Unveiling the Black Swan of the Finance-Growth Nexus: Assumptions and Preliminary Evidence of Virtuous and Unvirtuous Cycles

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Abstract: Empirical evidence behind the nature of the finance-growth nexus and mediating drivers behind this association is well documented in the literature. However, a framework that depicts the association between credit creation, financial innovation and endogenous creation of boom-bust cycles is less evident and the gap between empirical research and theoretical development remains. Hence, this study represents a first attempt to provide a framework that could explain the switch of economic cycles from virtuous to unvirtuous and vice versa. We examine the role of financial innovation and identify its "hidden soul" defined as the *rate of financial innovation* (RoFIN). We study RoFIN together with other structural factors, such as monopolistic financial power concentration and financial deregulation in the creation of what we identify as the *wealth trap*, as a potential mediating factor behind the creation of virtuous and unvirtuous cycles. A cross-country statistical exercise using the VUC indicator on the US, UK, and Euro area economies shows the exponential effect of the rate of financial innovation over time and provides indicative evidence in support of our framework. Finally, we report that the indicator is better able to identify the unvirtuous cycle stages than the traditionally used Credit-to-GDP ratio.

JEL codes: (E44, E32, E50, E51, G01, O33)

Keywords: Financial System, Growth, Business Cycle, Financial Innovation, Regulatory Dialectic, Financial Power.

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1. INTRODUCTION

A decade after the Global Financial Crisis (GFC) the debate on the finance-growth nexus and the role played by financial innovation in the process of endogenous money/credit creation still remains open and largely unresolved. Early studies attempted to find empirical evidence on the relationship between finance and growth (McKinnon, 1973; Greenwood and Jovanovic, 1990; Jappelli and Pagano, 1994; Levine, 1997; 2003 amongst a few). Other studies use more theory-based models formulated on mainstream assumptions to depict the growth-finance relationship (Robinson, 1952; Lucas, 1988) and finance-growth association (Greenwood and Jovanovic, 1990; Levine, 2003, 2005; Beck, 2012; Bezemer, 2012; Zingales, 2015).

More recent studies document the existence of a non-linear relationship between financial development and economic growth (Cecchetti and Kharroubi, 2012; Law and Singh, 2014; Arcand et al., 2015; Karagiannis and Kvedaras, 2016) to report that different sources of finance have differential effects on economic growth (Mishra and Narayan, 2015; Langfield and Pagano, 2016; Benczúr et al., 2019). These studies, based mainly on advanced economies, provide empirical evidence on the existence of a threshold as the turning point at which a faster financial sector growth can negatively affect economic growth (Checcetti and Kharroubi, 2012; Agnello et al., 2015; Arcand et al., 2015; Benczúr et al., 2019). However, most of these empirical-based studies use large-scale cross-country regressions on aggregate data, focused on country differences (Panizza, 2014; Benczúr et al., 2019). When comparing studies, this approach has led to heterogeneity in the evidence provided that often remains ambiguous or contradictory because empirical research has lagged behind theoretical development (O'Sullivanm, 2004; Arestis et al., 2015; Beck et al., 2016).

Further, recent studies document the important role of technological innovations on the finance-growth relationship (Dell'Ariccia et al., 2012; Mallick and Sousa, 2013; Amore et al., 2013; Beck et al., 2016). The aforementioned studies, together with the most recent research conducted in this area (e.g. Hardy and Sever, 2021; Ahn et al., 2020; among others), report conclusive evidence of a strong association between financial distress conditions, lax lending standards, technological innovation and output fluctuations. In addition, the wide financialization literature (Epstein, 2005; Krippner, 2011; Palley, 2013) and other studies have specifically focused on the broader concept of financial innovation (Rousseau, 1998; Levine, 1997, 2005; Klein and Olivei, 2008; Lerner and Tufano, 2011). However, the said studies mostly identify financial innovation within the securitisation process, when in fact the concept of financial innovation is much more extensive. There are few theoretical and empirical studies specifically focused on the broader concept of financial innovation and its impact on economic growth (Levine, 1997; Rousseau, 1998; Levine, 2005; Klein and Olivei, 2008; Lerner and Tufano, 2011). However, these studies define and model financial innovation in a way that overlaps with the concept of innovation used in the manufacturing sector. Their focus of

attention is restricted to a more generic concept of financial innovation, analysing its impact on financial depth and hence, economic growth. Therefore, the role of financial innovation remains unclear and not well modelled.

The literature on a theoretical framework of the finance-growth nexus is rather sparse. Werner (1997) is amongst a few who attempt to provide a theory-led explanation based on the "quantity theory" of credit-money circulation. He makes a clear distinction between credit creation used for 'real' and credit used for 'financial' transactions. This to highlight that excess in bank abilities to extend loans using real or financial assets as collateral for financial transactions will lead to boom and bust phenomena (see also Werner, 2005, 2014a). However, he does not consider financial innovation, which plays the role of encouraging and amplifying the endogenous credit creation mechanism for financial speculative purposes. Instead, the focus of the theory-led framework is limited to commercial banks, without considering the chain of financial operators, of which the commercial banks are only the tail end.

Motivated by the *prior* literature and the lack of a theoretical basis able to explain the interrelationship between financial transaction, financial development and financial innovation, the objective of this paper is to provide a framework that links credit creation for financial transactions, financial innovation and the endogenous creation of boom-bust cycles. The need to develop a theoretical background, currently lacking in the literature, has been stressed by many scholars (e.g. see Kirman, 2010; Ryan-Collins et al., 2011; Bezemer, 2012; Romer, 2016). Given this context, we consider three important issues in our study: first, how does the interaction between the economic and financial systems affect economic growth in developed countries? The literature on the growth-finance and finance-growth relationship potentially points to a switching mechanism within the business cycle from one relationship to the other, for which a broader explanation is required. Second, assuming the existence of a switching dynamic, we pose the question of whether a theoretical framework could provide a useful insight on the dynamics between financial development and economic growth. Thirdly, and most importantly, concerns the role of financial innovation in amplifying the endogenous money/credit creation mechanism in developed countries. In other words, is financial innovation beneficial for the real economy? The analysis takes inspiration from Schumpeter and Minsky's perspective regarding the central role of the financial system in the economy (see Schumpeter, 1934, 1939; Minsky, 1982, 1986) and contributes to the ongoing discussion on 'financial development' and 'financial innovation'. In particular, for what concerns the financial system's (mis)allocation of financial resources (Wolfson and Epstein, 2013; Bertay et al., 2017) to the economy, the concepts of 'disruptive innovation' (Christensen and Raynor, 2013; Christensen et al., 2015; Gomber et al., 2018) and 'diffusion and adoption of innovation' (Sinkey, 1992; Rogers, 2003; Mullineux, 2010) applied to the financial sector.

This paper contributes to the literature in a number of ways: first, given the lack of conclusive evidence on the role of financial innovation in facilitating the switch from a growth-led to a finance-led economy, we identify the "dark" side (or hidden soul) of financial innovation conceived as an endogenous phenomenon to the endogenous money/credit creation in the economy, thus increasing fragility (Dell'Ariccia et al., 2012; Gennaioli et al., 2012; Wang and Xia, 2014). We decouple the concept of financial innovation from the concept of rate of financial innovation (RoFIN). In our analysis 'financial innovation is defined as the interaction between securitisation and rate of financial innovation. Hence, RoFIN represents the level of development of financial tools, processes and services, given the financial operators' business decision for operational business usage of those financial tools, processes and services (Lauretta, 2018). In this context, we introduce the novel concept of *wealth trap,* which is a consequence (an externality) that can be identified as a result of RoFIN (Lauretta, 2018). The wealth trap combined with other structural factors, such as monopolistic financial power concentration, financial deregulation and financial innovation (Stiglitz, 2010; Turner, 2010) can lead to the persistence of instability (Beck et al., 2016).

Second, we attempt to address the gap between empirical research and theoretical development (Kirman, 2010; Ryan-Collins et al., 2011; Bezemer, 2012; Romer, 2016). Whilst empirical evidence on financial innovation is generally supportive in terms of its positive effect on growth (Lerner and Tufano, 2011), there still is a lack of clarity about its role as an accelerator of the money/credit creation mechanism that causes the economy to flip from a growth-led to a finance-led business cycle (Beck, 2016). Therefore, this paper aims to provide a systematic and formal framework on the real and financial implications of financial innovation within the finance-growth nexus. As highlighted in the *prior* literature, empirical studies cannot alone solve the puzzle as evidenced by the lack of consensus in past studies, plus a lack of data available (O'Sullivanm, 2004; Arestis et al., 2015; Beck et al., 2016).

Finally, previous studies have up to now, limited their focus either on the growth-finance or finance-growth relationship in isolation. To the knowledge of the authors, the *prior* literature has yet to address the switch from growth-led to finance-led and vice versa within the business cycle. Thus, motivated by the important contribution of Perez (2002), this study provides for the first time a theoretical framework that depicts the existence of two temporally opposite stages of the business cycle; namely, the virtuous and unvirtuous cycles (VUC) and embodies the role played by financial innovation in governing its dynamics. In support of our theoretical framework, we use the VUC indicator proposed by Mazocchetti et al. (2020) to test whether the prevailing states of the finance-growth nexus changes as a result of changes in the financial leverage caused by variations in RoFIN.

Our statistical exercise by using the VUC indicator shows evidence in support of the theoretical framework developed in the paper. According to our findings, not only the level of

financial development (financial tools, services and products) but also the innovative activities promoted by the financial actors (business decisions on how to use the financial tools, services and products) serves to boost economic growth (in line with Beck et al., 2016 empirical findings). However, we establish that this is made possible at the expense of exposing the economic system to greater risk of instability by switching from a virtuous to an unvirtuous anticyclical business cycle, thus, increasing the likelihood that the real economy will fall into the wealth trap.

The remainder of the paper is as follows: in the next section, we explain the VUC theoretical dynamics and followed by the main assumptions that cause the economy to switch from a virtuous to an anticompetitive unvirtuous cycle in section three. In section four, we perform a numerical example to explain the dynamics associated with a financial crisis within an unvirtuous cycle. In section five, we implement a cross-country statistical analysis of the US, UK and Euro area economies by applying the VUC indicator. Finally, we summarise and conclude the paper.

2. THEORETICAL FRAMEWORK

2.1. Virtuous and Unvirtuous Cycles (VUC)

The VUC postulates a by-directional association between finance and growth as depicted by Figure 1.

[Please insert Figure 1 here]

Intuitively, we define a *Virtuous Cycle* as the presence of a developed financial sector that channels high levels of savings into the real economy, spur investment into innovation and foster a high level of economic growth. In this cycle, political forces favour financial development (Rajan and Zingales, 2003) and growth leads financial system development and efficiency, known as the growth-finance relationship postulated by early studies (Greenwood and Jovanovic, 1990; Pagano, 1993; Greenwood and Smith, 1997; among others). Consistent with Minsky's (1986) perspective, the virtuous cycle envisages scenarios that range from a period of *prudential attitude*, with low levels of debt in the economy, to a period of prosperity, when the debt exposure of all the agents operating in the economic system grows rapidly.

By contrast, the *Unvirtuous Cycle* postulates the finance-growth nexus depicted by a parallel but more recently developed strand of the literature (e.g. Rajan and Zingales, 1998; Nesvetailova, 2010; Beck, 2012; Grydaki and Bezemer, 2013; Lauretta, 2018; among others). In essence, under the unvirtuous cycle, thanks to financial innovation, part of the wealth generated by the real economy is diverted (Boz and Mendoza, 2014; Hausman and Johnston,

2014)[1] from its allocation of financial resources to the productive sector towards speculative activities of financial agents (e.g. commercial banks, investment banks, mutual funds, brokers etc). As such, this cycle supports the reinforcement of monopolistic financial positions (i.e. financial power concentration), which previously triggered by the virtuous cycle as a consequence of the transition period from prudence to a period of prosperity (similarly to the "Minsky Cycle" - Minsky, 1986). As a result, the increased influence of financial market and political power is concentrated in the hands of the financial sector (Angelini and Cetorelli, 2003; Mandelman, 2010). This increases the likelihood of aggressive "boom-bust cycles" becoming a regular occurrence over time, with wider gaps with respect to potential GDP (Schularick and Taylor, 2012; Koo, 2014). The intuition is as follows: increased volatility within the business cycle induces fragility in the real economy, thus raising the likelihood of magnifying the impact of a shock into a severe economic crisis. As a consequence, business and investment into innovation slow down, the level of growth declines and a recession is the result (as it was observed after the 2007-2009 financial crisis; see also Jawadi and Arouri, 2011).

By contextualizing the discussion, historically, a virtuous cycle can be identified with the Post-War period, consisting of an era of rapid progress known as the golden age (Crafts, 1995). Until the 1970s and 1980s, developed economies had modest inflation rates, low unemployment levels, and rapid economic growth. However, the technological revolution over the same period promoted the creation of an "IT network economy" that facilitated an increasingly sophisticated and complex financial system (Crotty, 2009; Bezemer, 2012; Beck et al., 2016; Aikman et al., 2017). Intuitively, an increasingly complex financial integration and increased level of indebtedness within the real economy intensified the risk of associated emerging externalities. As such, this facilitated the creation of a switching mechanism from a virtuous to an unvirtuous cycle (Minsky, 1986; Lauretta, 2018).

For the purpose of this paper, we identify three key elements which are behind VUC dynamics: 1) the *financial market and political power concentration*; 2) the *wealth trap*; and 3) the central role of financial innovation in terms of the *rate of financial innovation*. Usually, in the context of business cycle dynamics, well-established variables such as employment, inflation, productivity, and interest rates are the focus (Stock and Watson, 1999). Variation in these variables determines the fluctuation in the business cycle from a period of economic and financial prosperity to a period of contraction and/or recession (Mazzocchetti et al., 2018).
However, the *prior* literature does not explain the switching mechanism of the business cycle from a virtuous to and unvirtuous anticyclical business cycle, which, as we postulate, starts to undermine wealth creation. The next subsections discuss each of the aforementioned elements.

[1] 'Financial market abuse' is identifiable as the starting point of the unvirtuous cycle (see Figure 1).

2.1.1 Financial Market/Political Power Concentration

The degree of market/political power concentration in the financial system (an externality of the evolution of the financial system) is hypothesized to be an important dynamic behind the switching mechanism between virtuous and unvirtuous cycles. Due to the recent growth of financialization, the financial oligarchy is seen as an increasingly strong influence in the political system (Johnson and Kwak, 2010; Calomiris and Haber, 2014), thus activating a regulatory capture and promoting liberalization or deregulation (Adolph, 2013; Kwak, 2013). A "regulatory dialectic" underpins the passage from one cycle to another (Kane, 1977). The acceleration of technological and market changes within the financial system has transformed the speed of the regulatory adaptation of the decision-makers and financial operators (Kane, 1983). It has also increased their regulatory adaptation gap that enables financial operators to respond more rapidly to regulatory changes, find new ways to circumvent regulatory constraints, while decision-makers respond more slowly to emerging problems (Kane, 1977, 1983).

How long a financial crisis lasts depends on the authorities' ability to react to specific crisis manifestations (Jemović and Marinković, 2021). This highlights the importance for decision-makers to keep pace with increasing environmental and structural changes. More specifically, in an unvirtuous cycle, the regulatory adaptation gap[2] widens and provides the conditions for an increasing concentration of financial power to financial institutions. While decision-makers try to adapt by making regulatory adjustments to keep pace with technological and market changes within the financial system, the financial-institution pressures upon the political powers increase. Therefore, if increased market/political power of the financial markets is not correctly managed, the relationship will evolve in the opposite direction to the *virtuous cycle*, thus activating a wealth-destroying cycle (see, *inter alia*, Delis et al., 2016).[3]

2.1.2. How the Wealth Trap is generated

The engineering ability to create new financial services and products, combined with deregulation and the operation of large financial institutions in the market, has fostered the development of the financial industry's oligarchic and monopolistic power over the economy and politics (Stiglitz, 2010; Turner, 2010). At a certain point, the excessive accumulation of debt in the economy causes a system breakdown that triggers a "domino effect". Temporal financial shocks and financial crisis could turn a "virtual" crisis into a major event (Beck et al.,

[2] See Chaudhry et al. (2015) for a discussion on the need for regulation and its comparison with revenue-based regulation, i.e. taxation.

[3] Delis, Kokas and Ongena's (2016) empirical analysis shows that financial institutions with more market power can facilitate access to credit by poorly performing firms.

2014) as experienced during the GFC. One implication of globalisation and the integration of financial systems is that a crisis originating from a country or region could have a contagious effect on the global economic system (Fecht et al., 2009; Caballero and Krishnamurthy, 2009; Popov and Udell, 2012). According to Minsky (1982) and the credit rationing Minsky models (Ryoo, 2013b; Nikolaidi, 2014; Nikolaidi and Stockhammer, 2017), the main consequences of a financial crisis status is threefold: 1) reduced access to funding for the real economy by the financial system, in particular, the banking system; 2) a credit crunch (also known as a credit squeeze or credit crisis) characterised by falling confidence amongst financial institutions and; 3) firms unable to invest to maintain and improve productivity or to finance innovation projects. As a result, in the endogenous target debt ratio Minsky models (Nikolaidi and Stockhammer, 2017; Dafermos, 2018), alteration to the economic cycle can occur because the endogenous change in the dynamics of debt and expenditure of the private sector is based on a change in the economic and financial agent's perception of risk.

Basically, the *unvirtuous cycle* generates what we have labelled as the *wealth trap*. The latter is the consequence of financial agents' exploitation of their gained "political/market power" over time within the virtuous cycle, which can shape the growth path. We postulate that if the financial system pursues its speculative interests, it captures the wealth created in the cycle and misallocates capital. Therefore, the *wealth trap* is the result of increasing levels of non-productive transactions. On the one hand, modern financial architecture has been able to create the illusion of fuelling productivity and innovation projects (i.e., increasing the level of GDP of developed countries). On the other hand, it allocates financial resources to specific trading activities related to the productive sectors, generating asset price inflation and bubbles that can turn into a crisis (Nesvetailova, 2010). The *wealth trap* differs from the short term Keynesian "liquidity trap", despite being a possible consequence of the *wealth trap*. The *wealth trap* generated by the unvirtuous cycle increases default risk over time. Hence, liquidity and ensuing solvency crises within the financial system could arise (Brunnermeier, 2009; Ivashina and Scharfstein, 2010; Straetmans and Chaudhry, 2015). Moreover, there is the risk of falling into a "liquidity trap", in which any monetary stimulus has no effect on interest rates or output. Thus, the real economy would suffer from wealth created in the liquidity trap, resulting in a slide towards negative growth.

2.1.3. The Core Role of Financial Innovation

Financial innovation plays a central role within the financial system (Bezemer, 2012; Mazzocchetti et al., 2018). Moreover, an advanced financial system facilitates financial product differentiation (through financial engineering), producing deep market segmentation (Tufano, 1989, 2003; Lerner and Tufano, 2011) and a multitude of new products (derivatives, alternative risk transfer products, exchange traded funds, and variants of tax-deductible equity). This

creates the perfect environment for the emergence of an unvirtuous cycle resulting from the financial system's discriminating monopoly and market/political power concentration (Stiglitz, 2010; Turner, 2010). The latter two promoted by a virtuous cycle arising from a period of financial prudence to a period of prosperity (Minsky, 1986). Therefore, the financial system uses its monopolistic position and its market/political power to increase self-gain and maximize economic rent. Hence, it captures consumer surplus.

Financial innovation, as any other type of innovations, enables inventions (such as securitisation) to be implemented in practice (Rogers, 2003), thus facilitating business decision making on the use of a new invention that can reduce marginal costs to business. Equally, the outcomes of these decisions depend on whether or not it is socially oriented (Zingales, 2015). Hence, good financial innovations improve risk management and reduce transaction costs. By contrast, bad financial innovation that facilitates market segmentation and rent-seeking speculation, acts as a financial accelerator that in turn increases the likelihood of default - thus ensuring that a financial crisis turns into an economic crisis (Zingales, 2015; Beck et al., 2016). In addition, when private interest "captures" the public interest, it is highly likely that speculative finance will build up, as predicted by Minsky (1982).

In sum, we characterize the economic model derived from the description of the VUC and its key elements by political economy dynamics with non-linearity, by which the system can flip from one cyclical equilibrium to another. In other words, the Minsky Cycle postulated in this study is one punctuated by major crises, with progressively fewer virtuous short-term cycles superimposed. Moreover, the presence of multi-leverage within the financial sector amplifies the development and impact of unvirtuous cycles. However, we postulate that regulations in favour of the financial system without the technologically advanced financial transformation would not have instigated any change in bank behaviour in terms of creditworthiness conditions (or it would have been very partial and not relevant).

To bring a step further the discussion, main assumptions are set up and explained in the next section with the aim to shed light on the aforementioned VUC switching mechanism.

3. CORE VUC ASSUMPTIONS[4]

3.1. Assumption 1: Total Output and Industrial Innovation

One cannot explain the switch from virtuous to unvirtuous cycle without accounting for the role of financial power in determining the dynamics of the business cycle. Therefore, as per convention in the economic literature, we begin the discussion of our set of assumptions by describing a total output function that accounts for financial power. According to Werner (2005; see also Ryan-Collins et al., 2011) it is relevant to distinguish between productive credit

[4] See in appendix 1, Table 3 for a summary of all the variables/parameters used in this section.

(i.e. investment credit) that translates into real economic growth and unproductive credit (i.e. consumption credit and financial credit) that can cause asset price bubbles and increase the likelihood of a banking crisis. However, although Werner's analysis departs from the conventional theory of money, he does not account for the endogenous role of financial innovation and what drives financial operator's business decision making in preferring more speculative credit over the productive one. Therefore, motivated by Werner (2005), we posit the variation of total output *Y* as a function of financial power *FP*, capital input *K*, labour input *L*, and industrial innovation *I*. Beginning with this first assumption, we try to set the logical path to widen what in Werner remains marginalised and only a glimpse of intuition when it comes to the role played by financial innovation. For the sake of clarity, we introduce a simple function that helps to understand how financial innovation embedded into the financial power variable can serve as a core variable, which directly impacts the business cycle:

$$Y = f(FP, K, L, I) \tag{1}$$

With equation (1), we assume that the term I includes only industrial Research and Development (R&D) into new processes, products and services (Dosi et al., 2013).[5] This ensures that I is closer to reality and more specific than the "technological innovation" or "technological change" envisaged in the Solow-Swan model (Solow, 1956; Swan, 1956), which focuses on technological progress embodied in new machines whilst ignoring the process of learning and investments in research. According to Uri (1983), one should not confuse the 'embodiment effect' with the 'augmentation effect' and the quality improvement of inputs that are not necessarily constant over time.[6] Therefore, our production factor I isolates the 'augmentation effect' and assumes a given common technology across the industrial sector. Moreover, it is a variable with a non-fixed linear trend and is endogenous to the production function (Doraszelski and Jaumandreu, 2013). Consequently, we regard industrial innovation as an intermediate input variable to the final output (Grossman and Helpman, 1994).

Most importantly, the production function described above embeds the role of financial intermediation. In particular, it incorporates the role of financial innovation and the ensuing increase in intermediaries' financial power (*FP*) on total output. It is founded within the *Credit Creation Theory of Banking* which argues that each individual bank has the 'power' to create money *ex nihilo* (Schumpeter, 1934; Werner, 2014c, 2016). This contrasts with the Solow-Swan neoclassical growth model (Solow, 1956; Swan, 1956), which does not consider the role

[5] Accounting for time, $I_t = \alpha_F(R\&D_{t-n})$, where α_F represents the level of investment channel by the industry to the R&D sector at time t-n.

[6] "Embodiment simply means that because of technological advance, new inputs are more efficient than old ones." However, "the augmentation effect means that the productivity increase of an input due to technical advances is expressed as equivalent to a specific increase in its quantity." (Uri, 1983, p. 400).

of financial intermediation. Additionally, it also differs from other models, such as Aghion and Howitt (1998) in accounting for the importance of financial intermediation whilst assuming that the role of financial markets is neutral, with a simple intermediation function and effects on growth rates. In other words, we depart from the dominant financial intermediation theory that considers banks as merely intermediaries collecting deposits and lending with no significant macroeconomic impact (Werner, 2014c, 2016). Finally, for the sake of simplicity and with the aim of isolating the *financial power effect* on total output, *FP* is also assumed as an exogenous variable.

3.2. Assumption 2: Financial Power (FP)

The importance of the financial system on the real economy cannot be understated. It is now well established among scholars the idea that the financial system holds financial power (*FP*) – i.e. monopolistic financial positions and regulatory capture capability, which can affect the total output (Stiglitz, 2010; Turner, 2010; Johnson and Kwak, 2010; Calomiris and Haber, 2014; Zingales, 2015). From the literature, we identify three main variables which form our baseline definition behind the *FP* function: leverage ratio (*LR)* (Papanikolaou and Wolff, 2014; Vazquez and Federico, 2015; Lauretta, 2018; Mazocchetti et al., 2020), financial innovation (*FI)* (Palley, 2013; Lerner and Tufano, 2011; Zingales, 2015; Beck et al., 2016) and the individual financial institution's size (*SZ)* (Mishkin, 1999; Crotty, 2009; Cornett et al., 2011; Vazquez and Federico, 2015). The choice of variables can be rationalized as follows: *LR* represents the amount of capital divided by total assets (i.e. risk-weighted assets). Therefore, the increase in capital relative to assets provide financial institutions with the appearance of financial soundness, helps growth in size and promotes market/political power concentration over time (Laeven and Levine, 2009; Karim et al., 2013, Mazzocchetti et al., 2020). As a result, banks improve their ability to manipulate total credit exposure/total deposits ratio in a way that can progressively enhance profit generation. To do so, financial institutions use *FI*, which enables banks to operate off-balance sheets, thus amplifying the endogenous money creation mechanism and manipulate *LR* (Papanikolaou and Wolff, 2014; Lauretta, 2018). Indeed, *FI* embodies the concept of the *rate of financial innovation*, which measures the development of financial tools due to the Financial Products and Service Development (*FPSD*) process in the financial sector (e.g. Tufano, 1989, 2003; Cressy et al., 2007; Lerner and Tufano, 2011, Laeven et al., 2015 among others, about the role played by financial engineering in conferring competitive advantage). As such, it represents the degree of technological advancement of the financial system (Lauretta, 2018; Mazzocchetti et al., 2020). Finally, *SZ* denotes the size of financial institutions defined as market share to GDP (Levine and Zervos, 1998; Beck, 2014) as it reflects market perceptions of financial stability in the institution. The latter variable *SZ*, closely related to the *rate of financial innovation*, is important and representative of the level

of investment by banks into innovation. Investments in *FPSD* (represented by α), in turn is a function of the size of the financial institution (Schumpeter, 1934; Bhattacharyya and Nanda, 2000; Gennaioli, 2012).[7]

The main driver behind financial institutions' growth in size and investment into *FPSD* relates to a continuous need for diversification of financial products to maintain and grow market share, whilst discouraging new entries (unvirtuous cycle) (Tufano, 1989; Gennaioli et al., 2013; Cecchetti and Kharroubi, 2015). Yet, there exists an inverse relationship by which investments and size are initially driven by innovation (virtuous cycle) (Schumpeter, 1934; Bhattacharyya and Nanda, 2000; Gennaioli, 2012). It is well documented financial sector growth promotes financial stability through increasing profitability and economic expansion (King and Levine, 1993; Pagano, 1993; Levine, 1997; among others). In fact, industry growth supported by policies has sought to facilitate financial institutions' use of financial innovation tools to increase investment levels and size (Levine, 2004, 2005; Beck, 2014). However, recent events suggest that the presence of a large financial system is beneficial for the economy no longer holds after the 2007-2008 financial crisis.

Based on the above discussion, our second assumption is presented as follows:

$$FP = f(LR, FI, SZ) \tag{2}$$

We can initially conclude that, in regarding financial power in terms of *LR, FI* and *SZ*, one could define *FP* as an externality caused by the rapid development of the financial sector, which in turn produces positive (in the virtuous cycle) or negative (in the unvirtuous cycle) effects on total output (Acharya et al., 2017; Lauretta, 2018); the outcome being dependent on how *FP* is managed within the financial system.[8] The intuition is as follows: on the one hand, if *FP* is oriented towards financing productivity, the effect on GDP is tangible and real (i.e., positive externality). Equally, should *FP* be mostly oriented towards self-seeking speculative and profit interests, the real economy will register a false positive signal (negative externality) (Minsky, 1986; Werner, 2005; Ryan-Collins et al., 2011). As a result, this will inflate the real value of GDP and distort economic agents' perception concerning economic trend expectations.

3.3. Assumption 3: Financial Innovation (FI) and the Rate of Financial Innovation (RoFIN)

[7] See equations 5 and 6.

8 Regulations, the political environment and corporate governance play core roles here in determining the orientation of financial power towards productive or speculative activities (Laeven and Levine, 2009; Beck, 2012; 2014).

We postulate that endogenous money creation is a function of the *rate of financial innovation* (*RoFIN*) within the financial system.[9] However, we need to separate the effect of financial innovation, which is always positive, from the *rate of financial innovation*, which could be positive or negative. In broad terms, financial innovation represents 'the tools', whilst the *rate of financial innovation* represents the 'use' of those tools.[10] The latter stands for the financial system's demand for more complex and sophisticated ways to circumvent current regulations (Kane, 1977, 1981) and to diversify risk while increasing profit levels at reduced costs (Levine, 1993; Pagano, 1993; Scanella, 2011; Gennaioli, 2012). Therefore, we can say that financial innovation *FI* simply mirrors Financial Products and Service Development (*FPSD*) process in finance. However, we assume the rate of financial innovation *RoFIN* to be the product of the parameter α that represents investment spending (a cost for the financial institution) channelled by each institution to their *FPSD* unit/team specialised in *FPSD* (Breuer and Perst, 2007). Furthermore, α depends on the size of the financial institution and it is used to create complex products and services (Schumpeter, 1934; Bhattacharyya and Nanda, 2000; Gennaioli, 2012). The scope is to increase extraction of economic rent and reinforce monopolistic financial positions - i.e., financial power concentration (Stiglitz, 2010; Turner, 2010). Hence our third assumption postulates:

$$FI = f(FPSD) \tag{5}$$

$$RoFIN = \Delta FI = \alpha(FPSD) \quad with \quad \alpha = f(SZ) \tag{6}$$

3.4. Assumption 4: The correlation between Financial System Default Risk (*FSDR*) *and FP*

As debated by relevant scholars, the high Financial System Default Risk (*FSDR*) state is created by the distortion of financial power (Kane, 1977; Minsky, 1982; Johnson and Kwak, 2010; Calomiris and Haber, 2014). Therefore, we can argue that a variation in *FP* changes the level of *FSDR* thereby changing what we can define as *systemic volatility* of the financial system. In particular, *FSDR*, through the accumulation of bad debts (*BD*) as a proportion of total assets *Tot Assets* (Reinhart and Rogoff, 2009; Papanikolaou and Wolff, 2014; Mazzocchetti, 2020), affects the growth path (Reinhart and Rogoff, 2009; Berkmen et al., 2012, Arcand et al., 2015) and increases the likelihood of an unvirtuous cycle (Lauretta, 2018). Hence, the existence of an inverted growth-finance relationship and our fourth assumption is:

$$\varepsilon = \frac{\Delta FSDR}{\Delta FP} = Systemic\ Volatility \tag{7}$$

[9] As previously defined, this represents the level of development of financial tools available at a certain time, driven by the *FPSD* in the financial sector and the level of investment spending to finance financial engineering development (as a parameter).

[10] Here, it is important to distinguish the concepts of "invention" from "innovation". Invention is the ability to create new processes or machinery/tools in order to improve efficiency and profitability and reduce costs. Innovation is the decision process about how to put an invention into practice (Kane, 1981). In our case, invention is represented by the securitisation process. Nevertheless, innovations are implemented by the *FPSD* unit/team, which acts as a complex, interactive and highly technologically advanced business decision maker within the financial industry (Vermeulen, 2002; 2004).

of which:

$$FSDR = f\left(\frac{BD}{Tot\ Assets}\right) \quad (8)$$

3.5. Assumption 5: The Unvirtuous Cycle Crisis Generator (CG)

The existence of boom and bust in the business cycle could be attributable to high levels of unproductive credit in the real economy. In particular, if the debt-to-GPD ratio grows faster (usually exponentially) than GDP, this creates the conditions for instability and crisis (Werner, 2005; Ryan-Collins et al., 2011; Vague, 2014; Keen, 2017). Financial innovation used for speculative/unproductive purposes and driven by the financial system's market/political power concentration (Stiglitz, 2010; Turner, 2010), affords market actors the prospect of expanding the money creation mechanism – i.e., through securitisation (Papanikolaou and Wolff, 2014; Lauretta, 2018). Intuitively, the expansion of the money/credit creation can cause financial instability and default risk endogenously (Nesvetailova, 2010; Beck, 2012; Grydaki and Bezemer, 2013). As a result, we assume an *unvirtuous cycle crisis generator (CG)*, endogenous to a finance-led economic system which is activated as an exponential function of the systemic volatility (ε) originated within the finance-growth nexus. Hence our last assumption postulates:

$$CG = e^{\varepsilon} \quad (9)$$

4. A NUMERICAL EXAMPLE ON THE DYNAMICS OF CG

To deepen theoretically the understanding of the interconnections between credit creation, financial innovation and endogenous creation of boom-bust cycles, for the sake of simplicity, we account for the structure of a hypothetical commercial bank's balance sheets (Koo, 2014) and provide a numerical example on how the dynamics of *CG* work.

Financial innovation has enabled financial agents to free up their balance sheet from risk-weighted assets (RWA) and transfer a fraction of RWA off-balance. Thus, these off-balance assets are securitised and packaged into new, complex and negotiable financial products (Allen and Carletti, 2006; Ryan-Collins et al., 2011; Bord and Santos, 2012; Lauretta, 2018). Knowing that credit expansion using assets as collateral for financial transactions can lead to the boom-bust phenomena (Minsky, 1982, 1986; Werner, 2005, 2014a), this mechanism can be amplified by financial innovation through the securitisation process (Ryan-Collins et al., 2011; Dell'Ariccia et al., 2012; Gennaioli et al., 2012; Wang and Xia; 2014). Moreover, the amplification power of financial innovation can be intensified by the decision of financial operators (*RoFIN*) (Zingales, 2015; Beck et al., 2016).

Therefore, variations in the endogenous creation of bank money *BMC*, represented as an exponential function, is given by a consequential change in the securitisation ratio *SR* calculated by *Tot Loans* relative to *Tot Deposits*.

$$BMC = \Delta e^{\delta \frac{Tot\ Loans}{Tot\ Deposits}} \tag{10}$$

in with δ is defined as:

$$\delta = \frac{Loans\ off-balance}{Tot\ Loans} = SR \tag{11}$$

For the sake of clarity, it is noteworthy to highlight that the securitisation ratio is, in turn, a function of the previously mentioned *rate of financial innovation*.

$$SR = f(RoFIN) \tag{12}$$

Equation (12) connects the creation of endogenous bank money and financial innovation represented by the securitisation ratio.

Suppose a bank balance sheet has a total of 320 loans as assets and 272 deposits as liabilities, in addition to different securitisation ratios (0.10, 0.15, 0.20, 0.25, 0.30, 0.35 and 0.40) over time. Intuitively, securitisation ratio that increases or decreases over time causes the curve to steepen or flatten, as illustrated in Figure 2. However, the driver of the securitisation ratio is the *rate of financial innovation* operating in the system at a certain time. Hence, the higher the demand for advanced financial tools for speculative purposes, the greater the *rate of financial innovation.* Therefore, financial agents rely more on the securitisation mechanism, thus inducing financial instability and increase financial system default risk (*FSDR*).

[Please insert Figure 2 here]

Eventually, the exponential function governs the interrelation between endogenous bank money creation, securitisation and the *rate of financial innovation*. In terms of the balance sheet approach, when the inclination of the curve is too high (i.e. bubbles), this implies that the gap between assets and liabilities become unsustainable. The exponential direction cannot continue to infinity, and naturally, the system creates its own upper limit (thus causing the bubble to burst and crisis propagation within the system). Therefore, both financial and economic systems need a period of adjustment and a crisis becomes the natural way to rebalance asset-liabilities in the entire system to a sustainable level. Indeed, adding an element of randomness to equation (10) could induce different boom-bust dynamics across differing rates of financial innovation, and ultimately securitisation ratios. According to Koo (2014), the "balance-sheet recession[11]" is attributable to the transmission mechanism of financial and economic system balance-sheet

[11] Koo (2014) coined the term *balance-sheet recession*. It occurs when high levels of indebtedness cause consumers and/or companies to save in order to repay their debts, rather than to spend or invest, slowing economic growth or even causing a recession.

adjustments. The systemic risks observed in the recent 2007-2008 credit crunch followed by the 2009 global economic recession illustrates this point.

5. THE VUC INDICATOR: A CROSS-COUNTRY COMPARISON

Do the assumptions underpinning the VUC dynamics hold? We can afford the luxury of addressing this question by undertaking a simple statistical exercise that determines and tests the VUC theoretical framework and related assumptions using a cross-country analysis involving the US, UK and Euro area. Specifically, we test the VUC indicator, which allows us to analyse with data how rigorous is the *CG* assumption and, consequentially, the theoretical validity of the other four main assumptions which flow into *CG.* To the knowledge of the authors, the VUC indicator sheds light for the first time on the complexities surrounding the finance-growth relationship – i.e., switching from virtuous to unvirtuous cycles and vice versa. A previous study used the indicator as an off-balance sheet systemic risk gauge to assess imbalances in the financial system and compare its performance with the mortgage-to-GDP ratio and Capital Adequacy Ratio (Mazzocchetti et al., 2020). The aforementioned study reported that higher securitisation propensities weakens financial stability of banks and reveals the importance of systemic risk indicators that integrate banks' off-balance sheet assets for predicting incoming financial crises.

The originality of the VUC indicator is such that it incorporates a securitisation mechanism, thus reflecting the financial system's endogenous money creation mechanism so that the endogenous role of financial innovation (*the rate of financial innovation*) is captured.

$$VUC\ indicator = \frac{\frac{\sum_{b=1}^{N} TC_T}{Eq^b}}{GDP} \tag{13}$$

The term TC_T is the percentage of total credits that each financial agent decides to bring off-balance sheet transferred to the securitisation process. Eq^b represents the total equity value of each financial agent and *GDP* is the Real Gross Domestic Product. Following the common practice in the literature, we use the GDP to scale the indicator (e.g. see Borio and Lowe, 2002, 2004; Drehmann and Juselius, 2014).

The VUC indicator of equation (13) can be seen as a transformation of the credit-to-GDP indicator, which only takes into account the leverage applied at commercial bank level. In fact, the credit-to-GDP indicator ignores the multi-leveraging effect, deemed as one of the main contributing factors of the recent financial crisis: the so-called OTD - Originate-To-Distribute model (Berndt and Gupta, 2009; Rosen, 2011; Bord and Santos, 2012; Tan et al., 2015; among others). Therefore, our indicator incorporates second-order leverage that depicts the presence of multi-leverage in the financial system. Intuitively, our indicator not only captures the direction of the business cycle path but also whether it is evolving towards an unvirtuous or virtuous cycle.

5.1. Data Description

As illustrated in Figure 2, the *rate of financial innovation* is a variable that causes the curve to steepen or flatten within the financial innovation and endogenous bank money creation nexus. By conducting the cross-country statistical exercise, we verify the existence of this mechanism when applied to real data. Specifically, we investigate whether the VUC indicator could predict the timing of a steeper curve (building an unvirtuous cycle) or a flatter curve (restoring a virtuous cycle) given the *multi-leverage mechanism* that triggers increased levels of unperceived risk associated with upcoming financial crises.

The numerator of our indicator represents the multi-leverage mechanism that embodies financial innovation – more specifically, trading and credit derivatives. However, as credit derivatives may be associated with a deteriorating state of the financial sector (Dieckmann and Plank, 2011), we separate the numerator into trading derivatives and credit derivatives - the former including: futures, options and interest rate swaps, credit derivatives involve credit options, credit swaps, and credit-linked notes.

The availability of data on credit transferred to the securitisation process represented a major issue and as such, impacted on the proxy most able to mimic reality.[12] Hence, annual data is only available from 1992 for the US and 1999 for the UK / Euro area. Additionally, the time series available for each country on the development of financial derivatives is not very long and exhaustive, thus preventing an analysis dated back to the 1970s or earlier.[13] Table 1 summarises the data used and its sources:

[Please insert Table 1 here]

5.2. The Cross-Country Statistical Exercise

The exercise is conducted on three levels: firstly, using current values; secondly, the fixed-based index (fi) methodology that involves fixing the denominator at a certain year and; finally, utilising the chain-based index (ci) approach by moving the denominator year by year. Using

[12] Only recently has the European Central Bank started to gather these kinds of data for the Euro area from the SPV/SPE – Special Purpose Vehicle/Entity (and strangely not from each bank). Annual data is available from 2012 and quarterly from 2014. The data is available on the ECB website – see the statistics section.

[13] Historically, the evolution of derivatives and modern financial innovation started in the 1970s. It is possible to distinguish three periods: first, the period 1972-1982 was characterized by the development and diffusion of futures not based on commodities but on mortgages, currency, interest rates, treasury bills, T-bonds, Eurodollars and the stock index; second, in 1983-1993 was characterized by the development and diffusion of options based on the Black-Scholes model, swaps and over-the-counter derivatives and; third, the year 1993 to date has been characterized by the development and diffusion of credit derivatives (funded and unfunded). Moreover, during the 1970s the Negotiable Order of Withdrawal (NOW) or super account was introduced, and in 1978 checkable deposits, accounts with automatic transfer from interest-paying saving accounts (ATS) thanks to the introduction of the electronic payment system. The proxy used in this paper is related to the third period. The time series in the first and second periods is fragmented and not available for all countries, so it is not possible to make a meaningful cross-country comparison. An issue of consideration for future research relates to addressing this gap in the data to investigate the historical conditions that led to the economic system reversing the pre-existing balanced relationship between growth and finance.

indices, often used in the economics and finance literature, simplify comparisons between sets of aggregate data across time (Diewert, 2008). In particular, given the unwieldy nature of our data and construction of the VUC indicator, indices represent the simplest and adequate method to isolate the role of financial innovation in the finance-growth relationship and capture the *rate of financial innovation* effect. In this case, the GDP is the denominator of the VUC indicator, thus it is fixed at the year 1992 for the US and 1999 for UK / Euro area, when applying the fixed-based index. By contrast, the denominator changes year-by-year using the chain-based index. This is done using the same start dates and moving the base date to 2016.

The analysis is completed with a comparison between outcomes, changing the denominator of the indicator to GDP growth rate, unemployment rate, and government deficit rate. In doing so, we facilitate a complete analysis of the financial components relative to the real variables. In the following subsection, we discuss the outcomes of the cross-country statistical exercise and show the plots for each case.

6. ANALYSIS OF THE OUTCOMES

6.1. Initial Analysis

In Figures 3-10, we show the application of the VUC indicator on the US, UK and Euro area (represented by Figs 3-5 – US; Figs 6-8 - UK and; Figs 9-10 - Euro area respectively). Specifically, Figure 3 for the US plots in the same graph trading and credit derivatives with equity to GDP as a denominator for all three levels of analysis: current values, fixed-based index (fi) and chain-based index (ci). Similarly, the UK and Euro area plots are represented in Figure 7 and Figure 10 respectively.[14] In Figures 4-5, we show the VUC indicator for the US by changing the denominator respectively with GDP growth, unemployment rate and fiscal deficit rate. In this case, we present trading and credit derivatives for the three steps of analyses in separate plots. We repeat the exercise for the UK (Figs 6-8) and Euro area (Figs 9-10).

Our findings provide interesting insights into the finance-growth nexus and inferences about the VUC theoretical framework and related assumptions developed. For instance, the indicator plotted for US, UK and Euro area (in Figs 3, 6 and 9) based on current values illustrates a link between the GDP growth and an exponential increase in derivatives as a proportion of equity over time.[15] Interestingly, these plots align with the dynamics explained and demonstrated earlier in the numerical exercise concerning the securitisation ratio variation as a function of the *rate of financial innovation*, and its impact on endogenous money/credit

[14] We do not distinguish between trading and credit derivatives for the Euro area as ECB Statistical Datawarehouse do not report data separately for the trading and credit derivatives.

[15] The lower three plots represent the trading derivatives as a proportion of equity relative to GDP, whereas the upper three plots depict the credit derivatives as a proportion of equity relative GDP. In Figures 4-10, Trd represents trading derivatives and CD represents credit derivatives.

creation over time. Moreover, the indicators provide clear picture of the existence of the VUC dynamics for the US, UK and Euro area (Mazzocchetti et al., 2020).

Additionally, the VUC indicator (specifically, US and UK) follow a similar downward trajectory after 2012, whilst the Euro area continues to exhibit a virtuous cycle. However, the Euro area does not follow a stable pattern, particularly during 2013-2015. It is only from 2015-2016 does the indicator start to stabilize in the direction of the virtuous cycle, confirming the direction of the previous year. Moreover, the UK trading derivatives curve gives the first signal of re-entering an unvirtuous cycle from 2015 (as observed in Fig 6), in contrast to the Euro area where we see signs of entering into the virtuous cycle as highlighted in Figure 9.

The same plots of Figures 3, 6 and 9, also yields insightful information using steps two and three of the methodology.[16] With the fixed-based approach, the numbers of derivatives and equities are current; however, we fix the GDP quantities at the base period. Given the base is fixed, the plots only show derivatives growth as a proportion of equity relative to fixed GDP. For the chain-based index, the base changes year by year (i.e., the current GDP is the previous year's GDP). The plots are robust according to the current year's GDP levels given that the difference in economic growth rates are small.

We substitute the VUC denominator with GDP growth rate, unemployment rate, and government deficit rate in order to observe how our 'innovation' proxy behaves relative to different macroeconomic indicators.[17] As we can see from Figure 4, the growth in trading derivatives and credit derivatives is significant; however, with the latter, the increase is exponential. We observe a slowdown and ultimately decrease in US GDP growth after the 2001 dot.com crash associated with an increase in the unemployment rate and government deficit. This is generally robust, as can be seen from the plots of trading derivatives, apart from the fixed-based index illustrated in Figures 4-5. The fact that the impact in credit derivatives is absent reflects a market at its infancy stage. We nevertheless observe a fall in all our selected macroeconomic indicators during the 2008 GFC.

The plots using current values and chain-based index with unemployment rate and GDP growth as denominators are quite similar for the US, UK and Euro area. Moreover, the indicator follows almost the same trend using GDP as a denominator (Fig 4 - US; Fig 7 - UK and; Fig 10- Euro area). Another interesting observation is that the plots using the fixed-based approach for almost all denominators (GDP levels, GDP growth, unemployment levels and budget deficit) show similar trends. Equally, the plots also show the growth of derivatives as a

[16] The suffix 'fi' represents the fixed-based index and 'ci' represents chain-based index in Figures 3-10.

[17] We also calculate our indicators with other macroeconomic variables such as consumption growth and investment growth. The behaviour of consumption growth is very similar to the unemployment rate for the US, analogous to GDP growth for the UK and Euro area. However, the behaviour of investment growth is very similar to the behaviour of consumption growth for the US and UK, except that investment fell during dot.com bubble of 2001. By contrast, investment growth increased during the dot.com bubble in the Euro area.

proportion of equity. For derivatives/equity/budget deficit in the US and Euro area, the VUC indicator is fairly similar, but differs for the UK. This is so given the corresponding UK plot shows a similar trend when we use other denominators (see Figs 5, 8, 10 for the US, UK and Euro area respectively). Intuitively, this could reflect the limited use of derivatives in the UK before 2005-2006 and as such, did not have a material effect on government budgetary balances. However, the growth in the use of derivatives after 2005-2006 that slowed down after the GFC, ultimately affected the government budgetary balances negatively in 2010-2011. This translated for the period 2014-2016 in the indicator registering an increase in government deficit.

Interestingly, the use of derivatives impacts the government budgetary balances with a lag for the US and Euro area. We observe a significant increase in derivatives as a proportion of equity in the US during mid-to-late 1990s that translates into a decline in government budgetary balances from 1998-2001. Further, the increase in derivatives use during 2007-2008 is associated in this case with a fall in government budgetary balances. On the one hand, the trend in US balances is stable from 2009, only to decline again after 2015. On the other hand, we capture the rising trend in government budgetary balances for the Euro area in 2010-2016 using the chained index and current quantities as a base.

The VUC indicator plots for derivatives as a proportion of equity with GDP growth as a denominator also provide interesting insights. The Figures show that the initial impact of an increase in derivatives on GDP growth is not significantly large. Derivatives as a proportion of equity fell sharply relative to the decrease in GDP growth. However, GDP growth remained low for some period of time, meaning that the growth in derivatives use is associated with the cycle becoming unvirtuous (Figs 5, 8, 10 for the US, UK and Euro area respectively). This phenomenon is quite consistent across countries.

[Please insert Figures 3 to 10 here]

6.2. Further results

Table 2 reports correlation estimates of the VUC indicators with other macroeconomic variables, only to observe some interesting relationships. For instance, GDP and credit-to-GDP ratio show a strong, positive and statistically significant relationship that is limited to the US. Further, correlation estimates are negative with GDP growth, indicating an unvirtuous cycle when there is low GDP and consumption cycle. The correlation estimates of our indicators are positive, with credit-to-GDP indicating an unvirtuous cycle when the credit-to-GDP ratio is high. All correlations with our indicators concerning the US are statistically significant at 1% level. In the case of the UK, we find strong negative and highly significant correlation of our indicators with GDP growth indicating that an unvirtuous cycle is associated with low GDP growth. Interestingly, we find only a moderate correlation between our indicators and the

credit- to-GDP ratio, which is statistically significant only at 10% level. By contrast, the results are different for the Euro area of which we observe a highly positive and statistically significant correlation of our indicators with GDP, the unemployment rate and credit-to-GDP ratio. Finding a positive correlation between our indicators and GDP is surprising, given that it indicates an economy in an unvirtuous cycle when GDP is high. However, the association between high levels of unemployment and credit-to-GDP ratio with unvirtuous cycles is intuitive. Overall, credit-to-GDP is highly and positively correlated with our indicators for the US and Euro area, but not the UK. This in line with Watchel (2018) who argues that credit booms could be beneficial as it increases economic growth whilst maintaining the potential of a financial crisis. GDP growth is strong and negatively correlated with our indicators for the US and UK, but not the Euro area. As such, this provides indicative evidence that the indicators developed are better able to inform the unvirtuous cycle in all three regions.

[Please insert Table 2 here]

7. FURTHER DISCUSSION OF THE RESULTS

The VUC indicator for all regions highlights the exponential effect of the *rate of financial innovation* at different time-periods. However, the development of the finance-growth nexus differs for each country/region, confirming that in isolation, each case can find itself at different stages of the "Minsky Cycle" (Minsky, 1986) and varying degrees of financial risk exposure.

The "regulatory dialectic" (Kane, 1977) and monopolistic financial power concentration (Stiglitz, 2010; Turner, 2010) endogenous dynamics appears to facilitate a liquidity illusion (Nesvetailova, 2010) and trigger an unvirtuous cycle based on our results. The plots show clearly that the US is reportedly the most exposed economy, already building up an unvirtuous cycle from the start of the sample period. The UK and Euro area, in following the same speculative trajectory, appears to be taking a more moderate position, operating at a lower multi-leverage level. In particular, we observe that by filtering and plotting the data from 1999-2009, the Euro area continuously developed its unvirtuous cycle after 2000. Similarly, for the US, such findings could be attributable to the increased use of credit derivatives in early 2000 (Stulz, 2010). By contrast, the UK shows the monetary and fiscal authorities attempt to restore a virtuous cycle between 2002 and 2004 given the EU SGP (Stability and Growth Pact) and their commitment to meet their "Convergence Programme" (UK Convergence Programme, 2001). However, the same international speculative financial sector pressures affecting the US and Euro area resulted in an unvirtuous cycle in the UK between 2004 and 2006. Such a finding is significant given that it coincided with the US boom in subprime lending (Dungey and Gajurel, 2015). According to our results, all three regions appear to fall into the *wealth trap*, thus increasing the likelihood of a liquidity and ensuing solvency default of the financial

operators (Brunnermeier, 2009; Ivashina and Scharfstein, 2010; Schularick and Taylor, 2012; Lauretta, 2018).

Our findings illustrate how the US, UK and Euro area provides a clear example of the impact of the speed regulatory adaptation problem (Kane, 1977, 1983; Jemović and Marinković, 2021) on determining the direction of the VUC. However, it can potentially be distortive, as in the case of Euro area[18]. In 2008, the plots for the US shows the beginning of a virtuous path and a move toward recovery (Kollman et al., 2016; Berger, 2018). Equally, the UK virtuous path started in 2011 only after minor adjustments in 2008-2010, most probably due to an inadequate policy response to the scale of the crisis (Kay, 2011; Sawyer, 2012; Werner, 2014a). By contrast, the VUC indicator for the Euro area shows a marked upward movement in 2009-2012 towards an unvirtuous cycle, reaching a turning point moving in the opposite direction between 2012 and 2013 towards a virtuous cycle. Then, the curve starts moving again in 2014 towards an unvirtuous cycle. More specifically, the period of 2009-2012 coincides with the period of the Eurozone debt crisis (Acharya et al., 2015) and our VUC indicators capture the distortion in the speed regulatory adaptation created by the disclosed European sovereign debt crisis[19] and ECB bailout program (Roch and Uhlig, 2018; Bergman et al., 2019). As Mario Draghi highlighted in his lecture entitled "Consistent Strategy for a Sustained Recovery" at Sciences Po, Paris, on 25 March 2014: *"Policymakers (after the financial crisis exploded) dealt with the immediate situation without simultaneously addressing all its consequences. It was only when this began to change in June 2012 that we returned to the path of recovery."* This latter period, however, was characterised by a considerable amount of slack and instability in the Euro area economy (OECD "Better Policy" Series, 2014; Werner, 2014b; Kollmann et al., 2016) - a finding that our indicator of Figure 9 captures in 2012-2014. Only from 2015 onwards, the Euro area appears to have taken a more stable recovery path in the direction of the virtuous cycle.

Finally, it is noteworthy to mention that differences in recovery speed, highlighted by our VUC indicators may be explainable by the timing of the Quantitative Easing (QE) programmes. In fact, since the post-crisis period, the Federal Reserve and the Bank of England have respectively announced rounds of QE (QE1 - November 2008, QE2 - November 2010 and QE3 - September 2012 for the US; March 2009 and October 2011 for the UK). By contrast, the ECB instigated a covered bond purchasing programme with the aim of sustaining the long-term debt market, and therefore the provision of banks' loans to the public and the private sector

[18] Unfortunately, this is a limited phenomenon observable pre-financial crisis given the data constraints.

[19] In fact, since 2009, the effect of the 2007-2008 GFC started to unveil the critical debt condition of the Eurozone members. From 1992, Eurozone countries were able to securitise future government revenues in order to reach and maintain the Maastricht criteria. This helped to exaggerate the governments' balance sheets, masking their real debts and deficit conditions. (Lane, 2012; Werner, 2014a)

(Petmezas and Santamaria, 2014). It was not until January 2015 did the ECB announce an expanded asset purchase programme.

8. CONCLUSIONS

In this paper, we provide a theoretical background and a set of assumptions that explains the interconnections between finance and growth as well as the role played by financial innovation in this nexus. The aim is to address shortcomings in the literature between empirical and theoretical development on the finance-growth relationship. The prior empirical literature up to now provides insightful evidence on the aforementioned nexus without a theoretical framework. As documented in the academic literature, there is inconclusive evidence on the switching mechanism from a growth-led to a finance-led economy and vice versa. Therefore, this study provides, for the first time, a framework of assumptions that postulates the existence of a switching mechanism that could explain the complexities surrounding the finance-growth relationship. Hence, the paper discusses the *virtuous* and *unvirtuous cycles* (VUC) and the novel concept of the *wealth trap*. We postulate that a virtuous cycle transition to an unvirtuous cycle is caused by the financial agents' development of their political/market power and increasing level of speculative transactions within the unvirtuous cycle. Only by restoring the condition for a virtuous cycle through targeted market and policy interventions can make the direction of this switching mechanism be reversed. The VUC dynamics are characterized by non-linear interactions that we find are influenced by different *rates of financial innovation* (the degree of how much technologically advanced is the financial system) and the structural leveraging subdivisions among agents involved in the financial system.

Within the theoretical framework, we provide a numerical example of the financial crisis generator dynamics (*CG*) when the business cycle has switched from a growth-led (virtuous cycle) to a finance-led economy (unvirtuous cycle). The numerical exercise shows that the higher the demand for advanced financial tools for speculative purposes, the greater the *rate of financial innovation*. Variations in the endogenous creation of bank money *BMC*, represented as an exponential function, is amplified by how much financial operators rely on financial innovation. The exercise conveys that increasing reliance of financial operators on the securitisation mechanism induces financial instability, increases financial system default risk and, consequentially, increases the chances of financial crises.

We apply the VUC indicator on a cross-country statistical exercise of the US, UK and Euro area to report some insightful findings. To start off, this is done to expand on the intuition about *CG* provided by the numerical exercise and establish support for the basis of the VUC indicator, analytical concepts and assumptions discussed in the paper. The investigation highlights the exponential effect in the rate of financial innovation at different time periods. However, the analysis shows that the development of the finance-growth dynamics is different

for each country and as such, poses challenges in identifying a common VUC switching point threshold. However, we report conclusive evidence of a switching mechanism between virtuous and unvirtuous cycles and hence our analysis sheds some unique insights into the finance-growth nexus. For instance, the VUC indicator involving the credit-to-GDP ratio is more reliable in detecting financial imbalances in all three regions under investigation. Yet, it is noteworthy to mention that our indicator does not have any predictability power and neither does it explain the exact timing of an unvirtuous cycle.

The VUC indicator embodies the potential to be useful for policy purposes. Together with the credit-to-GDP indicator, it may serve as a useful guide for setting effective policies on the emerged variables (i.e. financial power concentration and rate of financial innovation) produced as a result of switching from a growth-finance to a finance-growth cycle. Equally, the VUC indicator could be seen as an "early warning system" on the balance sheet status of the finance-growth relationship, showing whether or not the system is balanced in terms of assets and liabilities. Moreover, our results promote the importance of finding an alternative approach by scholars, analysts and policymakers that ensures a balance-account equilibrium in the economic system as opposed to the mainstream focus on "steady-state equilibrium."

Finally, this paper opens up new avenues for future research. For instance, the VUC could be modified further to include a component that is able to capture "emergent events". Further, future research could focus on empirically testing each assumption or extending the assumptions and theoretical background. This could be done by developing a set of stylised facts from which to investigate the formal link between financial instability, financial market/political power concentration and increased levels of investments channelled into financial innovation. By setting specific indices on the aforementioned variables, future studies may be able to analyse and test the conditions that drive the creation of monopolistic financial power, regulation loosening and increasing levels of financial innovation within the economy. Finally, future research may consider endogenizing *FP* and investigate potential interdependencies with *K* and *L* in determining total output. Further, it is possible to extend the concept of Financial System Default Risk (*FSDR*) by considering market risks (for instance, a decrease in the value of investments, MTM on derivatives etc.) to expand the concept of financial distress which, in the context of our study is limited to bad debts/credit losses accumulation.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

CONFLICT OF INTEREST STATEMENT

The authors have no conflicts of interest to declare. All co-authors have seen and agree with the contents of the manuscript and there is no financial interest to report.

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Appendix 1

[INSERT TABLE 3 HERE]

LIST OF TABLES

Table 1: Variables for the VUC indicator and data source

Variable	**Data Source**
Derivatives (Trading and credit derivatives)	**US:** Federal Deposit Insurance Corporation (FDIC); **UK:** Bank of England Interactive Database; **Euro area:** ECB Statistical Data Warehouse.
Equity (Bank Equity)	**US and UK:** Bankscope; **Euro area:** ECB Statistical Data Warehouse.
GDP	OECD Statistics (All)
GDP Growth	**US:** Federal Reserve Economic Data (FRED); **UK:** Office of National Statistics (ONS); **Euro area:** OECD Statistics
Unemployment Rate	**US:** Federal Reserve Economic Data (FRED); **UK:** Labour Market Statistics (LMS); **Euro area:** Statistical Office of the European Commission (Eurostat);
Government Deficit Rate	**US:** Federal Reserve Economic Data (FRED); **UK:** Office of National Statistics (ONS); **Euro area:** ECB Statistical Data Warehouse

Source: Authors' elaboration

Table 2: Correlation analysis - VUC indicators with macroeconomic variables (US, UK and Euro area)

Counrty/Area	Indicator	Macroeconomic Variables				
		GDP	GDP Growth	Govt Deficit	Unemployment Rate	Credit to GDP Ratio
USA	TrD/Equity/GDP	0.55***	-0.61***	0.74***	0.49***	0.78***
	TrD/Equity/GDP (fixed index)	0.84***	-0.64***	0.66***	0.49***	0.89***
	TrD/Equity/GDP (chained index)	0.49***	-0.54***	0.80***	0.58***	0.75***
	CD/Equity/GDP	0.51***	-0.62***	0.76***	0.51***	0.88***
	CD/Equity/GDP (fixed index)	0.51***	-0.62***	0.76***	0.51***	0.88***
	CD/Equity/GDP (chained index)	0.59***	-0.62***	0.76***	0.55***	0.88***
UK	TrD/Equity/GDP	0.07	-0.73***	-0.25	0.26	0.43*
	TrD/Equity/GDP (fixed index)	0.40*	-0.78***	-0.46**	0.36	0.63***
	TrD/Equity/GDP (chained index)	0.10	-0.75***	-0.28	0.25	0.54***
	CD/Equity/GDP	0.10	-0.75***	-0.28	0.25	0.54***
	CD/Equity/GDP (fixed index)	0.24	-0.83***	-0.37	0.22	0.59***
	CD/Equity/GDP (chained index)	0.26	-0.82***	-0.38*	0.23	0.60***
EUROAREA	Derivatives/Equity/GDP	0.76***	-0.24*	0.38*	0.77***	0.77***
	Derivatives/Equity/GDP (fixed index)	0.76***	-0.31	0.16	0.87***	0.69***
	Derivatives/Equity/GDP (chained index)	0.76***	-0.19***	0.35***	0.79***	0.78***

Note: *** shows 10 percent, ** shows 5 percent and * shows 1 percent level of significance

Source: Authors' elaboration

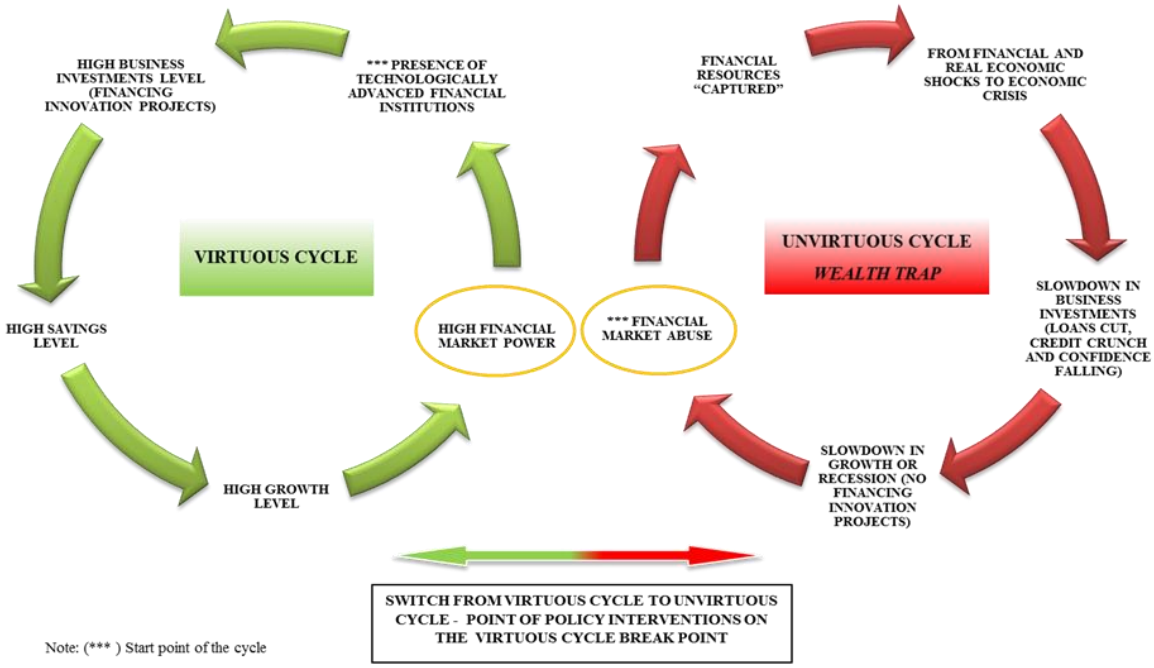
Table 3: Summary of the variables used - theoretical assumptions and the VUC indicator

Variables	**Description**
Y	Total output
FP	Financial power
K	Capital input
L	Labour input
I	Industrial innovation
LR	Leverage: amount of capital/total assets
SZ	Size of financial institution (e.g. market share/GDP)
FI	Financial Innovation
$RoFIN$	Rate of financial innovation
$FDRS$	Financial Systemic Default Risk
BD	Bad Debt
CG	Crises Generator
ε	Volatility
BMC	Bank Money Creation
$SR = \sigma$	Securitisation Ratio
TC_T	Total Credits transferred to Securitisation process
GDP	Gross Domestic Product
Eq^b	Total bank's equity
VUC	Virtuous-Unvirtuous Cycle Indicator

Source: Authors' elaboration

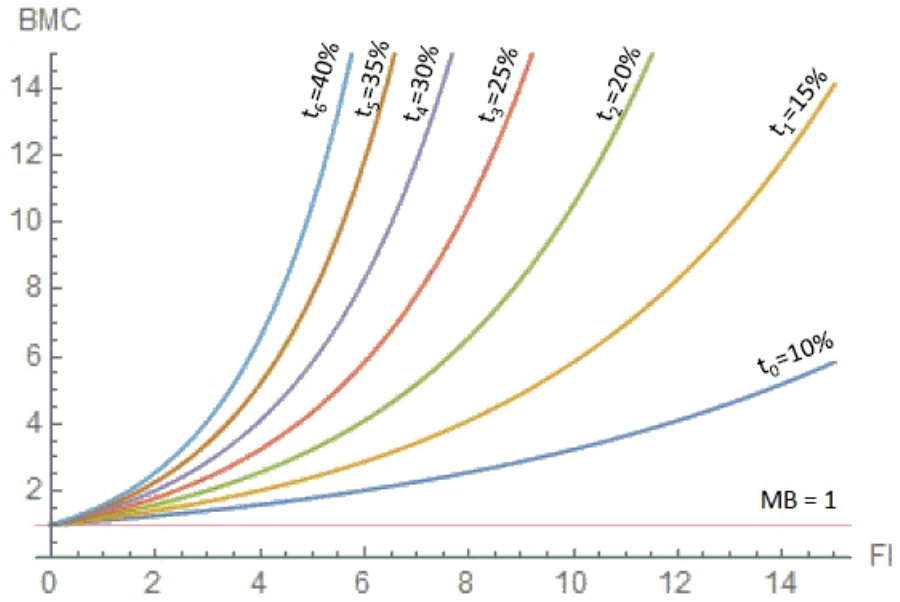
LIST OF FIGURES

Figure 1: Virtuous and Unvirtuous Cycle Theoretical Scheme



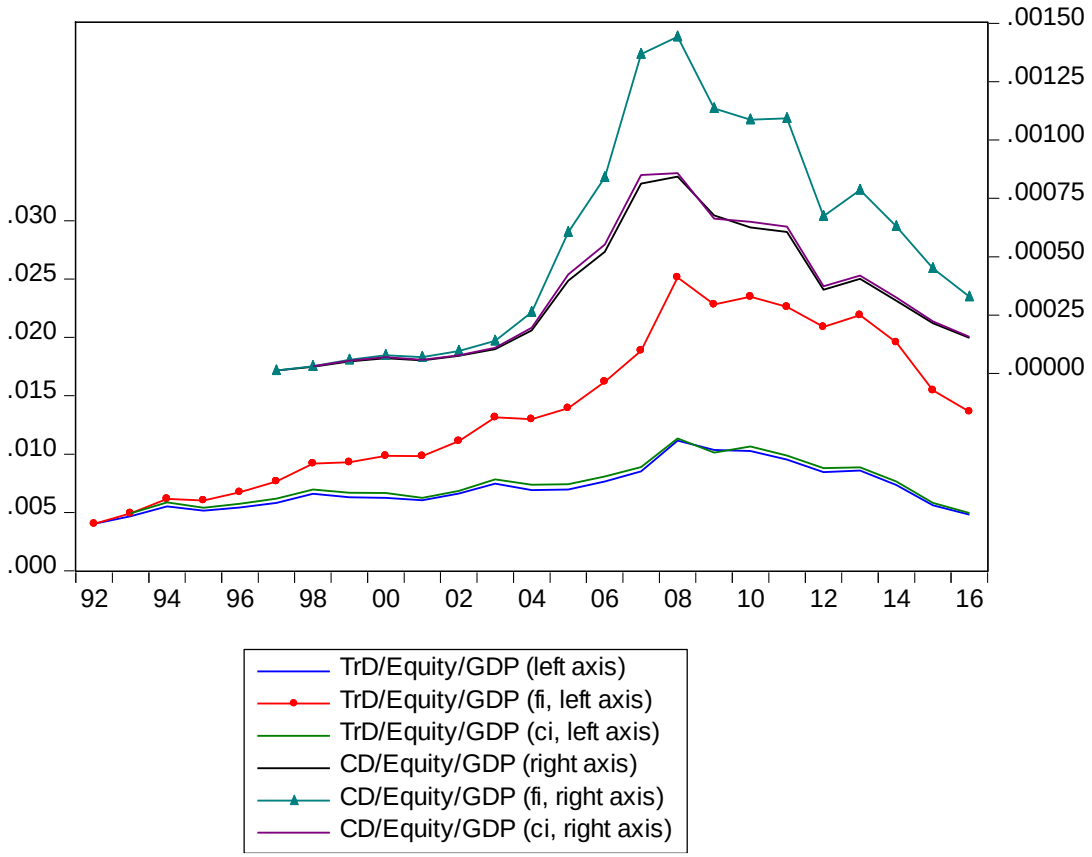
Source: Authors' elaboration

Figure 2: Representation of the dynamics of the securitisation ratio variation and its impact on endogenous money/credit creation over time. For the exercise, the hypothetical securitisation ratios applied were t_0=10%, t_1=15%, t_2=20%, t_3=25%, t_4=30%, t_5=35% and t_6=40%. The x-axis shows financial innovation (FI) and the y-axis shows bank money creation (BMC). The red line represents the Monetary Base, assumed to be variable over time but, for the sake of clarity, is constant in each period (MB = 1). The variation in the function incorporates the rate of financial innovation effect.



Source: Authors' elaboration

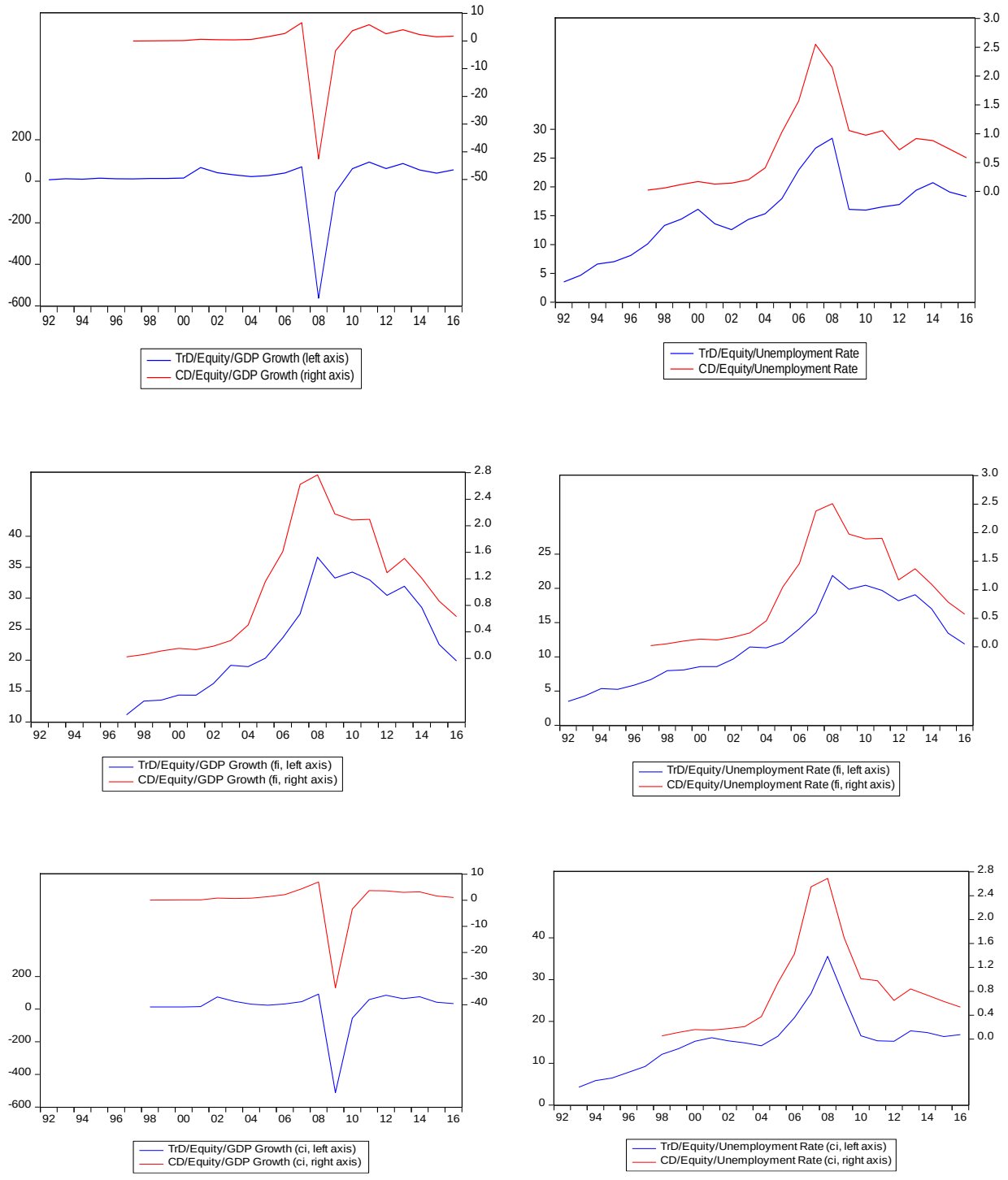
Figure 3: VUC indicator – US – current value, fixed-based index(fi) and chain-based index(ci).



Note: the lower three plots represent the trading derivatives as a proportion of equity relative to GDP, whereas the upper three plots depict the credit derivatives as a proportion of equity relative GDP. *Trd* represents trading derivatives and *CD* represents credit derivatives.

Source: Authors' elaboration

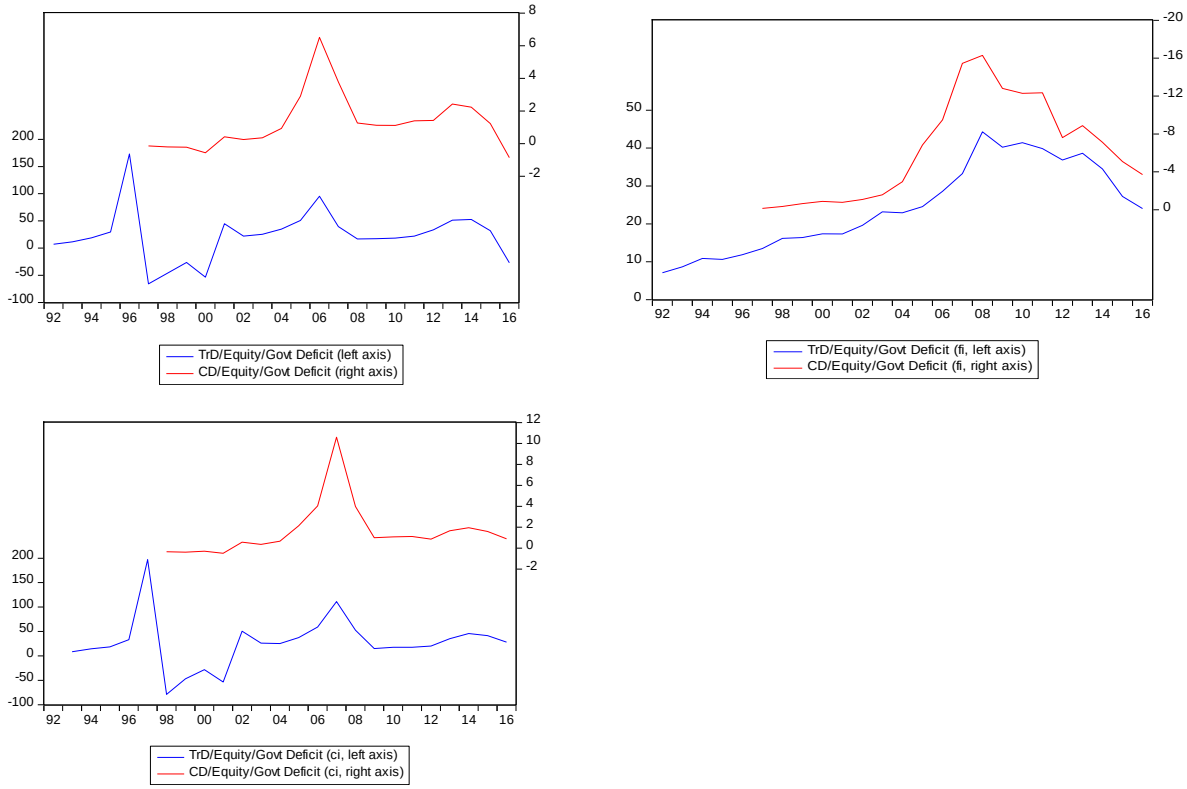
Figure 4: VUC indicator with GDP growth and unemployment rate as the denominator – US



Note: The left-hand side three figures represent the trading derivatives and credit derivatives as a proportion of equity relative to GDP growth, whereas the right hand side three figures depict the credit derivatives as a proportion of equity relative unemployment rate. TrD represents trading derivatives and CD represents credit derivatives.

Source: Authors' elaboration

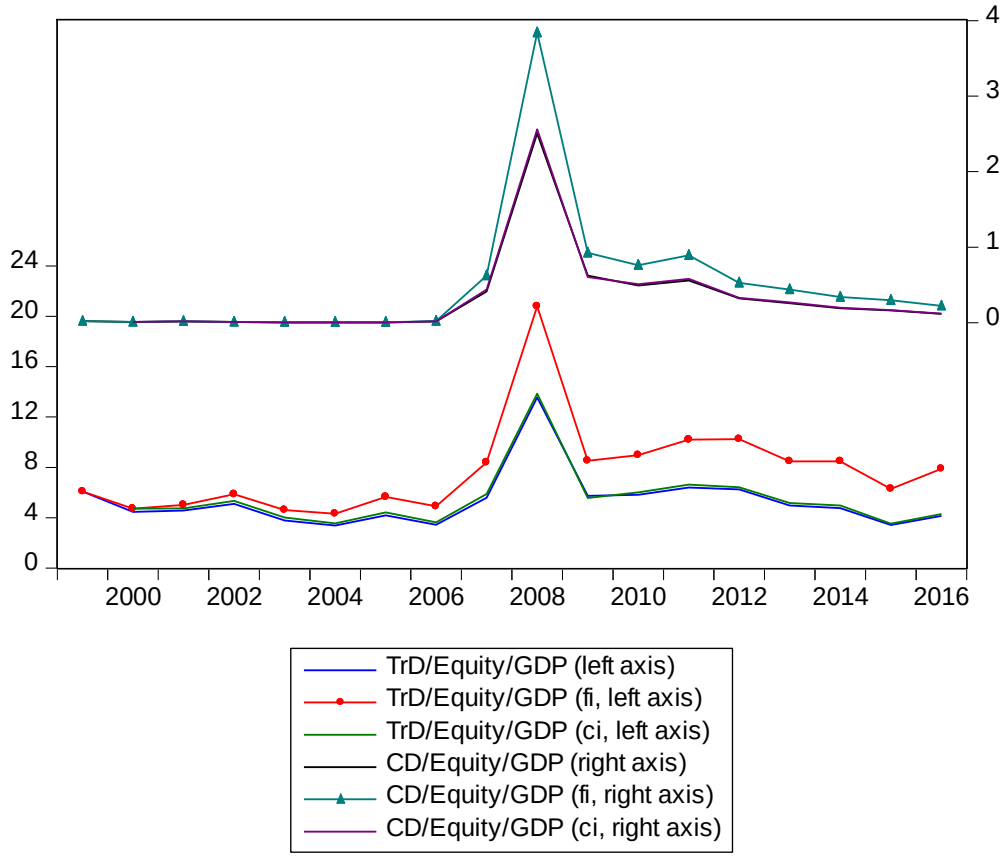
Figure 5: VUC indicator with government deficit as the denominator - US



Note: This figure represents the trading derivatives and credit derivatives as a proportion of equity relative to government deficit. TrD represents trading derivatives and CD represents credit derivatives.

Source: Authors' elaboration

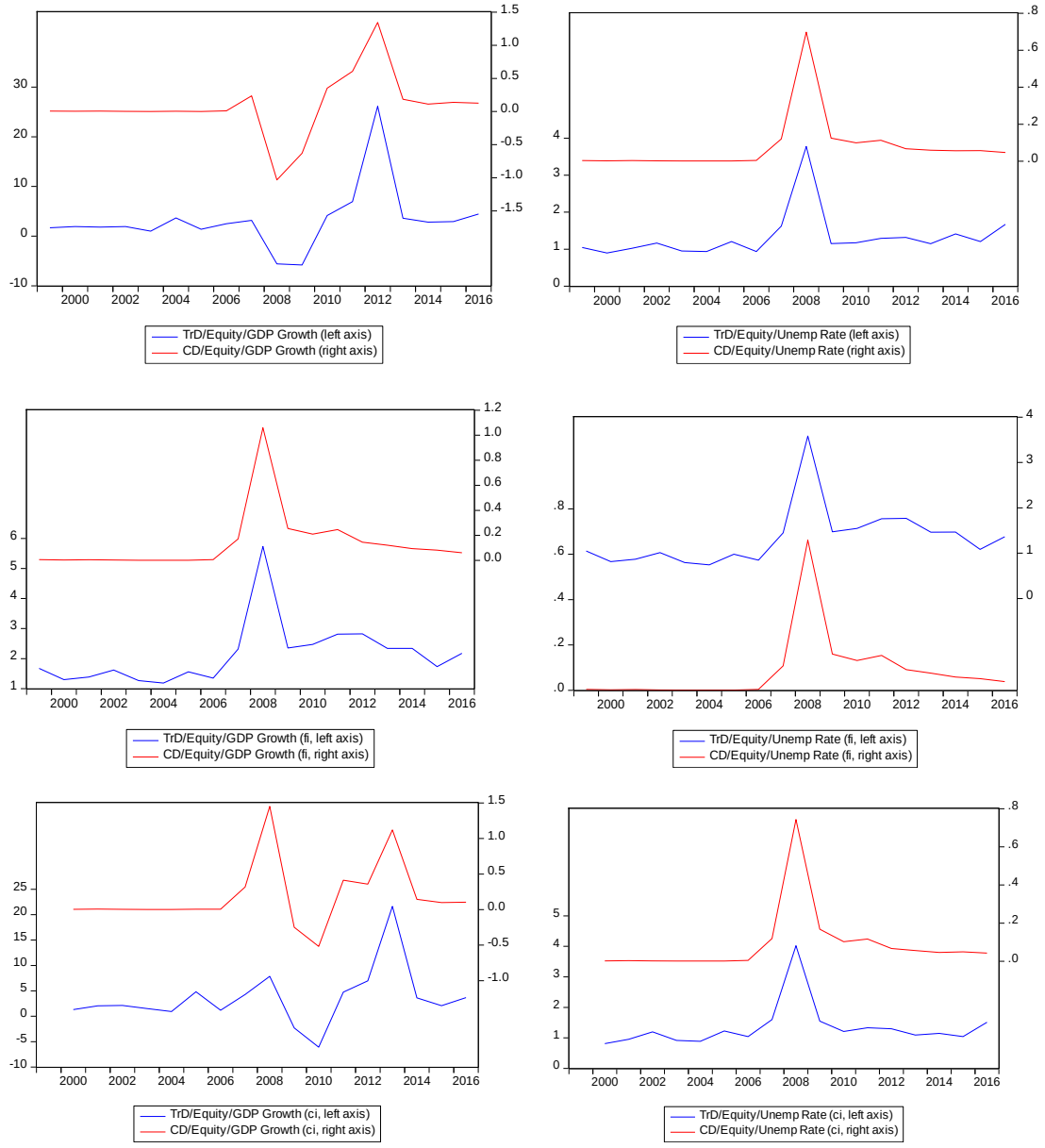
Figure 6: VUC indicator – UK – current value, fixed-based index(fi) and chain-based index(ci).



Note: The lower three plots represent the trading derivatives as a proportion of equity relative to GDP, whereas the upper three plots depict the credit derivatives as a proportion of equity relative GDP. TrD represents trading derivatives and CD represents credit derivatives.

Source: Authors' elaboration

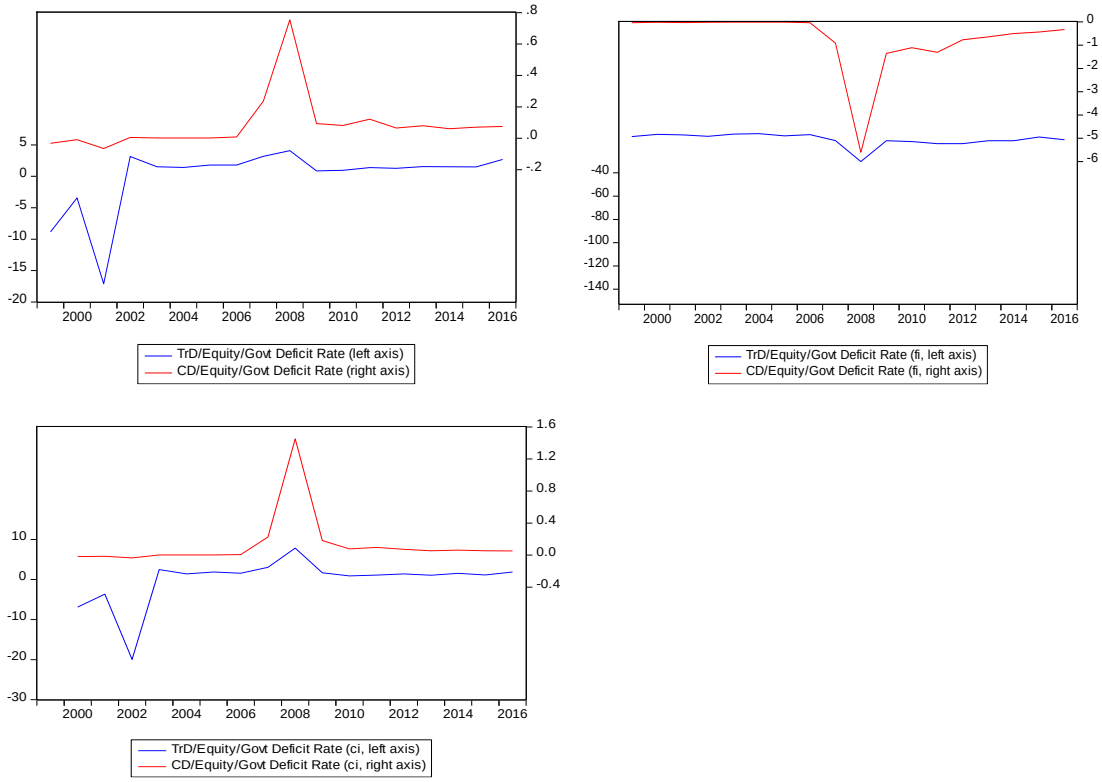
Figure 7: VUC indicator with GDP growth and unemployment rate as the denominator - UK



Note: The left-hand side three figures represent the trading derivatives and credit derivatives as a proportion of equity relative to GDP growth, whereas the right hand side three figures depict the credit derivatives as a proportion of equity relative unemployment rate. TrD represents trading derivatives and CD represents credit derivatives.

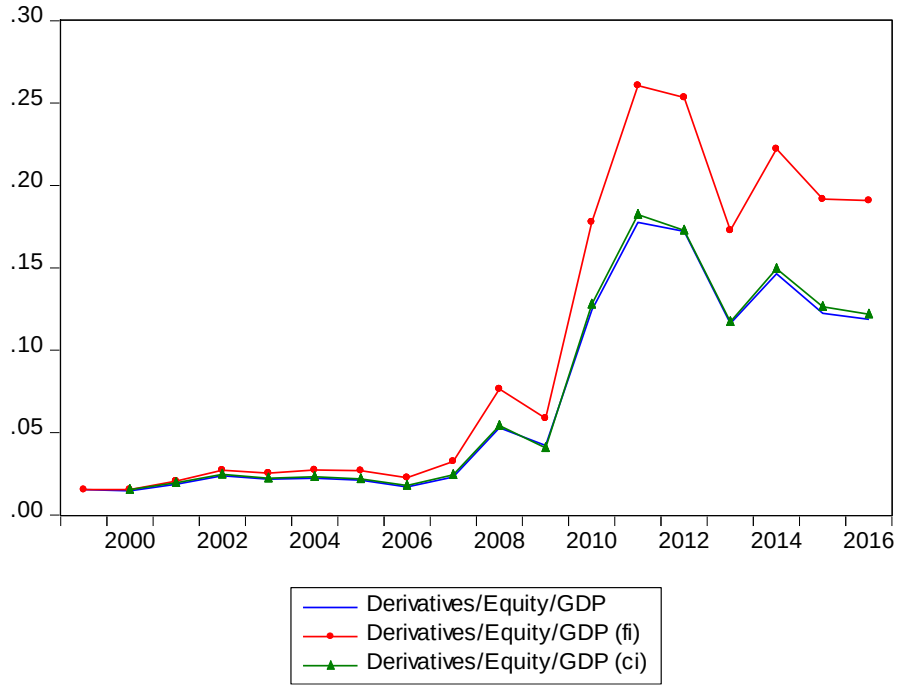
Source: Authors' elaboration

Figure 8: VUC indicator with government deficit rate as the denominator – UK



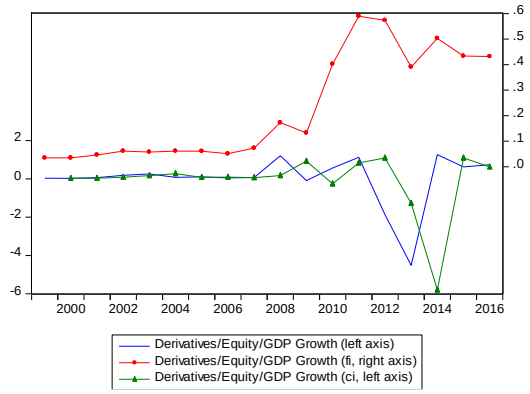
Source: Authors' elaboration

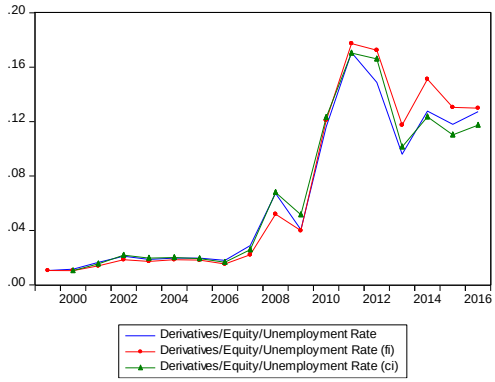
Figure 9: VUC indicator - Euro area – current value, fixed-based index(fi) and chain-based index(ci).

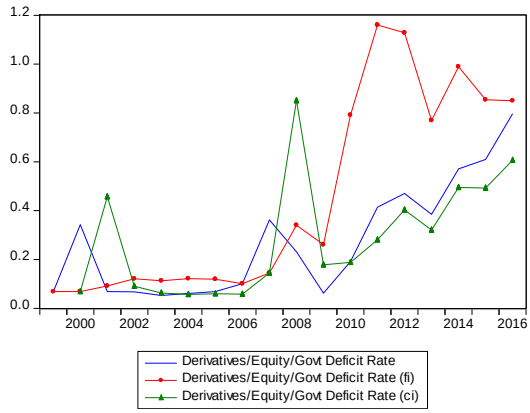


Source: Authors' elaboration

Figure 10: VUC indicator with GDP growth, unemployment rate and government deficit rate as the denominator - Euro area







Source: Authors' elaboration