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On the paradigm shift of asset pricing models, before and after the global financial crisis: a literature review

Carolina Carbajal-De-Nova*
Francisco Venegas-Martínez**

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Abstract

This is a literature review on the paradigm shift of asset pricing of the mainstream and other trends, from the beginning of the xx century to date, by considering two periods: before and after the global financial crisis of 2007-2009. The first period shows inconsistencies between agent's behaviors in the asset pricing mainstream modeling. The second period includes Fin Tech for determining patterns of agent's behaviors allowing big data mining at any level of aggregation, either micro or macro, and machine learning, a statistical technique that give computer systems the ability to learn from data.

Keywords: agent behavior; asset pricing methodologies; global financial crisis.
JEL classification: D53, E44, G01.

* Profesor-investigador en la Universidad Autónoma Metropolitana-Iztapalapa. México. <enova@xanum.uam.mx>.
** Profesor-investigador en el Instituto Politécnico Nacional. México. <fvenegas1111@yahoo.com.mx>.

Sobre el cambio de paradigma de los modelos de fijación de precios de activos, antes y después de la crisis financiera mundial: una revisión de la literatura

Resumen

Esta es una revisión de la literatura sobre el cambio de paradigma en la fijación de precios de activos de la corriente principal y otras tendencias, desde el comienzo del siglo xx hasta la fecha, considerando dos periodos: antes y después de la crisis financiera mundial de 2007-2009. El primer periodo muestra inconsistencias entre los comportamientos del agente en el modelado general de precios de activos. El segundo periodo incluye Fin Tech para determinar los patrones de comportamiento de los agentes que permiten la minería de big data en cualquier nivel de agregación, ya sea micro o macro, y aprendizaje automático, una técnica estadística que brinda a los sistemas informáticos la capacidad de aprender de los datos.

Palabras clave: comportamiento del agente; metodologías de fijación de precios de activos; financiero global.
JEL clasificación: D53, E44, G01.

1. Introduction

Since the global financial crisis of 2007-2009, the interest on better asset pricing methodologies has being increased. Academics and practitioners have recognized that before this crisis, methodologies have failed to predict the global financial crisis and their side effects. This failure may be associated to the lack of an asset price methodology that could include agents' behaviors both in a micro and macroeconomic environment.

During the financial bubble that arose in the US mortgage market in the 2000's decade, many asset prices were rated "AAA" from Moody's Investors Service, Standard and Poor's, and Fitch Ratings to mention a few agencies. The "true" asset price was multiplied by itself several times, which confuses the "true" price with the number of times it circulates.[1] This is an example of a wrong asset pricing methodology application.[2] In simple terms, the financial bubble was fueled by the existence of two mortgage asset prices for the same asset: the rated and the "true" prices. This double asset pricing generated market discrepancies and financial distress in markets prices.[3] The financial bubbles during the 2000's decade and they outburst on 2007-2009 have manifested the biggest economic downturn on registry (Bank of England, 2017;[4] Kobayashi and Takaguchi, 2018;[5] and Atkinson *et al*., 2013).[6] The impact of this crisis was negative over the Gross Domestic Product (GDP) around the globe and cause catastrophic social welfare losses in many countries (Kapp and Vega, 2012;[7] Luttrell *et al*., 2013;[8] Helbing, 2013;[9] Kobayashi and Takaguchi, 2018[10,11]).[12] Needless to say, to avoid the undesirable effects of financial crises over the real economy, it is desirable to overcome the double asset pricing.[13]

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1 "By 2007, lending by British Banks had grown to five times the size of the UK economy." Bank of England (without year). From Blanchard (2008) view there are "… large deviations of prices from fundamentals". See also Lucas (2014).

2 The Bank of England (2017c) classifies financial assets in loans and advances; in fair value through profit or loss; in available for sale. A second asset category contains derivatives including securities.

3 Egan (2015) states that the International Monetary Fund warned about the surge of junk bond issuance by US companies, and about signs of overvaluation.

4 The global hedge fund industry experienced a growth by a factor of 14 since 2000.

5 The appellation 'Second Great Contraction' was coined by Reinhart and Rogoff (2011). It applies to output and employment in recession. For Fisher (2006) poor data led to a policy action that amplified speculative activity in the housing market and a significant foreshadowing for the years to come.

6 These authors point that economic recovery has been disappointingly tepid. Growth of 9.4% would be required just to reach the previous path.

7 These authors argue that extreme financial crisis episodes as the one happened during 2007-2008 could have associated losses between 2.95% and 4.54% on real world GDP.

8 The measuring crisis' cost of these authors is 40-90% of output, and 100-190% of consumption, both figures in relation with 2007 year.

9 The investor Warren Buffett warned that massive trade in financial derivatives would create mega-catastrophic risks for the economy. Five years later, the financial bubble imploded and destroyed trillions of stock value.

10 "We conservatively estimate that 40 to 90 percent of one year's output ($6 trillion to $14 trillion, the equivalent of $50 000 to $120 000 for every US household) was foregone due to the 2007-09 recession."

11 The aggregate cost of the crisis covers 2008 to 2023, the year output is assumed to have fully returned to trend, with a spillover to the global economy greater than the lost US. output.

12 "Therefore, humans need to learn how to quantify and protect social capital. A warning example is the loss of trillions of dollars in the stock markets during the financial crisis…" (Helbing, 2013).

13 "However, structural barriers have impeded accountability of institutional investors to beneficiaries, making it difficult for retail savers to police the stewardship behavior of their agents in respect of investee companies. Such barriers have roots in law, regulation and commercial practice that have failed to keep pace with market change" Davis (2016).

The period after the global financial crisis is immersed in Fin Tech.[14] Extended Internet and web connections expand the capacities for collecting and storing data. The Fin Tech has the tools, as big data mining, for analyzing asset pricing at a microeconomic or macroeconomics agent level behavior. Machine learning gives computers systems the ability to learn from agent's data. One important tool in Fin Tech consists on cash-payment technologies, which could account efficiently all financial operations in a particular trade chain. Thus, the period after the global financial crisis of 2007-2009 have the conditions to produce a "better asset pricing methodology." This methodology could aid policy makers and regulators in reducing or smoothing social-economic welfare losses due to financial distress.[15] Moreover, policy makers could have additional information to guide public policy interventions as: regulations, bank bailouts, subsidies and taxes (Engle, 2011; Engle and Brownlees, 2012; Engle *et al*. 2015; Tobias and Brunnermeier, 2016; and Brownlees and Engle, 2016).

The search of a "better asset pricing methodology" is ambitious. So far, it is still missing an asset pricing methodology that could provide coherence between the theoretical equilibrium uniqueness and the empirical evidence of multiple equilibria. A "better asset pricing methodology" should prevent financial crisis distress, *i.e*., world GDP losses (Lucas, 2014), or Real Business Cycles (RBC) downturns (Friedman *et al*., 1989). Besides, it could prevent uncertainty in resource allocation and income distribution (Batra, 1974). According to the theoretical equilibrium uniqueness, economies are viewed as systems that tend to evolve towards a unique equilibrium state. Under this framework, bubbles and crashes should not happen, and hence, would not require any precautions.

This paper attempts to provide a literature review on the asset pricing shift paradigms from the beginning of the xx century to date, by taking into account two periods: before and after the global financial crisis of 2007-2009. The first period shows inconsistencies between agents' behavior in asset

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[14] Bank of England (2017c) mentions the impact of Fin Tech in the financial services value chain are through digital wallets, eMoney, cross-border payments, robo advisors, big data analytics, high-frequency trading algorithms, and distributed ledger. This last category stands for operational infrastructure and ciber risk.

[15] "Around the globe regulators and market participants are confronted with the challenge of managing ever larger amounts of data essential for financial system oversight and risk management." Bank of England (2017b).

pricing. The second period includes Fin Tech for determining patterns of agents' behavior in both micro and macroeconomic environments.

This paper is organized as follows. Section two and three present a short literature review on the mainstream asset pricing paradigm and other trends before and after the global financial crisis of 2007-2009, respectively. Section four discusses a characterization of the asset pricing main stream paradigm transition. Finally, section five provides the conclusions.

2. First period: before the global financial crisis of 2007-2009

Most of the methodologies on asset pricing of the first period consider homogeneous agents (Gorman, 1953). This approach was supported from the scarce information that National Statistic Offices have during the xix century and most of the xx century; for example, few records on GDP and international commerce.[16] Besides, these records were delivered to these agencies on aggregated form. The technology at that time did not allow for tracking back the operations of each individual agent in the trade chain.

During the xix and xx centuries, economics was conceived as science, departing from philosophical and moral studies approaches (Smith, 1759 and 1776).[17] It is during these times that the general assumptions of the RBC models were constructed underlying the general equilibrium theoretical tenets.[18] Any modern orthodox neoclassical economist could enumerate these assumptions: homogenous, rational, and independent agents, complete and perfect information, and complete and

[16] Kondratieff (1935) mentions that "We have, however, no data before the end of the eighteenth century and even the data that we do have are too scanty and not entirely reliable." For its part, Spanos (1995) mentions that econometrics deals with economics nonexperimental data, and therefore its results are not aligned with the statistic theory based in experimental design and Gauss errors. Sims (2006) has the acumen for recognizing that a rationally inattentive agent will respond imprecisely, and Sims (2018) says that the literature has often assumed Gaussian uncertainty even where it cannot be justified as optimal.

[17] *The laissez faire-laissez passer* is explained by Sala Martin (2002) as free markets as the only efficient organization to guaranty citizens prosperity in all poor and rich countries on the world.

[18] Under the mainstream theoretical framework, the global financial crisis does not have a place, as the general equilibrium is always reached. In this sense, crisis studies, *i.e.*, Kondatrieff (1935) theory of long economic cycles, to mention only one, are disregarded.

efficient markets.[19],[20] All these assumptions together have the purposed of constructing the existence and uniqueness of the general equilibrium at the aggregated level (Allias, 1953; Savage, 1954; Arrow et al., 1961; Muth 1961; McFadden, 1962; Dhrymes, 1967; Kmenta, 1967; Lucas, 1976; Vriend 1996, and Allen, 2014).[21] Before, the global financial crisis of 2007-2009 several asset pricing methodologies were implemented, but only few of them depart from the representative agent general equilibrium. Hahn and Solow (1997) argue that Ramsey normative model, useful for working out what an idealized omniscient planner should do, RBC models have been transformed into models for interpreting last year's and next year's national accounts. The RBC models of Kydland and Prescott (1982) and Rebelo (2005), and others, were developed under the assumptions given in the above paragraph. Some representative veins of these methodologies, from the mainstream and other trends before the global crisis of 2007-2009 are listed in table 1.

[19] If these assumptions applied, then here is no need for government presence neither regulations. This idea is embedded in mainstream economics. In this regard, Continuity, Central Archive (2018) says that Helbing states: "Perhaps, this is because there should not be any bubbles and crashes according to the predominant theoretical paradigm of efficient markets." Toporowski (2005) mentions that financial crises that emerged in over financed developing countries, and eventually in banking and securities markets in the xx century were caused by policy failures, rather than to the intrinsic tendencies of financial markets.

[20] "Two main pillars of mainstream economics are the equilibrium paradigm and the representative agent approach. According to the equilibrium paradigm, economies are viewed as systems that tend to evolve towards an equilibrium state. Bubbles and crashes should not happen and, hence, would not require any precautions." Helbing (2013).

[21] "Keynes, by contrast, argued that while this might make sense for an individual worker or industry, there was a fallacy of composition if the same approach was used for the whole economy." Mills (2003).

Table 1
First period. Some of the main methodologies on asset pricing

Methodology	Year	Author
Continuous time finance and brownian motion	1863	Regnault
	1900	Bachelier
	1965	Samuelson
	1973	Black and Scholes
	1969	Merton
	1971	Merton
	2003	Gatfaoui
Portfolio selection	1952	Markowitz
	1970	Rothschild and Stiglitz
	1972	Kamien and Schwartz
	1994	Markowitz *et al*.
	2002	Rockafellar and Uryasev
	2002	Markowitz
Sharpe ratio and expected-variance principle	1965a	Sharpe
	1965b	Sharpe
	1966	Sharpe
	1978	Sharpe
	1987	Sharpe
	1990	Black
	1991	Sharpe
	1995	Sharpe
	1997	Hansen and Jagannathan
	2002	Sharpe
	2006	Bao and Ullah
	2007	Sharpe

Continuacion. Table 1

Methodology	Year	Author
Fixed factor proportions	1928	Cobb and douglas
	1955	Solow
	1970	Lucas
	1970	Nordhaus
	1978	Lucas
	1990	Mitchell
	2004	Geanakoplos
Arbitrage pricing theory	1960	Kaldor
	1970	Tobin
	1976	Ross
	1977	Minsky
	1977	Tobin
	1986	Minsky
	1997	Kiyotaki and Moore
	2004	Gordon
	2005	Kiyotaki and Moore
Consumption-based asset pricing	1979	Breeden
	1981	Grossman and Shiller
	1982	Hansen and Singleton
	1983	Hansen and Singleton
	1986	Mankiw and Shapiro
	1999	Campbell and Cochrane
	2000	Campbell and Cochrane
Price extrapolation	1978	Kindleberger
	1981	Shiller
	1982	Nelson and Plosser
	1988	Friedman
	1990	DeLong *et al*.
	1994	Ball and Mankiw
	1998	Easton and Pinder

Conclusión. Table 1

Methodology	Year	Author
Returns extrapolation	1982	Kydland and Prescott
	1985	Mehra and Prescott
	1994	Pesaran and Timmermann
	1996	Markowitz and Usmen
	1999	Hong and Stein
	2001	Gollier
	2003	Barberis and Shleifer
	2005	Rebelo
	2010	Tsay
Copula function	2000	Li
	2004	Cherubini *et al*.
	2009	Chollete *et al*.
	2012	Wu *et al*.
	2014	Boubaker and Sghaier
	2015	Brayek *et al*.
	2016	Aloui *et al*.
	2016	Gurgul and Machno
	2017	Allen *et al*.
	2017	Pircalabu and Benth
	2018	BenSaïda

Source: Based on Venegas-Martinez (2005) and own elaboration.[22]

Table 1 displays some of the theoretical methodologies implemented before the global financial crisis of 2007-2009. According to Bigio and Schneider (2017) many of these methodologies "cannot account for the dynamics of premiums

[22] See also Climent-Hernández and Venegas-Martínez (2013), Venegas-Martínez (2001), (2008) and (2013), Contreras-Piedragil and Venegas-Martínez (2011), González-Aréchiga *et al*. (2001), Venegas-Martínez and González-Aréchiga (2002), and Venegas-Martínez *et al*. (2002).

and macro quantities." This is because they focus on finding the theoretical general equilibria, which globally is nonlinear, whereas at the same time, they have infinite-horizon log-linear empirical restrictions. Some of these methodologies are still applied today, but with some relaxed constraints.

Lucas (1970) uses agents that have fixed factor proportions. Tobin (1970) critics this last author, since his aggregate representative agent are invariant to any "systematic" changes in the sequence of aggregate money demand, either in the level of such demand or in any of its time derivatives. Although, Lucas (1978) evolves theoretically by introducing the stochastic behavior of equilibrium asset prices in a one-good pure exchange economy, he continues using homogeneous agents. Tobin (1977) expresses that the assumption of homogeneous agents washed out monetary operations of central banks, which are transmitted by portfolio substitution towards bond rates and equity yields.

Now then, regarding the copula function reported in the last row of table 1, it prices an asset using a multivariate normal distribution function, beside a timeless lineal correlation with other asset prices (the habit of living in a normal world). The copula approach constructs a new instrument call collaterized debt obligation (CDO). Under this framework, CDOs new credit lines were issued and the financial market expanded in value. This credit lines expansion was blamed as one of the principal causes of the global financial crisis of 2007-2009.

Previously to the copula function, asset price methodologies were used by traders to speculate and obtain private gains (Sharpe, 1965a; Sharpe, 1965b; Sharpe, 1978; Sharpe, 1987; Davis, 1990; Sharpe, 1991; Sharpe, 1995; Markowitz and Usmen, 1996; and Sharpe, 2007). These private gains slowly started to concentrate in hands of few investors over the last 30 years (Piketty and Saez, 2006). The investment decisions during the global financial crisis of 2007-2009 were made by these few investors, who already disposed of concentrated wealth.[23] In Minsky's (1977) view, the actual owners of wealth have claims, not on real assets, but on money.[24] Thus, investors focus on speculation rather than in real economic growth (Piketty, 2014). The

[23] Gordon (2004) claims: "The markup hypothesis is dead" as a secular reversal was observed from the previous upswing in labor's share.

[24] He claims for a "good financial society" in which the tendency by business and bankers to engage in speculative finance is constrained. According with Toporowski (2006), at the roots of Minsky's theory of critical finance and his financial instability hypothesis are the ideas of Fisher and his teacher Henry Simons.

growing speculation decision making in financial markets increased their degree of uncertainty. As uncertainty increased in financial markets, so does the corresponding insurance costs. Therefore, hiking insurance costs leads to increasing the discrepancies, between financial and "true" asset prices.

Table 1 shows several methodologies that have difficulties to model agents' behavior observed from micro and macroeconomic empirical evidence and their theoretical framework.[25] An example of these discrepancies is the global financial crisis of 2007-2009. In fact, some authors, v.g., Brown and De-Cani (1963); Bollerslev *et al*. (1988); Batra (1974); Cherubini *et al*. (2004), and Luttrell *et al*. (2013), to mention few of them, blame asset pricing methodologies based on general equilibrium assumptions of being responsible for the global financial crisis of 2007-2009. The mainstream methodologies gave pace to a speculative multitrillion-dollar financial bubble were banks, mutual banks, pension funds, insurance companies, and hedge funds, could provide trillions of dollars to companies and mortgages agents.

No all the asset pricing methodologies in the first period were based on general equilibrium assumptions. A realistic approach was proposed by Modigliani and Miller (1958) who stated that firm asset pricing is not independent from its capital structure. That is to say, the individual firm financial asset price is given by capitalizing today. The firm ranks the expected return rate based on its capital structure. In this sense, it is not possible characterize all the first period methodologies as purely theoretical.

3. Second period: after the global financial crisis of 2007-2009

This section briefly presents the principal trends in asset pricing methodologies after the global financial crisis of 2007-2009. Some of these methodologies try to override the limitations that the general equilibrium assumptions have imposed on the first period.

The presence of heterogeneous agents in the second period is enabled by the nature of the empirical data that National Statistic Offices have at the beginning of the xxi century. The nature of this information is based on micro data. The Fin Tech and its technology allow micro data records with a folio

[25] For a discussion about micro versus macro data different econometric descriptions, see Blanchard and Katz (1980).

number that identifies each individual agent. In this way, in the second period of study, micro data storage and management are easily administrated by National Statistic Offices. Besides, the Fin Tech permits the collection of micro data in real time. The use of micro data enables individual agent trade chain market operations tracking. This feature permits agent behavior analysis at any level of aggregation. Therefore, agents' heterogeneity is no longer an empirical constraint to analyze economic data at a micro and macroeconomic levels with efficiency, by using big data mining and machine learning.

Blanchard (2008) mentions that the current financial crisis makes it clear that in the first period the basic New Keynesian model falls short out of the mark. He points that the crisis made evident asymmetric information in asset pricing between managers and outside investors. Therefore, asset pricing methodologies in the second period could consider misleading the complete and perfect information assumptions.

In the second period, the search for a "better asset pricing methodology" capable to generate identical rated and "true" prices, led to exploring several fields and techniques, v.g., game theory, arithmetic of investment, econometrics, factor pricing models, networks, big data mining, and machine learning, either individually or combined.[26] Some advances have been made towards finding a "better asset pricing methodology". For instance, Sharpe (2010) and (2013) changes investment practice, where more data will need to be made available about the securities market values, for avoiding the efficient market assumption. Chaves and Arnott (2012) argue for rebalance rules to document "true" and "rated" portfolios. Bogle (2014) and Jacobsen (2017) try to identify investors and account their assets and cash. For their part, Magni (2014) shows that the internal rate of return (IRR) is a weighted mean of holding period rates associated with interim values, which differs from market values and contravenes value additivity property.

At the wake of the global financial crisis of 2007-2009, Charles (2008) proposes a manageable suggestion of Minsky's financial instability hypothesis to study real economic growth and debt by using three types of agents: firms, investors and workers. The tractability of his models resides on its agent heterogeneity. By the same guise, Caiani *et al.* (2016) present a based-stock flow

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[26] This possibility has been already noted by Modigliani and Miller (1958).

model using agents' heterogeneity. Pernell *et al*. (2017) point out the hazards of expert managerial control on risky derivatives, and he proposes an organizational licensing to avoid financial crunch and crisis.

For its part Maćkowiak and Wiederholt (2009) firm's inability to process all available information is modeled as a constraint on information flow. Shimer (2009) model does not have the efficient market assumption. Sharpe (2010) and (2013) considers an institutional investor that avoids agents' contrarian behavior. Mertens and Ravn (2011) try to explain financial frictions by means of the financial accelerator and liquidity traps. Allen and Powell (2012) address the global financial crisis of 2007-2009 by incorporating in their model conditional probability of default. Blanchard *et al*. (2013) build a signal model to extract consumers' information. Finally, Cristiano *et al*. (2014) use risk shocks to allow uncertainty fluctuation.

The pricing kernel methodology from Schneider (2015) sets a linear Capital Asset Model (CAPM) without the representative agent assumption. Barberis *et al*. (2015) use the X-CAPM to extrapolate past prices. However, Schneider's (2015) model allows the general equilibrium assumption without assuming perfect information. For their part, Kiyotaki and Moore (2012) in their RBC study have introduced collateral constraints and liquidity shocks for gaining a more realistic setting. These authors do not assume perfect information. Other variation in asset price paradigm, where the assumption of efficient markets is relaxed, is presented by Fama and French (2015, 2017). These authors propose a five-factor asset pricing model based on size, market capitalization, book-to-market ratio, profitability, and investment, in domestic and international settings, respectively. These authors find in both cases, that asset prices are their discounted value of expected dividends. It is important to point out that Fama and French (2015, 2017) do not implement double asset price accountability. Table 2 contains a summary of some the representative authors and their methodologies for the second period.

Table 2
Second period. Main methodologies on asset pricing

Methodology approach	Year	Author
Rebalancing and the arithmetic of investment	2009	Appell
	2010	Sharpe
	2010	Kinnel
	2012	Chaves and Arnott
	2012	Dimson *et al*.
	2012	Ellis
	2013	Sharpe
	2014	Bogle
	2014	Magni
	2017	Jacobsen
	2018	Pedersen
Arbitrage asset pricing	2008	Charles
	2009	Lester
	2011	Mertens and Ravn
	2016	Caiani *et al*.
	2017	Pernell *et al*.
	2018	Papadia
Collateral constraints and liquidity shocks	2009	Maćkowiak and Wiederholt
	2009	Shimer
	2011	Kiyotaki *et al*.
	2012	Kiyotaki and Moore
	2013	Blanchard *et al.*
Capital asset pricing model	2008	Aït-Sahalia and Brandt
	2009	Carr and Wu
	2009	Kan and Robotti

Continuación. Table 2

Methodology approach	**Year**	**Author**
Capital asset pricing model	2010	Bakshi *et al*.
	2010	Li *et al*.
	2011	Backus *et al*.
	2011	Nagel and Singleton
	2011	Ang and Kristensen
	2012	Allen and Powell
	2012	Chabi-Yo
	2012	Neuberger
	2013	Filipović *et al*.
	2013	Kozhan *et al*.
	2014	Christiano *et al*.
	2014	Bondarenko
	2015	Schneider
	2015	Barberis *et al*.
	2015	Ross
	2017	Bigio and Schneider
Factor asset pricing model	2010	Lewellen *et al*.
	2010	Fama and French
	2011	Hou *et al*.
	2012	Fama and French
	2013	Titman *et al*.
	2013	Watanbe *et al*.
	2015	Ball *et al*.
	2015	Fama and French
	2016	Fama and French
	2017	Fama and French
	2018	Sun *et al.*
	2018	Kozak *et al.*

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Methodology approach	Year	Author
Networks and systemic risk	2008	Freixas and Rochet
	2010	Freixas
	2011	Freixas and Christian
	2011	Christopher
	2012	Acemoglu *et al.*
	2012	Freixas and Rochet
	2014	Bramoullé *et al.*
	2014	König *et al.*
	2015	Freixas and Ma
	2015	Acemoglu *et al.*
	2016	Bolton *et al.*
	2017	Acemoglu *et al.*

Source: own elaboration.

Christopher (2011) calls for an integrated supply chain management, where the firm is at the centre of an interdependent network. Acemoglu *et al*. (2012) introduce networks to study productivity shocks, while in (2015) they use the (2012) general schema to study systemic risk. Bramoullé *et al*. (2014) and König *et al*. (2014) study game theory in a network context. Acemoglu *et al*. (2017) provide a network approach by using an idiosyncratic microeconomic shock and sectoral heterogeneity. Freixas (2010), Freixas and Rochet (2012), Freixas and Ma (2014), and Bolton *et al*. (2016) study banking competition and systemic risk networks under a regulation framework.

It is worth mentioning that table 2 displays heterogeneous agents' asset pricing methodologies. These methodologies pertain to the proposed second period, and they do not have the full set of theoretical general equilibrium assumptions underlined in the previous section.

4. Discussion on the transition of the asset pricing mainstream paradigm

The financial crisis of 2007-2009 marks a structural change with respect to leading economic indicators. This structural change is related with a shift in the Kondratieff long GDP wave economic cycle, as pointed for the empirical evidence provided by some of the authors already cited in section 1. The transition on the asset pricing mainstream paradigm is necessary to avoid discrepancies between rated and "true" prices. As mentioned before, these discrepancies were an important factor of the financial bubbles that lead to the global financial crisis of 2007-2009.

One example of asset pricing double accountability is narrated by Lucas (2014). He focuses on cash-payment technologies, which account for a total annual payment in the US during 2013 of $1 057 400 billion: roughly a quadrillion of dollars; while the corresponding dollar value of the US GDP in 2013 was about $17 000 billion. If one takes the ratio between both figures, it delivers the figure of $62 dollars. This implies that $62 dollars were transferred from someone to someone else, for every dollar of final goods and services produced in this economy, during this year. It is clear for Lucas (2014) that the payment system must cover much more than real purchases of goods and services. He says that the rest of payments -most of it- must be settlements of asset exchanges.

Lucas (2014) cash-payment technology example could be seen as if the same asset were traded 62 times under not uncertainty conditions. This does not imply that the asset price is $62 dollars. It could imply that the same asset was traded 62 times at one-dollar "true" price each time, even if there were only two traders and only one market. Given the figures provided by Lucas (2014), the financial market rated an asset price of $62 dollars per asset, whereas the "true" price is $1.00 dollar.

As show above, there is confusion between the financial asset price and the number of times it circulates. Therefore, the stage transition in the asset pricing mainstream paradigm needs to disentangle the number of transaction, from the "true" asset price. It seems erroneous to conclude that an asset whose "true" price is $1.00 dollar ends rated by the financial market in $62.00 dollars, as explained in the previous paragraph.[27]

[27] One example of this misconception is founded on Newman, *et al.*: "The instantaneous percentage change in price for a zero[-coupon] equals the change in yield times the maturity." p. 823. (Squared parenthesis added Carbajal-De-Nova, and Venegas-Martinez). It should be said, that in this definition "times" should be changed by adding. The theorem 2 of Berndt and Christensen (1973) supports this paper stand: "Strong separability with respect to the partition R is necessary and sufficient for the production function F(X) to be of the form $F(X^1 + X^2 + ... + X^r)$, where X^s is a function of the elements of N^s only." See also Sandmo (1972).

In order to keep separate asset prices and their number of transactions, the Fin Tech may help. This is because Fin Tech provides the statistical tools for both micro and macroeconomic efficient empirical analysis, as described previously. Besides, if financial and real markets operated with efficiency, then uncertainty and its insurance cost would not be a part of the asset price accountability. Solow (2008) expects a broadening in the kinds of data that are eligible for use in estimation and testing.

5. Conclusions

In the "before" period analyzed in section 2, data availability imposed on theoretical and empirical grounds the representative aggregate agent assumption, which causes inconsistencies between agents' behavior in asset pricing.

In the "after" period analyzed in section 3, the Fin Tech allows big data mining and machine learning at any level of aggregation, either micro or macro. Perhaps, the after period data availability is driven the theory and empirics to override the representative aggregate agent assumption, in the search for more reliable and realistic assumptions. A more realistic economic theory in agents' behavior asset pricing could help in preventing global financial crises, as the one occurred for 2007-2009 years.

As facts do not go away, economists are looking for a "better asset pricing methodology," were account efficiency could reduce discrepancies in asset prices. Therefore, it is desirable an evolution in the empirics and theoretical fields methodologies to reduce the double accounting methodology in asset pricing. On the whole, there is not still consensus on how the "better asset pricing methodology" should be. Perhaps, there would be still some years ahead until a more general agreement around this issue will be made.

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