The Santa Fe Institute, pp. 3–14.

Awrey, D. (2012), 'Complexity, innovation, and the regulation of modern financial markets', *Harvard Business Law Review* **2**(2), 235–294.

Balland, P.-A. and Rigby, d. (2017), 'The geography of complex knowledge'.

Battiston, S., Farmer, D. J., Flache, A., Garlaschelli, D., Haldane, A. G., Heesterbeek, H., Hommes, C., Jaeger, C., May, R. and Scheffer, M. (2016), 'Complexity theory and financial regulation', *Science* **351**(6275), 818–819.

Bertay, A., Gong, D. and Wagner, W. (2017), 'Securitization and economic activity: The credit composition chanel'.

Botta, A., Caverzasi, E., Russo, A., Gallegati, M. and Stiglitz, J. E. (2019), 'Inequality and finance in a rent economy', *Journal of Economic Behavior and Organization* **forthcoming**.

Botta, A., Caverzasi, E. and Tori, D. (2020), 'The macroeconomics of shadow banking', *Macroeconomic Dynamics* **24**(SI 1), 161–190.

Boyer, R. (2010), 'Is a finance-led growth regime a viable alternative to fordism? a preliminary analysis', *Economy and Society* **24**(1), 111–145.

Brunnermeier, M. (2009), 'Deciphering the liquidity and credit crunch 2007-2008'.

C., B. (2010), 'Joseph schumpeter lecture: The great moderation, the great panic, and the great contraction'.

Caverzasi, E., Botta, A. and Capelli, C. (2019), 'Shadow banking and the financial side of financialization', *Cambridge Journal of Economics* **43**(4), 1029–1051.

Caverzasi, E. and Godin, A. (2014), 'Stock-Flow Consistent Modeling trough the Ages', *Cambridge Journal of Economics* **1**(34).

Caverzasi, E. and Russo, A. (2018), 'Toward a new microfounded macroeconomics in the wake of the crisis', *Industrial and Corporate Change* **27**(6), 999–1014.

Cecchetti, S. G. and Kharroubi, E. (2012), 'Reassessing the impact of finance on growth', *BIS Working Paper* (381).

Celerier, C. and Vallee, B. (2017), 'Catering to investors through security design: Headline rate and complexity', *Quarterly Journal of Economics* **132**(3), 1469–1508.

Coval, J., Jurek, J. and Stafford, E. (2009), 'The economics of structured finance', *Journal of Economic Perspectives* **23**(1), 3–25.

Demirguc-Kunt, A. and Levine, R. (1999), Bank-based and market-based financial systems. cross-country comparisons, Policy Research Working paper 2143, The World Bank.

Douglas, J., Goodman, L., Fabozzi, F., Manning, R., Pritchard, M. and L., L. (2007), 'Developments in collateralized debt obligations: New products and insights'.

Felipe, J., Kumar, U., Abdon, A. and Bacate, M. (2012), 'Product complexity and economic development', *Structural Change and Economic Dynamics* **23**(1), 36–68.

Fleming, L. and Sorenson, O. (2001), 'Technology as a complex adaptive system: evidence from patent data'.

Furfine, C. (2012), Kellogg school of management northwestern university paper.

Ghent, A. C., Torous, W. N. and Valkanov, R. I. (2017), 'Complexity in structured finance', *Review of Economic Studies* .

Godley, W. and Lavoie, M. (2007), *Monetary Economics An Integrated Approach to Credit, Money, Income, Production and Wealth*, Palgrave MacMillan, New York.

Gorton, G. B. (2010), *Slapped by the Invisible Hand: The Panic of 2007*, number 9780199734153 *in* 'OUP Catalogue', Oxford University Press.

Greenwood, R. and Scharfstein, D. (2013), 'The growth of finance', *Journal of Economic Perspectives* **27 (2)**, 3–28.

Hartmann, D., Guevara, M. R., Jara-Figueroa, C., Aristaran, M. and Hidalgo, C. A. (2017), 'Linking economic complexity, institutions, and income inequality', *World Development* **93**(May), 75–93.

Hausmann, R., Hwang, J. and Rodrik, D. (2007), 'What you export matters', *Journal of Economic Growth* **12**(1), 1–25.

Hidalgo, C. A. and Hausmann, R. (2009), 'The building blocks of economic complexity', *Proceedings of the National Academy of Sciences of the United States of America* **106**(26), 10570–10575.

Hoffmann, M. and Nitschka, T. (2012), 'Securitization of mortgage debt, domestic lending, and the international risk sharing', *The Canadian Journal of Economics* **45**(2), 493–508.

Kregel, J. (2009), Financial experimentation, technological paradigm revolutions and financial crises, *in* W. Drechsler, R. Kattel and E. S. Reinert, eds, 'Techno-economic paradigms: Essays in honour of Carlota Perez', Anthem Press, pp. 203–220.

Law, S. and Singh, N. (2014), 'Does too much finance harm economic growth?', *Journal of Banking and Finance* **41**, 36–44.

Levine, R. (1997), 'Financial development and economic growth: Views and agenda', *Journal of Economic Literature* **35**(2), 688–726.

Levine, R. (2005), Finance and growth: Theory and evidence, *in* P. Aghion and S. Durlauf, eds, 'Handbook of Economic Growth', North-Hollad, pp. 866–934.

Marin, G. and Vona, F. (2017), Finance and the misallocation of scientific, engineering and mathematical talent, Sciences PO OFCE working paper 27.

Minsky, H. (1988), Schumpeter: Finance and evolution, Hyman P. Minsky Archive Paper 314, Levy Economics Institute of Bard College.

NCCEFC (2011), The financial crisis enquiry report, Technical report, US Government.

Philippon, T. and Reshef, A. (2012), 'Wages and human capital in the u.s. financial industry: 1909-2006', *Quarterly Journal of Economics* **127**(4), 1551–1609.

Russo, A., Riccetti, L. and Gallegati, M. (2016), 'Increasing inequality, consumer credit and financial fragility in an agent based macroeconomic model', *Journal of Evolutionary Economics* **26**(1), 25–47.

Schumpeter, J. A. (1934), *Theory of economic development*, Harvard University Press.