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REGULAR ARTICLE

Share price formation, market exuberance and financial stability under alternative accounting regimes

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Abstract This paper develops a theoretical analysis of share market price formation driven by accounting and market structures. Heterogeneous investors are assumed to discover and process fundamental information disclosed by accounting system of share-issuing entity. Information set available to share market investors for decision-making comprises then market-driven and firm-specific (non-market) information. On the one side, accounting system provides collective signal of fundamental information; on the other side, price system provides collective signal of market-driven information over time. Both jointly drive the formation of aggregate share market prices through limited knowledge, hazard, and social interaction. Numerical simulations are provided under alternative accounting designs (namely, historical cost and fair value accounting regimes), to derive implications and recommendations for the concept and occurrence of speculative bubbles and herd behavior; the cyclical effects of accounting regime on share market dynamics; and the "value relevance" of accounting information and its role in the formation of share market prices over time. This numerical statistical analysis contributes to shed light on accounting anomalies and fundamental analysis.

Keywords Accounting information · Asset pricing model · Fundamentalism · Chartism · Large fluctuations · Financial bubbles · Market exuberance · Market microstructure · Historical cost accounting · Fair value accounting · Mark-to-market · Accrual anomalies

JEL Classification C63 · D4 · E17 · E37 · G17 · M41 · M48 · G1

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1 Introduction

The global financial crisis—triggered by the breakdown of interbank loan market during the summer of 2007—has resulted in partial and temporary suspension of fair value accounting and given impetus for its reassessment. Hearings held before committees of the US House of Representatives in October 2007 led to the drafting of a report by the "Financial Stability Forum" at the G7 meeting of April 2008. This report recommended strengthening the prudential supervision of leverage, liquidity and risk, clarifying and limiting the use of fair value accounting, improving off-balance-sheet accounting and increasing the resilience of financial and banking systems to tensions and crises (Bignon et al. 2009; Banque 2008; Banca d'Italia 2009; Henry and Holzmann 2009). On 2nd October 2008, the US Parliament adopted the so-called "Paulson plan," which, in sections 132 and 133, granted the Securities and Exchange Commission (SEC) with power to suspend application of fair value accounting for reasons of "public interest" and consistent with "protection of investors".[1] In January 2009, a report by the "Group of Thirty" (G30) condemned fair value for its role in creating systemic risks, low resilience and financial instability. These triggering events have renewed long-standing debates on suitable modes of accounting and prudential regulations for financial markets, questioning not only fair value accounting, but also its overarching reference to financial market-based regulation (Bignon et al. 2004; Acharya et al. 2011; Stout 2011; Biondi 2011a).

Contrary to other economic regulations and policies, recent literature has neglected economic consequences of accounting regulatory regimes. In the aftermath of the global financial crisis, however, accounting ceased to be relegated among obscure, irrelevant technicalities to be included into the core of financial market architecture. Accounting has then become a major financial regulatory issue (Enria 2004; Magnan 2009; Pozen 2009; Acharya et al. 2011). Generally speaking, accounting plays two main roles in securities and exchange regulation (Pinnuck 2012; Henry and Holzmann 2011): On the one side, information provision to prospective investors, financial analysts and other gatekeepers; on the other side, corporate stewardship for and accountability to shareholders and other holders of listed securities, which are issued by business firms and financial institutions, and traded on regulated exchanges. In this way, corporate accounting systems make securities-issuing entities accountable for their financial performance. Already in 1943, George May (1943: 21) argues that "the present ferment in accounting thought is very largely due to conflicting objectives of those who would continue to regard financial statements as reports of progress or of stewardship, and those who would treat them as being in the nature of prospectuses". Concerned with both accounting roles, policy-makers and regulatory bodies

[1] Emergency Economic Stabilization Act of 2008, 3 October 2008, Sec. 132. Authority to suspend mark-to-market accounting: "(a) AUTHORITY—The Securities and Exchange Commission shall have the authority under the securities laws (as such term is defined in section 3(a)(47) of the Securities Exchange Act of 1934 (15 U.S.C. 78c(a)(47)) to suspend, by rule, regulation, or order, the application of Statement Number 157 of the Financial Accounting Standards Board [concerned with fair value measurements, NdA] for any issuer (as such term is defined in section 3(a)(8) of such Act) or with respect to any class or category of transaction if the Commission determines that is necessary or appropriate in the public interest and is consistent with the protection of investors." Analogous decisions were taken by European authorities thereafter.

have recently realized that accounting numbers are not straightforward “natural” measurements, but socioeconomic “artificial” constructions that are framed and shaped by standards and conventions, which fundamental accounting principles of reference underpin (Biondi 2011b). Let us label every whole of accounting techniques, standards and principles as an “accounting regime” hereafter.

To assess alternative accounting regimes (Bignon et al. 2004; Ijiri 2005; Laux and Leuz 2009; Barth and Landsman 2010; Yuan and Liu 2011; Kusano 2012), some students try to develop empirical tests exploiting available data. These empirical analyses face serious theoretical and practical limits. Concerning the global financial crisis, fair value accounting was factually suspended before that its application would trigger its main effects. Although suspension itself can be considered as evidence of accounting relevance for financial crisis dynamics (at least in actors’ perception), its empirical assessment is irremediably undermined. In addition, only one series of market prices—that generated under the accounting regime that is currently in place— can be assessed by econometric methods, while possible series under alternative regimes cannot be obtained under identical identifiable conditions that are under experimenter’s control. Moreover, it seems difficult to disentangle and assess the distinctive contribution of fair value accounting since corporate accounting policies—which interpret and apply accounting standards—constitute a further autonomous dimension that prevents straightforward transmission between accounting regimes and accounting numbers. In this context, other students aim to identify mode and channel of interaction between accounting numbers and actors’ behaviors. Most contributions point then to sudden illiquidity of financial assets, or unexpected lack of funding for actors involved in distressed financial market dynamics. Although relevant, these cases remain special ones. Focus on them may eventually justify inconsistent accounting rules which depend on peculiar circumstances: Fair value accounting may be and have been considered as the most suitable mode of accounting as long as share market is “liquid” and “active” (or going-up, cynically speaking), while it would require suspension once share market becomes “illiquid” or “inactive” (or going-down). Opportunistic behavior, structuring opportunities, moral hazard and regulatory capture may be reinforced by such an intermittent theoretical position, while the comprehensive relationship between accounting and financial market dynamics remains unaddressed.

Our paper aims to comprehensively address the relationship between accounting regimes and the dynamics of share market price formation over time. Share market price cycles and their aggregate characteristics in terms of market volatility and market exuberance shall be connected to alternative accounting regimes in a comparative analysis that applies the theoretical model developed by Biondi et al. (2012) and Biondi (2013). The latter provide a complex systems approach to financial market dynamics based upon common knowledge and social opinion dynamics. Embedded in a financial system, interacting heterogeneous investors are imagined to trade entity shares through a collective device (a Share Exchange, or share *price system*), under collective provision of accounting information on financial performance of a share-issuing entity (through a corporate *accounting system*). This approach develops a model of the role of accounting in financial market dynamics that allows an assessment of the relative capacity of alternative accounting regimes to enhance financial market resilience while explicitly recognizing the socio-economic context that underlines the formation of share market prices over time. This context involves social interaction, processes and institutions. In particular, this model purports to improve understanding of and provide insights into the effects of alternative institutional configurations, striving then for simplicity with the ultimate goal of incorporating only the features that are necessary to generate the phenomenon of interest. This model consists of a population of heterogeneous investors, an environment in which the investors interact (a financial system), and some sets of rules (or minimal institutions, in Shubik's words) that frame and shape the interaction among investors. It considers two minimal institutions that constitute a dual institutional architecture for the financial system under investigation: An accounting system related to the congeries of the business firm; and a market price system related to the Share Exchange. Both institutions provide collective mechanisms that enable investors' interaction, common knowledge discovery and transmission, and collective action over space and time.

From this perspective, discovery and processing of entity-specific accounting information is expected to play a specific role in the making of individual expectations and related investment decisions, influencing the formation of aggregate market prices over time. According to the conceptual framework of US Financial Accounting Standards Board (FASB, CON 2—par 98), "accounting information cannot avoid affecting behavior, nor should it," for accounting does integrate modes of management, governance, and regulation. This implies that alternative accounting representations cannot be "neutral" with respect to the underlying socioeconomic activities, i.e., they cannot rest "without influence on human behavior" (*ibidem*). Information set available to investors is then jointly composed by market-driven and firm-specific information. On the one side, share market (or Share Exchange) constitutes an institution that collectively generates an aggregate share price over time. On the other side, accounting system (and regulation) conveys a specific representation of corporate affairs that defines accrued performance and payments of the business entity to shareholders (influencing share investment pays-off in this way), providing a collective signal to current and prospective investors interested in trading entity shares.

This concept of a dual information set expands upon semi-strong form of market efficiency (Fama 1970, 1991), which Fama and French (1992) relate to firm-specific information driven by fundamental analysis. Fama (1970) distinguishes three forms of share market efficiency depending on alternative information sets available to investors. Weak form includes only history of market prices; semi-strong form includes all publicly available information; strong form includes all publicly and privately existing information. Our approach delves into publicly available information set to disentangle two distinctive subsets: one driven by share market pricing (essentially, a history of market prices), another one comprising firm-specific information made available to investors by another institution that complements the share market itself. The first subset is generated by a price system; the second subset is provided by an accounting system of reference. This dual structure fits the duality that characterizes the share pricing process, making it dependent on a monetary and an epistemic dimension. Concerning the monetary dimension, each investor forms his own expectations (or guesses) on the dividend flow (earnings) and capital gains or losses (equity premium) from share market prices over time. Individual investor's financial return (pay-off) depends then on the market price he may obtain by selling his shares (or the market price he should pay for buying the entity shares), and on dividend flow (earnings) that is distributed by (accrued to) share-issuing entity. This dividend flow is defined and represented by an accounting regime of reference. Concerning the epistemic dimension, individual investor's decision-making deals with two information flows provided by distinctive institutions. One flow of information is generated by the Share Exchange and subsumed by aggregative (collective) pricing processes through time (Phelps 1987; Kirman 1999). Another flow comes from the accounting system that generates collective information from outside the market trading. Together with other institutions external to share market trading (Frydman 1982), accounting system facilitates then the working of the share market over time (Sunder 1997; Biondi 2008, 2011a,b).

Following Biondi et al. (2012) and Biondi (2013), in presence of heterogeneous individual mindsets, price system and accounting system complement each other in driving share market price formation trough time. This financial *system* (which is no longer an equilibrium)[2] consists in, and depends upon the coherence and universal diffusion of relevant and reliable knowledge by means of both a price system and an accounting system publicly determined and announced. The current period in-between ex ante and ex post locates here among future time, submitted to individual guesses and intentions, hopes and fears, and past time, a history of reporting that, in principle, may be partly public, consistent, and conventionally agreed (Shackle 1967). In this context, accounting reporting and disclosure provide public common knowledge (Sunder 2002) through relevant and reliable signals on financial performance generated by share-issuing entity over time (entity-specific information). Share Exchange provides aggregate pricing of entity shares through trading between interacting heterogeneous investors, which are potentially informed on entity-specific information that is reported under an accounting regime of reference.

Drawing upon this theoretical framework (Biondi et al. 2012; Biondi 2013), our paper introduces alternative accounting regimes that provide distinctive fundamental information signals of accounting performance. In this way, each accounting regime frames and shapes an imagined world in which investors are embedded and make share trading and investment decisions. Numerical simulation shall provide comparative assessment of aggregate performance of various financial systems submitted to these 'imagined worlds of accounting' (Sunder 2011). A systemic statistical analysis shall then address the following three issues: market volatility, related to occurrence and impact of speculative bubbles (fluctuations) generated by herd behavior by individual investors; market exuberance, related to formation of market price fluctuations over intrinsic fluctuations driven by underlying economic fundamentals; and the statistical correlation between accounting signal series and market price series, which relates to the so-called "value-relevance" of accounting information for share investment decision-making. This latter analysis may shed light on "accounting anomalies" discovered by Sloan (1996) and recently discussed by Richardson et al. (2010) and Lewellen (2010).

[2] Our analysis distinguishes system and equilibrium as distinctive concepts (Shubik 1993; Foley 1994; Biondi 2013).

The rest of the paper is organized as follows. The next three sections summarize our model, which comprises alternative accounting regimes (Sect. 2); formation of individual expectations and decision-making (Sect. 3); and evolution of market clearing price generated by matching aggregate share demand and supply through time (Sect. 4). Section 5 provides numerical simulation findings of aggregate performance of financial systems under alternative accounting regimes. In particular, it investigates economic consequences of accounting systems which do either replicate information generated by the share market (so-called fair value accounting regime), or constitute an autonomous source of firm-specific information (so-called historical cost accounting regime). Theoretically informed implications and recommendations are then derived regarding cyclical effects of accounting information on share market dynamics and allocative efficiency of share market price formation (Boyer 2007; Rochet 2008), including interpretation and occurrence of speculative bubbles, as well as "value relevance" of accounting information. A brief summary concludes.

2 Accounting Information under alternative accounting regimes

Information set available to investors for share investment decision-making comprises two subsets of collective information:

- market-driven information subsumed by an history of share market price formation;
- firm-specific information subsumed by financial reporting and disclosure over time.

While the following section treats individual discovery and processing of available information, this section disentangles entity-specific collective signal $f_t(\cdot)$ that every investor i can integrate in his own mindset through an individual weight $0 \leq \varphi_i \leq 1\ \forall i$. Each investor is then supposed to apply his own interpretation of this "fundamental" while all investors attribute the same sign to it. A further extension may consider a disturbed or misunderstood signal.

For every investor, a subset of fundamental information Y_t is available on period t and specific to business firm k. Through this subset, the accounting system provides an *accounting lighthouse* for share market dynamics by delivering a collective signal of financial performance $f_t(\cdot)$. Theoretically speaking, Y_t refers to information provision through an accounting system that makes share-issuing entity accountable for its financial performance and position, while $f_t(\cdot)$ refers to a collective signal inferred through fundamental analysis from Y_t by individual investors involved in share investing and trading. Changes in this signal F_t are expected to assist individual investors in forming their own expectations through time:

$$f_t = f_t(\cdot\,|Y_t) \quad \forall t \tag{1}$$

$$F_t = f_t - f_{t-1} \quad \forall t > 0. \tag{2}$$

This simple formulation is sufficient for our aggregate statistical analysis of financial systems under alternative accounting regimes. We can imagine that $f_t(\cdot)$ comprises several methods of fundamental analysis, all based on the subset of entity-specific information Y_t. Financial performance ratios such as price-to-earnings and market-to-

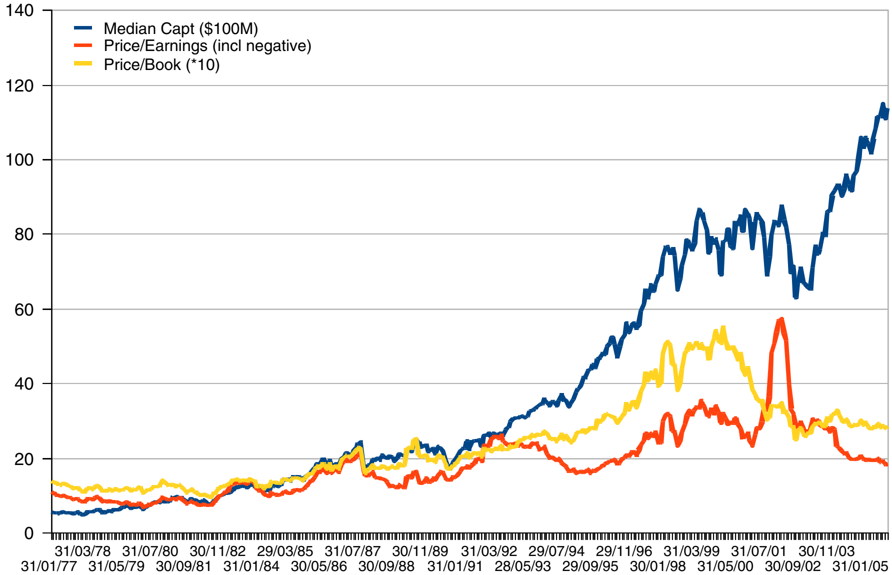

Fig. 1 Median market capitalisation, price-to-earnings ratio, and price-to-book ratio (S&P500; 1977–2005). Descriptive statistics based on S&P/Barra Monthly Indexes available at http://www.barra.com/Research/Description.aspx

book provide heuristic examples of these methods (Fig. 1). This heuristic leads to the following clear-cut interpretation:

- When $F_t > 0$, fundamental signal communicates improving perspectives, then attentive individual investors may expect that future prices increase;
- When $F_t < 0$, fundamental signal communicates worsening perspectives, then attentive individual investors may expect that future prices decrease;
- When $F_t = 0$, fundamental signal conveys an unclear message, leading attentive individual investors to ignore it in individual expectation formation.

In sum, heterogeneous investors are supposed to interpret available fundamental information Y_t to assess the *gap* between current aggregate pricing p_t and the fundamental pattern of financial performance of share-issuing entity k. Attentive investors may then include this gap in their expectations at some extent, according to their views on respective evolutions of business firm and share market price dynamics.

An empirically-based interpretation of this accounting signal f_t consists in exploiting accounting information to assess market pricing (Demsetz 1995: 93). This interpretation is in line with financial accounting literature that assumes *unconstrained* and *constrained* relationships between share market price series and available accounting information.[3] Concerning unconstrained relationship analysis,

[3] Accounting studies analyse an ‘unconstrained relationship’ when they delegate their implicit model of reference to applied econometric methods (usually linear regressions). They analyse a ’constrained relationship’ when they explicitly introduce a model which generates hypotheses (and restrictions) on the parameters to be estimated.

Lev and Zarowin (1999) disentangle three measures of f_t for each company k listed on the NYSE between 1977 and 1996, that is, $f_t \equiv \{f1_{k,t}; f2_{k,t}; f3_{k,t}\}$. By defining $p_{k,t} = \alpha_0 + \alpha_1 f1_{k,t} + \alpha_2 f2_{k,t} + \alpha_3 f3_{k,t}$, they analyze the *unconstrained* relationship between yearly average market prices $p_{k,t}$, and accounting measures of shareholders' accounting earnings $f1_{k,t}$, cumulated shareholders equity $f2_{k,t}$, and other relevant information on the business firm $f3_{k,t}$ (independent from $f1_{k,t}$ and $f2_{k,t}$). Accordingly,[4] the yearly cross-sectional association between share prices and accounting measures, as assessed by R^2, is above 0.9 during 1977 and 1988, and around 0.6 during 1989–1996— R^2 being here a measure of estimation error of p from accounting measures weighted by firm, with weights α obtained by cross-sectional annual regression. Concerning *constrained* relationship between market price series and accounting information, our design relates to the fundamental financial analysis literature (Dechow et al. 1999; Ohlson 1995; Feltham and Ohlson 1995; Ou and Penman 1989; Abarbanell and Bushee 1998). This literature empirically investigates persistence of corporate earnings to shareholders (determined by corporate accounting systems) through either time-series behavior or conditioning determinants (Lev and Thiagarajan 1993; Chant 1980; Freeman et al. 1982).

In fact, to comparatively assess alternative accounting regimes, our statistical mechanics approach looks beyond empirical analysis to compute share market price series under possible accounting regimes of reference. A simple representation of these regimes is then required for numerical simulation purposes. Therefore, we look for a synthetic design of F_t in its reduced form.[5] Generally speaking, two distinctive families of accounting regimes exist: one based on fair value accounting, another one on historical cost accounting (Anthony 2004; Biondi 2011b). They do respectively perform:

- Collective provision of firm-specific information that follows information provided by share market (so-called fair value accounting model);[6]
- Collective provision of firm-specific information that constitutes an autonomous source of firm-specific information (so-called historical cost accounting model).

In both cases, accounting system is an integral part of institutional architecture that contributes to define investment pays-off over time:

- From a monetary viewpoint, accounting system declares financial performance accrued to shareholders (whether distributed as dividends and buybacks, or not);
- From a cognitive viewpoint, it provides collective signal of fundamental performance of share-issuing entity to current and prospective investors.

According to Nissim and Penman (2008), a perfect fair value accounting model matches each asset and liability (shareholders equity being a residual between them) to its current market price of reference. Changes in accounting performance are then

[4] See also Nichols and Wahlen (2004), Bissessur and Hodgson (2012).

[5] A further extension may develop a two-step modeling strategy, moving from fundamentals (Y) to further design the ways to represent them through accounting reporting and disclosure (f).

[6] For sake of simplicity, we consider mark-to-market accounting and fair value accounting synonymously, under the label FVA. While mark-to-market accounting implies the use of observable market prices to measure current value of every asset and liability, fair value accounting includes the recourse to observable and unobservable inputs to reproduce that value.

Table 1 Heuristic balance sheet and fundamental accounting information under fair value accounting model (and efficient markets hypothesis)

Time	Asset market price $E_t(\mu_t)$	*Asset* μ_t	Shareholders equity (e_t) $t: e_t = \mu_t$	Earnings (F_t) $t > 0: e_t - e_{t-1}$	Cumulated earnings + initial equity (f_t) $t: e_{t=0} + \sum F_t$	Share market price (p_t) $E_t(e_t)$
$t = 0$	1,000	1,000	1,000	0	1,000	1,000
$t = 1$	1,100	1,100	1,100	100	1,100	1,100
$t = 2$	975	975	975	−125	975	975
$t = 3$	900	900	900	−75	900	900
$t = 4$	1,050	1,050	1,050	150	1,050	1,050
$t = 5$	1,000	1,000	1,000	−50	1,000	1,000

delivered by aggregate changes of this portfolio of assets and liabilities in kind and current value. The simplest case consists in one share-issuing entity which indefinitely holds one permanent financial asset μ, whose initial acquisition was fully financed by issuance of shareholders equity. This asset has an efficient market price of reference $E_t(\mu_t) = u_t$ which varies exogenously. At every point of time t, accounting system is updated to the most recently available price for the asset μ_t. No measurement problems occur in this context. A perfect share market is then supposed to match the share price p_t with the asset price in a one-to-one correspondence, that is, $\mu_t = E_t(e_t) = p_t$, because corporate portfolio is exclusively composed by that asset whose market price is supposed to incorporate all relevant information at each point of time t. Under fair value accounting, every change in accounting performance F_t corresponds then to an equal change in share price p_t. The reverse is also deemed true: since market pricing is supposed to incorporate all available information timely, accounting information f_t should follow market price pattern p_t (Biondi 2013; Kothari 2001). Table 1 summarizes this temporal correspondence between accounting information and a perfect efficient share market price.

Therefore, a reduced form of fair value (mark-to-market) accounting implies to connect accounting signal F_t to changes in current share price p_t in a one-to-one correspondence, even though some time lags and white noises should be added to take into account actual accounting processes over time. This simplified form is sufficient for aggregate statistical analysis that is purported by our approach. Accordingly, under fair value accounting (FVA), F_t may be designed alternatively as:

$$F_t^{FVA1} = p_{t-1} - p_{t-2} \pm \epsilon$$

or

$$F_t^{FVA2} = p_t - p_{t-1} \pm \epsilon$$

According to Biondi (2011b), a perfect historical cost accounting model delivers a fundamental signal that is deemed independent from share market conditions. This accounting method points to economic and financial flows generated by the business entity over time, ignoring capital market fluctuations. A simplified form of historical cost accounting generates then a fundamental signal that is exogenous to share price dynamics. Under historical cost accounting (HCA), F_t may be designed alternatively as:

$$F_t^{HCA1} = U[-a, +a] \pm \epsilon \quad \text{with } a \geq 0$$

or

$$F_t^{HCA2} = U[-a, +a] + N[0, +b].\frac{\sum F_{t-1}^{HCA2}}{f_{t=0}} \pm \epsilon \quad \text{with } b > 0.$$

In sum, two distinctive forces drive share price formation over time: a pattern of fundamental information; another pattern of aggregative market pricing. In Lucas's terms, this framework distinguishes between a "real" (or productive) driver (related to the accounting system of share-issuing entity) and a "monetary" (or distributive) driver (related to the price system generated by Share Exchange). Each driver generates a distinctive pattern, providing specific cognitive features. Every investor exploits both patterns to infer a personal assessment of aggregative market pricing process while revising his expectations over time. The way in which these two patterns interact over time further depends, therefore, on individual expectations formation and revision through time and social interaction.

3 Individual investor's decision-making

Aoki and Yoshikawa (2006) show that two broad categories of chartism and fundamentalism account for most of possible investment strategies in financial markets. Drawing upon Biondi et al. (2012), our model introduces individual expectations formation featured by chartism (speculation) and fundamentalism. In line with Chiarella and Iori (2002), Horst (2005), and Anufriev and Panchenko (2009), chartists are investors that only care about the market-side of the financial system dual structure, while fundamentalists are assumed to be committed to discover and treat also the accounting-side of it. Individual investors deal with this dual information set (and react to its dual incentive structure) according to their individual strategies. However, their bids and asks occur under conditions of limited rationality that common knowledge provided by the price and accounting systems cannot overcome. No such a thing as perfect foresight exists in our financial system that introduces degrees of freedom, chaos and dynamics in ways that no equilibrium model can solve and reduce. Therefore, our financial system is no longer captured by a unique steady state pattern. In particular, while individuals apply heuristics, rules-of-thumb and biases to make decisions in this *puzzling* world, alternative accounting regimes shape the market pricing process over time. Therefore, the aggregative market process delivers different pricing according to the ways information on (and incentives from) fundamentals are designed for, and exploited by share market participants.

Two main classes of investors exist: investors $j = S$ that do hold shares (shareholding investors inside the share market) and investors $j = D$ that do not (potential shareholders outside the share market). For each class, every investor is individually characterized by an individual parameter $0 \leq \varphi_i \leq 1\ \forall i, j$. All these risk-neutral investors i conjecture about share price-return relationship over time. They form heterogeneous and timely expectations based upon available information set comprising market-driven and firm-specific information. No discount or alternative investment option rates apply.[7] On this basis, following Hirota and Sunder (2007) and Heemeijer et al. (2009), our generic model[8] of individual expectations $E_{i,t}(p_{t+1})$ comprises current market price p_t, forecast revision of past price expectation $E_{i,t-1}(p_t)$, market price trend $(p_t - p_{t-1})$, and the accounting signal from fundamental analysis F_t. Let define the following price expectation function which includes all the possible mindsets of generic investor i:

$$E_{i,t}(p_{t+1}) = p_t + \alpha_{j,t}(p_t - p_{t-1}) - \beta_j \varepsilon_{i,t} + \gamma \varphi_i F_t \tag{3}$$

where

$$\varepsilon_{i,t} \equiv E_{i,t}(p_t) - p_t. \tag{4}$$

Investors outside the market ($j = D$) are potential investors which currently do not hold shares. Consequently, these investors are assumed not to revise their past expectations on market prices, while investors inside the market (which currently hold shares, $j = S$) do:[9]

$$\beta_j = \begin{cases} 0 & \text{if investors do not hold shares (potential demand, } j = D) \\ \beta_{j=S} & \text{if investors do hold shares (potential supply, } j = S). \end{cases}$$

Each investor has featuring preferences about relative weights attributed to each component. This means that our frame of analysis does not assume an alleged identity between market clearing price and firm's value (Biondi 2013). Together with β_j, individual heterogeneity is denoted by an individual parameter φ_i and a social group parameter $\alpha_{j,t}$. Through φ_i, every investor pays a personal degree of attention and confidence to accounting signal F_t derived from fundamental analysis applied to entity-specific information Y_t. The latter includes an history of dividends, accounting data such as earnings and book values, and qualitative information concerned with fundamental performance and position generated by the share-issuing entity through time. For instance, fundamentalists $(i : \varphi_i > 0)$ are investors which are capable to discover and process firm-specific information provided by accounting system under alternative

[7] This is not less restrictive than the widespread hypothesis of a fixed discount rate on the whole time period of analysis.

[8] This model of price expectation $E_{S_{t,I}}(p_{t+1})$ results from a combination between a "first order adaptive model": $E_t(P_{t+1}) = E_{t-1}(P_t) + \beta' \left(P_t - E_{t-1}(P_t)\right)$ where β' weights the revision of the most recent expectation error, and an "extrapolative expectation model": $E_t(P_{t+1}) - (P_t) = \gamma(P_t - P_{t-1})$ where γ weights the most recent price change (trend). With $\gamma > 0$, any market price increase results in increasing the price expectation.

[9] This is equivalent to set $\beta_i = 0$ in Eq. (3), implying an "extrapolative expectation model" outside the market. This hypothesis increases heterogeneity between investors but remains a minor analytical assumption that is not critical for our theoretical frame or simulation findings.

accounting regimes. Pure fundamentalist and pure speculator are then included as special cases with $\varphi_i = (0; 1)$: Pure speculator is characterized by $\varphi_i = 0$; pure fundamentalist by $\varphi_i = 1$; all other investors by $\varphi_i \in (0, 1)$. Investors further attribute a weight $\alpha_{j,t}$ $(j = S, D)$ to share market price trend. This latter parameter is fixed at each period for each class of investors before trade occurs, but it may evolve period after period according to social opinion dynamics on market price evolution: $\alpha_{j,t}$ captures then social group j sentiment (mood) on share market pricing evolution expressed by shareholding $(j = S)$ and potential $(j = S, D)$ investors over time (Biondi et al. 2012).[10]

Conditions of limited information, uncertainty, heterogeneity and social interaction prevent investors to conform to rational expectation behavioral frame. However, they still *intend to* link their individual strategies to expected return (pays-off) R from share investment:

$$R = E_{i,t}(G_{i,t} - p_t) \quad \forall i, t \tag{5}$$

where $G_{i,t}$ is the prospective potential gain which depends upon both expected dividend flow d_{t+1}, and expected equity premium on share price change period by period $p_{t+1} - p_t$, $\forall t$. Fundamentalists may also purport to exploit signals of fundamental analysis F_t (based upon Y_t) in order to better estimate prospective dividend flow generated by the share-issuing entity over time. They may then look after accounting earnings and other accounting measurements instead of dividends (Campbell and Shiller 1988; Ohlson 1995). Therefore, investors inside (outside) the market S (D) decide to sell (buy) or hold (wait to buy) shares as follows:

$$\begin{aligned} &\text{if } p_t \geq E_{j,t}(G_t) \text{ then investor } i_{j,t} \text{ wishes to sell (waits to buy)} \\ &\text{if } p_t < E_{j,t}(G_t) \text{ then investor } i_{j,t} \text{ does hold (wishes to buy)} \\ &\text{where } j = S, D. \end{aligned}$$

At each period t, investors decide their strategy according to their time horizon, by looking at the market side and the firm-specific (non-market) side of the financial system. Notably, no investor i is forced to sell immediately according to his fundamental analysis findings. For instance, although one share-holding investor expects that, on a longer run, market price will eventually decrease because of a fall of prospective fundamental performance F_t, he may nevertheless decide to hold his shares if he believes that next period market price—being so higher than current market price—may compensate this fall and deliver then an expected net gain. In this case, a fundamentalist investor acts like a short-term speculator in his search for satisficing expected return from share investment. For sake of simplicity, we neglect hereafter ongoing dividend flow d_t that can be subsumed by fundamental performance F_t, theoretically speaking. Accordingly, every investor decides his strategy according to his *focal price* $E_t(p_{t+1})|_i^j$. In particular, every shareholder i $(j = S)$ would wish to sell if

[10] A further extension may analyze changing pattern of individual price expectation, by considering transaction and information-treatment costs, as well as revision of individual parameters (including φ_i) according to individual learning or social interaction over time (Frydman and Goldberg 2008; Biondi et al. 2012). Biondi and Righi (2013) investigate simulation results across parameter space of $\alpha_{j,t}$ $(j = S, D)$ that is then assumed to depend on dominant market mood expressed by supply and demand sides through time.

$p^*_{t+1} \geq E_t(p_{t+1})|^S_i$, while every potential buyer i ($j = D$) wishes to buy if $p^*_{t+1} \leq E_t(p_{t+1})|^D_i$.

4 Aggregate market matching

At this stage, individual trading strategies are only *wishes*, since they *may or not* meet a willing counterpart to eventually perform a share trade. This matching step may be realized through aggregation of individual buy/sell orders on the marketplace. Trading occurs then on disagreement (Stout 2011; Biondi 2011a): Speculative capital gains (or losses) are then made possible by inconsistent plans between investors (Tirole 1982).

Our model applies Biondi et al. (2012)' model which proves to capture stylized facts of empirical significance for financial market dynamics at the aggregate level. Bensimhon and Biondi (2013) and Biondi (2013) provide further experimental evidence corroborating the model working in several artificial security markets. This model is designed to capture aggregate behavior of the financial system generated by the share market pricing process under alternative accounting regimes, in line with Foley (1994) and Di Guilmi et al. (2012). Our share market enables trading on shares of one business firm. To perform aggregate statistical analysis, total number of entity shares is normalized to one. Total number of investors is also normalized to one, while a biunivocal correspondence exists—period by period—between each investor i and his individual parameter $\varphi_i \in [0, 1]$, both inside the market (among shareholders, $j = S$) and outside it (among potential investors, $j = D$). Most of idiosyncratic individual heterogeneity is then captured by this parameter φ_i.

From this perspective, Share Exchange is a collective institution that, according to its own design, generates an aggregate market price p_t at every period t. In our model, at each period, a market-making rule places all the orders posted by individual investors (according to their focal prices) in a limit order book that ranks these orders according to their reference price. Orders are satisfied (when possible) according to this ranking. This mechanism to aggregate demand and supply is designed as a one-period batch auction where investors simultaneously post buy/sell orders, while a market-making rule calls an aggregate price in search of achieving aggregate clearing that matches individual bids and asks over time, in line with Anufriev and Panchenko (2009).

Following Foley (1994), if investors are many and relatively small, a homogenous aggregate distribution can be assumed for both classes that respectively denote potential demand side ($j = D$) and potential supply side ($j = S$) of the share market. Accordingly, market-clearing price p^*_{t+1}—being settled at period t - depends on *focal prices* by extreme investors outside ($\underline{P}_I$ and $\overline{P}_S$) and inside ($\underline{P}_D$ and $\overline{P}_D$) the market as follows:

$$p^*_{t+1} = \begin{cases} p^{NC} = p_t + \varepsilon_{t+1} & \text{if } \overline{P}_{D,t} \leq \underline{P}_{S,t} \\ \frac{\overline{P}_{D,t}(\overline{P}_{S,t} - \underline{P}_{S,t}) + \underline{P}_{S,t}(\overline{P}_{D,t} - \underline{P}_{D,t})}{(\overline{P}_{D,t} - \underline{P}_{D,t}) + (\overline{P}_{S,t} - \underline{P}_{S,t})} & \text{if } \overline{P}_{D,t} > \underline{P}_{S,t} \end{cases}$$

This market microstructure implies that collective pricing does not simply result from spontaneous and always perfect matching of individual expectations, since individual expectations may differ one from another and be disappointed in some circumstances. Furthermore, investors cannot react upon contemporaneous equilibrium-fixing price because they trade through a market orders book. Therefore, Share Exchange may experience aggregate lack of demand or supply, and even lack of transactions, at the called market-clearing price. In the latter case $p^*_{t+1} = p^{NC}$, we assume that a market-making rule calls again the last clearing price p_t with a small tick value: ε_{t+1}.

In sum, clearing price settlement passes through computation of focal prices expressed by extreme investors on demand and supply sides ($\overline{P}_S$, $\underline{P}_S$, $\overline{P}_D$ and $\underline{P}_D$). Focal prices ranking especially depends on the sign of fundamental signal $F_t(\cdot)$ that evolves over time. Notably, relative aggregate degree of fundamentalism—for both demand and supply sides of share market—is *endogenously* determined by share market dynamics; therefore, aggregate market sentiment does not depend only on exogenous subjective attitudes and beliefs (see "Appendix" for further analysis and details; Biondi et al. (2012)). Through this market mechanism, Share Exchange generates a time series of aggregate market prices over time. Two systemic forces jointly drive this series: the price system generated by individual bids and asks, and the accounting system that denotes established processes of reporting and disclosure of fundamental performance generated by the share-issuing entity. Accordingly, dual information set available to investors at time t includes present and past fundamental information, and an history of share market prices. This framework of analysis shall apply to comparatively assess aggregate performance of financial systems under alternative accounting regimes, through numerical simulation.

5 Simulation

Share price formation depends here on heterogeneous individual decision-making, aggregate market matching, and alternative accounting regimes. From this perspective, investors do not know (agree on) fundamental value of shares, but receive two distinctive collective signals about it: one from accounting system, and another one from market price system. This dual structure establishes a comprehensive relationship between alternative accounting regimes and share market process of investors' decision-taking and bidding. In order to provide numerical assessment of alternative accounting regimes, we shall utilize the following specification:

$$E_{i,j,t}(p_{t+1}) = p_t + \alpha (p_t - p_{t-1}) - \beta_j \varepsilon_{i,t} + \gamma \varphi_i F_t$$

where

$$\alpha = \frac{1}{2}$$

$$\beta_j = \begin{cases} 0 & \text{if investors do not hold shares (potential demand, } j = D) \\ \beta_j = \frac{1}{2} & \text{if investors hold shares (potential supply, } j = S) \end{cases}$$

$$\gamma = 1.$$

This calibration aligns both the weight $\alpha = \frac{1}{2}$ for market price trend and the weight for forecasting error revision $\beta_{j=S} = \frac{1}{2}$, with median investor identifier $\varphi_i = \frac{1}{2}$. This makes model microstructure as much neutral as possible, since all individual expectations drivers have the same weight fixed at the median point of aggregate uniform distribution. At the same time, this model microstructure calibration concentrates all the driving dynamics on fundamental signal F_t generated by alternative accounting regimes. Drawing upon our assumption of uniform class distribution among investors, we can further define forecasting error revision by generic investor i as follows:

$$\varepsilon_{i,t} = (1 - \varphi_i)\, \varepsilon_{i=0,t} + \varphi_i \varepsilon_{1=1,t} \quad \forall i, t$$

with

$$\varepsilon_{i=0,t} \equiv E_{i=0,t}(p_t) - p_t$$
$$\varepsilon_{i=1,t} \equiv E_{i=1,t}(p_t) - p_t.$$

Expected focal prices by four extreme investors become:

$$E_{i=0,j=D}(p_{t+1}) = p_t + \frac{1}{2}(p_t - p_{t-1}) \equiv P_{0,t}$$
$$E_{1,D}(p_{t+1}) = P_{0,t} + F_t$$
$$E_{0,S}(p_{t+1}) = P_{0,t} + \varepsilon_{i=0,t}$$
$$E_{1,S}(p_{t+1}) = P_{0,t} + \varepsilon_{i=1,t} + F_t.$$

For simulation purposes, we assume that aggregate market price when market does not clear is fixed by the following rule:[11]

$$p^{NC} \equiv p_t^* + 0.01\varepsilon \quad \text{with } \varepsilon \sim U(0; 1)$$

and

$$p_t \text{ and } \sum_{s=0}^{t} F_s > 0 \quad \forall t$$
$$p_0 = f_{t=0} = 1{,}000$$
$$F_{t=0} = 0.$$

Under fair value accounting, we calibrate a signal F_t that reproduces the change in the market price level with one period lag (that is, either $p_{t-1} - p_{t-2}$ or $p_t - p_{t-1}$) plus a small uniform random noise:

$$F_t^{FVA1} = p_{t-1} - p_{t-2} \pm \frac{1}{2} U[-1, +1]$$

or

$$F_t^{FVA2} = p_t - p_{t-1} \pm \frac{1}{2} U[-1, +1].$$

[11] This random error ϵ_t could result here from the working of a drunk auctioneer!

This calibration corresponds to fair value accounting regime that assumes a perfect correlation between accounting information and current market price with some time lags. It applies then a perfect stock accounting method on information *available* at period t (accounting information on period t being generally available only at period $t + 1$).

Under historical cost accounting, we calibrate a signal F_t that generates an exogenous time series in the following ways:

$$F_t^{HCA1} = U[-1, +1]$$

or

$$F_t^{HCA2} = U[-1, +1] + N(0, 1)\frac{\sum_{s=0}^{t-1} F_s}{f_{t=0}}.$$

This calibration corresponds to an accounting regime that determines accrued performance to shareholders, period by period, exogenously from share market conditions. It applies then a perfect flow accounting method on fundamental information available at period t, jointly composed by randomized positive and negative flows which ignore capital market fluctuations. Notably, uniform random noise added to these series is twice larger that uniform random noise added to fair value accounting series.

In order to focalize simulation results only on comparative assessment of alternative accounting designs, we perform all the simulations under initial individual price expectations $E_{i,j,t}(p_{t+1})$ that are at very small variance around the initial price and initial fundamental signal $p_0 \equiv f_0$. These random values are required to start-up the aggregative market matching computation at period $t = 0$, while simulation results are computed upon periods from $t = 1$ to $t = 100$. These initial assumptions are expected to become irrelevant because of period 0 waiving, periods' sequence, simulation replications and aggregate treatment of simulation results on all replications. For all these reasons, this parameters set remains virtually neutral to simulation results concerned with impact of alternative accounting regime on share price formation, which mostly depends indeed on the accounting regime that is under consideration. On this basis, we simulate market price series over 100 periods, and we replicate simulation for 2,500 times, for each alternative accounting regime.

Through this specification of our model, under every accounting regime, each simulated market price series (p_t) and each cumulated fundamental signal series (e_t^f) follows its own unique temporal pattern dependent on interactive combination of structural assumptions and randomized factors period after period. In particular, share market price series shows non-normal distributions that fit empirical evidence (Biondi et al. 2012) while making difficult to aggregate and compare results. Replication and aggregation through numerical simulation do not necessarily converge towards one normal (and normally distributed) world (Fig. 2a), showing instead what *could* happen in more and more possible (imagined) "worlds of accounting" (Sunder 2011). However, some

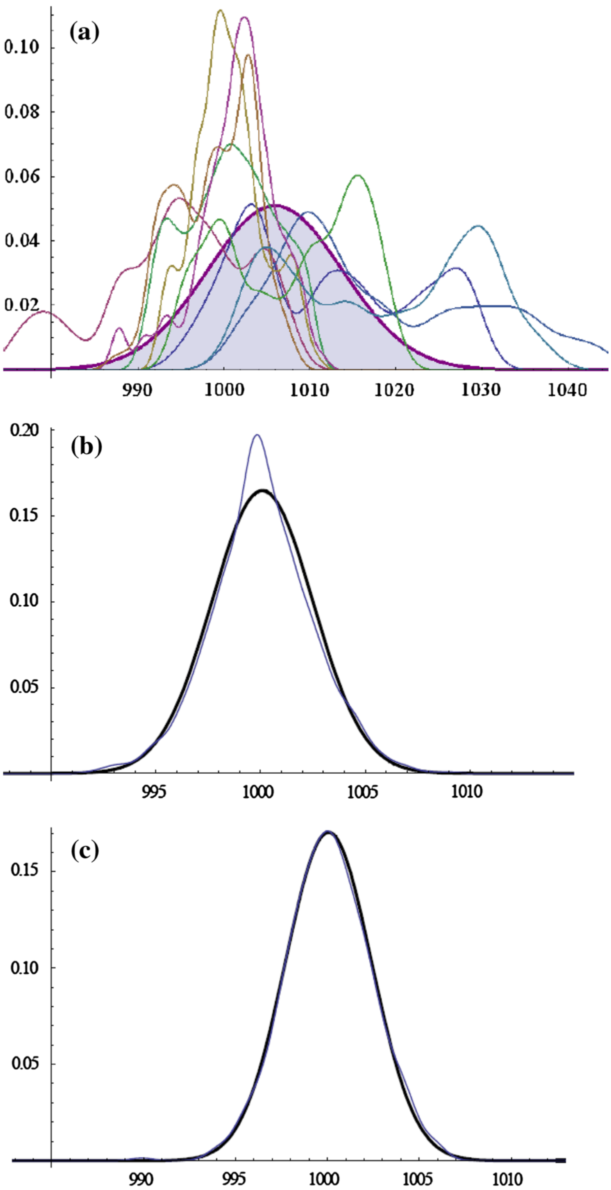

Fig. 2 **a** Simulation of ten share market price aggregate distributions (*colored lines*) compared with estimated normal aggregate distribution with same mean and standard deviation (*colored purple region*). **b** Median share price aggregate distribution through 2,500 replications (*blue line*), compared with estimated normal distribution with same mean and standard deviation (*darker black line*). **c** Mean share price aggregate distribution through 2,500 replications (*blue line*), compared with estimated normal distribution with same mean and standard deviation (*darker black line*) (color figure online)

aggregate descriptive statistics extracted from those patterns (such as mean and median prices) show quasi-normal distributions that enable clear-cut comparison between financial systemic performances under alternative accounting regimes (Fig. 2b, c).

On this basis, we shall perform aggregate statistical analysis through numerical simulation, in order to adress to several issues: assessment of alternative accounting regimes providing distinctive modes of firm-specific information; their impact on market volatility, market exuberance and occurrence of speculative bubbles; and the relationship between quality of accounting information and market share price dynamics over time.

5.1 Assessing alternative accounting regimes

A technical notion of market efficiency points to uni-variate analysis of the market price series. An efficient share market is then supposed to generate a well-shaped price series over time (Biondi 2013, providing further references). Through numerical simulation, we measure and compare respectively: mean average price, mean median price, mean and median *statistical price range* (defined as the difference between third and first quartiles of market price series scaled by median price), average and median relative price range (defined as the difference between maximum and minimum prices scaled by median price), and mean market volatility (defined as standard deviation scaled by average price). Tables 2, 3, 4, 5 and 6 provide simulation results:

Table 2 Mean market price aggregate distribution

	min {Quartile25, Median, Quartile75} max	Mean average price ± mean standard deviation
HCA1	992.47 {998.38, 1,000.03, 1,001.59} 1,007.67	999.99 ± 1.54
HCA2	987.37 {997.83, 1,000.02, 1,002.28} 1,010.52	999.98 ± 2.19
FVA1	953.34 {989.46, 999.991, 1,009.87} 1,057.88	999.95 ± 10.41
FVA2	934.82 {985.73, 999.70, 1,013.88} 1,090.31	1,000.02 ± 15.16

Table 3 Median price aggregate distribution

	min {Quartile25, Median, Quartile75} max	Mean Median price ± median standard deviation
HCA1	991.05 {998.38, 1,000.01, 1,001.59} 1,008.48	1,000.01 ± 1.37
HCA2	984.34 {997.78, 999.98, 1,002.24} 1,012.92	999.98 ± 1.94
FVA1	958.75 {991.30, 1,000, 1,008.31} 1,046.06	1,000 ± 8.80
FVA2	936.89 {987.6, 999.98, 1,012.33} 1,070.7	999.98 ± 12.69

Table 4 Mean and median statistical price range

	HCA1	HCA2	FVA	FVA2
Mean statistical price range	2.32009×10^{-3}	3.29181×10^{-3}	17.7725×10^{-3}	25.1582×10^{-2}
Median statistical price range	2.02846×10^{-3}	2.8186×10^{-3}	14.5767×10^{-3}	20.5545×10^{-3}

Table 5 Mean and median relative price range

	HCA1	HCA2	FVA	FVA2
Mean relative price range	5.50627×10^{-3}	7.83974×10^{-3}	33.2949×10^{-3}	47.3303×10^{-3}
Median relative price range	5.19836×10^{-3}	7.37463×10^{-3}	28.0127×10^{-3}	39.314×10^{-3}

Table 6 Average volatility aggregate distribution

	min	{Quartile25, Median, Quartile75}	max	Mean average volatility
HCA1	3.98×10^{-4}	$\{1.04 \times 10^{-3}, 1.37 \times 10^{-3}, 1.81 \times 10^{-3}\}$	4.43×10^{-3}	1.49866×10^{-3}
HCA2	6.32×10^{-4}	$\{1.46 \times 10^{-3}, 1.93 \times 10^{-3}, 2.61 \times 10^{-3}\}$	7.28×10^{-3}	2.12881×10^{-3}
FVA1	5.85×10^{-4}	$\{4.67 \times 10^{-3}, 8.82 \times 10^{-3}, 1.44 \times 10^{-2}\}$	4.67×10^{-2}	10.4133×10^{-3}
FVA2	8.20×10^{-4}	$\{6.70 \times 10^{-3}, 12.32 \times 10^{-3}, 2.08 \times 10^{-2}\}$	7.10×10^{-2}	14.7794×10^{-3}

To be clear, *no accounting regime can avoid occurrence of* large fluctuations *("speculative bubbles").*[12] Nevertheless, likelihood and magnitude of a large market price fluctuation is greater under FVA regime than under HCA regime, since share market price walk becomes auto-referential and does not have any non-market stabilizing device in the first case. Both average and median price distributions are significantly less skewed under HCA regimes, which consistently reduce statistical price range, relative price range and market volatility. This means that share market price series are less erratic and the overall financial system more stable; occurrence and impact of speculative waves are then reduced by the presence of such an autonomous source of fundamental information. Because historical cost accounting is independent from share market prices, it induces behaviors that dampen the financial market cycle. Figures 3 and 4 visualize this broad message. In the first case (HCA), the market price walk remains quite near to its theoretical level of 10.00×10^2 (Fig. 3).

In the second case (FVA), the market price walk shows an erratic pattern far away its theoretical level of 10.00×10^2 (Fig. 4).

Theoretically speaking, fair value accounting is then expected to involve greater pro-cyclical effects on share market dynamics than historical cost accounting. The following numerical simulation shall confirm this theoretical insight by connecting market price pattern to its underlying cumulated fundamental signal series through a bivariate statistical analysis.

5.2 Market Exuberance

This finding from uni-variate statistical analysis (on price series alone) is reinforced by testing and comparing "market exuberance" (Shiller 2000; LeRoy 2004; Biondi 2011a, 2013) for each market price series under alternative accounting regimes. This concept denotes "errancy" exhibited by the share market, that is, share market price

[12] Bubbles cannot be defined here through a collective concept of fundamental value that does no longer exist. They may be denoted according to the stability and resilience of share price formation over time.

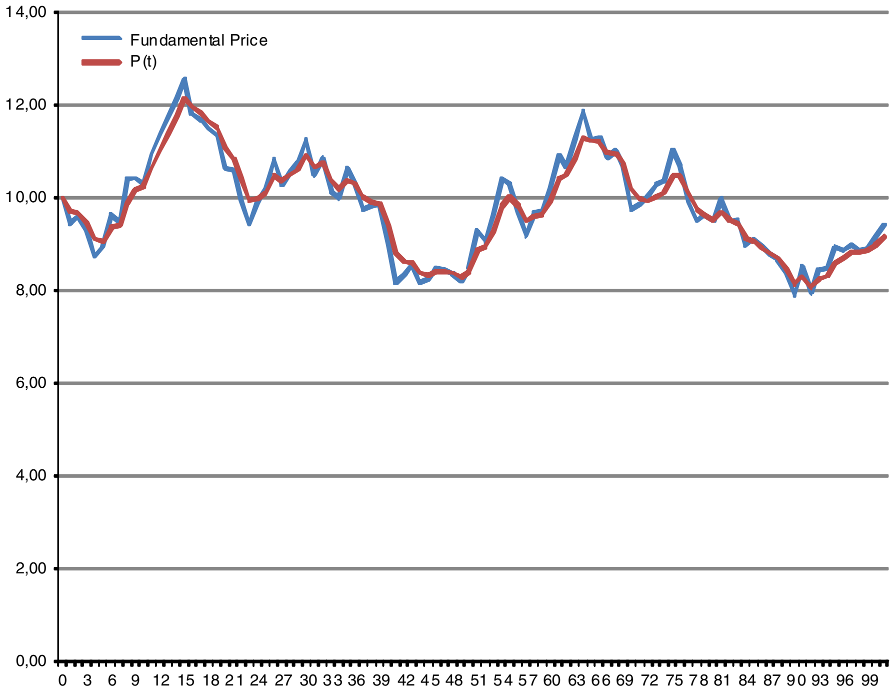

Fig. 3 Share price formation under historical cost accounting. Both market prices and fundamentals are scaled by 1:100. Fundamental price (or cumulated shareholders' equity) is computed as: $e_t^f = f_{t=0} + \sum F_{t-1}$

fluctuations induced by trading that are larger than related movements in underlying "real" fundamentals. Our conceptual framework does not include the concept of one unique fundamental value known and exploited by all the investors.[13] Instead, in line with our statistical mechanics approach to financial system aggregate analysis, we design several aggregate descriptive statistics that relate market "exuberance" and "errancy" to differences and distances between market price pattern and fundamental signal pattern. These statistics employ a fundamental signal series (or cumulated shareholders equity) that is based upon cumulated fundamental signals (Table 1) period after period: $e_t^f = f_{t=0} + \sum F_{t-1}$. These statistics point then to excessive fluctuation that is added by share market price dynamics beyond the "intrinsic" fluctuation triggered by an evolving fundamental signal over time. Tables 7, 8, 9 and 10 provide some simulation results for difference ($\frac{p_t - F_{t-1}}{F_{t-1}}$), cumulated absolute difference ($\sum \frac{|p_t - F_{t-1}|}{F_{t-1}}$), maximum difference ($\max[\frac{p_t - F_{t-1}}{F_{t-1}}]$), and relative statistical range (defined as the difference between statistical ranges of market price series and cumulated fundamental signal series).

[13] After all, if all investors know (agree on) one unique fundamental value, why do they still need a share market to perform price-fixing and trades?

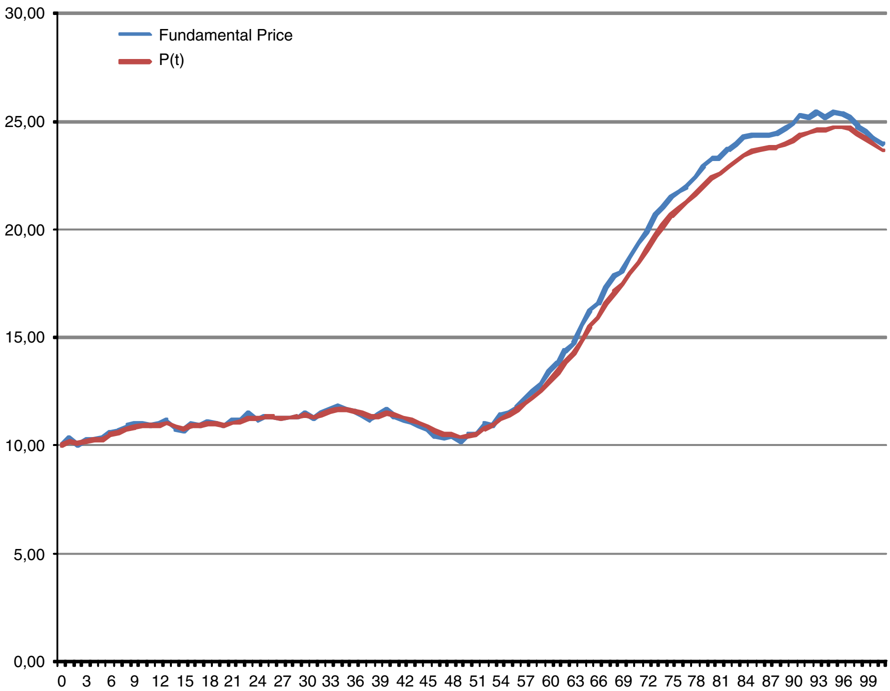

Fig. 4 Share price formation under fair value accounting. Both market prices and fundamentals are scaled by 1:100. Fundamental price (or cumulated shareholders' equity) is computed as: $e_t^f = f_{t=0} + \sum F_{t-1}$

Table 7 Cumulated absolute difference aggregate distribution

	min {Quartile25, Median, Quartile75} max	Mean Cum. Abs. Diff. ± mean standard deviation
HCA1	$0\,\{1.85 \times 10^{-1}, 4.27 \times 10^{-1}, 7.11 \times 10^{-1}\}\,15.28 \times 10^{-1}$	$(4.67 \pm 1.16566) \times 10^{-1}$
HCA2	$0\,\{2.75 \times 10^{-1}, 6.60 \times 10^{-1}, 10.03 \times 10^{-1}\}\,17.37 \times 10^{-1}$	$(6.88 \pm 1.99) \times 10^{-1}$
FVA1	$0\,\{4.56 \times 10^{-1}, 10.36 \times 10^{-1}, 14.21 \times 10^{-1}\}\,19.5647 \times 10^{-1}$	$(9.73 \pm 3.22) \times 10^{-1}$
FVA2	$0\,\{3.89 \times 10^{-1}, 7.50 \times 10^{-1}, 11.56 \times 10^{-1}\}\,20.59 \times 10^{-1}$	$(7.91 \pm 2.48) \times 10^{-1}$

Table 8 Mean difference aggregate distribution

	min {Quartile25, Median, Quartile75} max	Mean difference ± mean standard deviation
HCA1	-1.12×10^{-4} $\{-1.59 \times 10^{-5}, 1.12 \times 10^{-5}, 3.91 \times 10^{-5}\}$ 1.37×10^{-4}	$(0.120 \pm 2.29) \times 10^{-4}$
HCA2	-1.61×10^{-4} $\{-2.66 \times 10^{-5}, 1.30 \times 10^{-5}, 5.22 \times 10^{-5}\}$ 2.09×10^{-4}	$(0.129 \pm 3.25) \times 10^{-4}$
FVA1	-14.16×10^{-4} $\{-23.93 \times 10^{-5}, 1.91 \times 10^{-5}, 29.34 \times 10^{-5}\}$ 12.82×10^{-4}	$(0.262 \pm 2.69) \times 10^{-4}$
FVA2	-21.93×10^{-4} $\{-34.16 \times 10^{-5}, 1.68 \times 10^{-5}, 39.48 \times 10^{-5}\}$ 18.85×10^{-4}	$(0.297 \pm 3.83) \times 10^{-4}$

Table 9 Median difference aggregate distribution

	min {Quartile25, Median, Quartile75} max	Median difference ± median standard deviation
HCA1	-1.36×10^{-4} $\{-1.27 \times 10^{-5}, 7.96 \times 10^{-6}, 3.76 \times 10^{-5}\}$ 1.57×10^{-4}	$(0.0796 \pm 2.29) \times 10^{-4}$
HCA2	-2.38×10^{-4} $\{-2.91 \times 10^{-5}, 6.46 \times 10^{-6}, 5.52 \times 10^{-5}\}$ 2.36×10^{-4}	$(0.0646 \pm 3.24) \times 10^{-4}$
FVA1	-16.44×10^{-4} $\{-22.80 \times 10^{-5}, 11.89 \times 10^{-6}, 27.47 \times 10^{-5}\}$ 15.26×10^{-4}	$(0.1189 \pm 2.45) \times 10^{-4}$
FVA2	-27.11×10^{-4} $\{-33.18 \times 10^{-5}, 7.19 \times 10^{-6}, 37.77 \times 10^{-5}\}$ 20.08×10^{-4}	$(0.7189 \pm 3.50) \times 10^{-4}$

Table 10 Other statistical measures of market exuberance

	Maximum difference	Statistical range for mean/ median Cum. Abs. Diff.	Mean (median) relative exuberance range
HCA1	1.55×10^{-3}	2.11×10^{-4}	-3.37×10^{-5} (-4.25×10^{-5})
HCA2	1.88×10^{-3}	2.92×10^{-4}	-5.63×10^{-5} (-5.89×10^{-5})
FVA1	5.37×10^{-3}	3.85×10^{-4}	-45.8×10^{-5} (-35.6×10^{-5})
FVA2	7.55×10^{-3}	3.07×10^{-4}	-63.62×10^{-5} (-50.16×10^{-5})

According to these simulation results, financial system shows significantly higher exuberance under fair value accounting regime. Not only mean, median and maximum values for all aggregate descriptive statistics of systemic performance are consistently higher under fair value accounting regime, but its aggregate distributions of those performance measures are always more skewed at each quartiles. According to our statistical analysis approach, financial fragility is then amplified whatever measured at some extreme point or over some extreme interval of these distributions (Taleb and Douady 2012). Therefore, share market aggregate performance is more exposed to speculative waves that increase market errancy beyond the level that is driven from, and justified by signals of fundamental performance. Theoretically speaking, fair value accounting is then expected to involve greater pro-cyclical effects on share market dynamics than historical cost accounting, which provides a stabilizing lighthouse for the market price walk confronted with limited knowledge, hazard and social interaction, even *absent a fundamental value that is known and exploited by all investors*.

All together, these findings concern allocative efficiency of Share Exchange under alternative accounting regimes. They point to aggregate properties of market share price series in connection with fundamental signal series. A further extension of the model may investigate allocative efficiency of Share Exchange with reference to income and wealth distribution among investors, as well as relative performance of individual investment strategies over time.

5.3 The quality of accounting information

Drawing upon these findings on aggregate performance of share market, our framework of analysis may be applied to assess the quality of accounting information. Most studies of accounting and economics refer to an econometric approach called "value relevance," which consists in assessing accounting quality by measuring simultaneous correlation of market share price (p_t) and accounting information (F_t). This correlation is also applied to measure quality of accounting regulation, which is then expected and required to improve on "value relevance" of reported accounting information. From this perspective, our model can be applied to assess correlation of accounting information (F_t) with current (p_t) and future market share prices (p_{t+1}) under alternative accounting regimes. For each regime, we shall compute two Pearson's correlation coefficients through numerical simulation: $a(p_t, F_t) = \frac{Cov(F_t, p_t)}{\sigma_{F_t} \cdot \sigma_{p_t}}$ and $c(p_{t+1}, F_t) = \frac{Cov(F_t, p_{t+1})}{\sigma_{F_t} \cdot \sigma_{p_t+1}}$. Table 11 and 12 show simulation results for simultaneous correlation coefficient $a(p_t, F_t)$, while Tables 13 and 14 for temporal correlation coefficient $c(p_{t+1}, F_t)$.

Findings for $a(p_t, F_t)$ clearly shows the distinctive properties of alternative accounting regimes. HCA regime provides a fundamental signal that is exogenous to market price dynamics; it results then to be less correlated with current market prices in the long run. On the contrary, FVA accounting regime is more correlated to current share prices, in a significant and consistent way. Remembering the worst systemic efficiency involved by FVA, this better correlation results to show a worst

Table 11 $a(p_t, F_t)$ aggregate distribution

	min {Quartile25, Median, Quartile75} max	Mean $a(p_t, F_t) \pm$ standard deviation σ_a
HCA1	0.571307 {0.910351, 0.945653, 0.968124} 0.994651	0.932671 ± 0.0490911
HCA2	0.653872 {0.908726, 0.943922, 0.969203} 0.995681	0.930964 ± 0.0516678
FVA1	0.907901 {0.996615, 0.99918, 0.999666} 0.999951	0.996656 ± 0.0064424
FVA2	0.921567 {0.996735, 0.999141, 0.999668} 0.999972	0.996985 ± 0.0000280397

Table 12 $a(p_t, F_t)$ estimated normal distribution

	ℕ [mean, standard deviation]
HCA1	ℕ[0.932671, 0.0490753]
HCA2	ℕ[0.930964, 0.0516579]
FVA1	ℕ[0.996656, 0.00644117]
FVA2	ℕ[0.996985, 0.00529419]

Table 13 $c(p_{t+1}, F_t)$ aggregate distribution

	min {Quartile25, median, quartile75} max	Mean $c(p_{t+1}, F_t) \pm$ standard deviation σ_c
HCA1	−0.920064 {−0.560186, 0.0177525, 0.550336} 0.991135	0.0051991 ± 0.56677
HCA2	−0.772943 {−0.247993, −0.00910502, 0.238233} 0.969925	0.0043970 ± 0.30449
FVA1	−0.999441 {−0.960139, −0.0516929, 0.957773} 0.99986	0.0123552 ± 0.88966
FVA2	−0.994649 {−0.933553, −0.0584623, 0.931041} 0.999612	−0.00819715 ± 0.754072

Table 14 $c(p_{t+1}, F_t)$ estimated normal distribution

	$\mathbb{N}$[mean, standard deviation]
HCA1	$\mathbb{N}[0.0051991, 0.56666]$
HCA2	$\mathbb{N}[-0.00439704, 0.304428]$
FVA1	$\mathbb{N}[-0.0123552, 0.889479]$
FVA2	$\mathbb{N}[-0.00819715, 0.8682]$

systemic performance for accounting information, not a better one, contrary to current wisdom on this matter. Concerning one-period-ahead temporal correlation coefficient $c(p_{t+1}, F_t)$, simulation results show that no accounting regime provides an estimated normally-distributed coefficient range (that is, average $\widetilde{c} \pm \widetilde{\sigma}_c$ as reported in Table 14) that is clearly defined (entirely positive or negative), while coefficient c averages (both actual mean $\overline{c}$ and estimated mean $\widetilde{c}$ under normal distribution hypothesis) is near to zero under every accounting regime. Accordingly, no accounting signal alone can predict share market price behavior on one-period-ahead in a clear-cut way that would be exploitable by individual investors through time.

Summing-up, FVA regime does not result to show any superior quality, if any at all, as provider of fundamental accounting information. Its simultaneous correlation with market prices is superior to HCA regimes, but it results to exacerbate financial market cycle, volatility and exuberance. FVA fails therefore to stabilize share market dynamics, making financial system more fragile. In this context, *the ideal of one unique fundamental value that would be common knowledge for all investors being unattainable*, HCA regime results to constitute the most satisficing accounting system. Being less connected to current market prices in the long run, HCA is capable to provide a stabilizing feedback that helps keeping share market dynamics on track. These findings provide a clear-cut message for accounting regulatory bodies: keep accounting as distinct as possible by share market may improve on information quality, helping to stabilize financial system dynamics and better its systemic performance in terms of systemic risk and financial stability.

6 Conclusion

Responding to the claim by Kothari (2001) for improved theorizing on the relationship between accounting information and the share market dynamics, we have developed a theoretical frame of analysis for comparatively assessing alternative accounting regimes in terms of systemic risk and financial stability. Our approach maintains focus on flow of aggregate market prices through time. Two distict forces are then assumed to jointly drive the overall *financial system*: one originated by the market share *price system*; another one by established accounting processes of reporting and disclosure (corporate *accounting system* of share-issuing entity). This theoretical framework is expected to enhance our understanding of the behavior of market pricing processes through time and social interaction.

In line with Foley (1994); Aoki and Yoshikawa (2006), and Di Guilmi et al. (2012), but also Chiarella and Iori (2002), Horst (2005), Hommes (2005), and Anufriev and Panchenko (2009), our approach is then concerned with different patterns of aggregate market prices under alternative institutional configurations, which are featured by structural and behavioral assumptions. In particular, accounting system is supposed to constitute an accounting lighthouse for share market price walk confronted with limited knowledge, hazard, and social interaction. Accordingly, we have simulated this special accounting role in share market price formation, assessing its impact on speculative bubbles and herd behavior; market volatility, exuberance and errancy; and the "value relevance" of accounting information. Simulation findings cast doubts on allocative efficiency of fair value accounting regime. This latter accounting regime involves significantly higher market volatility and exuberance relative to historical cost accounting regime, making the overall financial system more instable, fragile and erratic. On the contrary, likelihood and magnitude of excess fluctuations in share pricing dynamics are expected to be reduced by adopting historical cost accounting regime, which is capable to provide an autonomous source of information on fundamental performance and position of the business firm over time.

7 Appendix

This appendix explains in further details the market clearing process designed by our approach. Formation of market clearing price p^*_{t+1} over time depends on aggregation of individual bids of demand and supply at each period t. In particular, every shareholder $(j = S)$ i wishes to sell if $p^*_{t+1} \geq E_t(p_{t+1})|^S_i$, while every prospective investor $(j = D)$ i wishes to buy if $p^*_{t+1} \leq E_t(p_{t+1})|^D_i$.

By assuming uniform distribution of individual investors within each group $j = S, D$, individual price expectation (focal price) $E_t(p_{t+1})|^j_i$ of investor i belonging to group j may be rewritten as a function of expectations expressed by extreme investors $i = 0$ and $i = 1$ as follows:

$$E_t(p_{t+1})|^j_i = p_t + \alpha^j_t\,(p_t - p_{t-1}) - \beta^j_i\left(E_{t-1}(p_t)|^j_i - p_t\right) + \gamma^j \varphi_i F_t \qquad (6)$$

with $j = S$ (Inside), D (Outside); $i, \varphi_i \in [0, 1]$; $\alpha^j_t \in [0, 1]$; $\beta^j_i \in [0; 1]$; $\gamma^j > 0$.

In this paper, we assume that $\alpha^j_t = \alpha \in [0, 1]$, $\gamma^j = \gamma = 1$ and $\beta^D_i = 0\ \forall i$.[14] On this basis, individual price expectation (focal price) by individual investor i may be rewritten as:

$$E_t(p_{t+1})|^j_i = p_t + \alpha\,(p_t - p_{t-1}) - \left(\beta^j_0\,(1 - \varphi_i)\,\varepsilon^j_{0,t} + \beta^j_1 \varphi_i \varepsilon^j_{1,t}\right) + \varphi_i F_t$$

where

$$\varepsilon_t|^j_0 \equiv \left(E_{t-1}(p_t)|^j_0 - p_t\right)$$
$$\varepsilon_t|^j_1 \equiv \left(E_{t-1}(p_t)|^j_1 - p_t\right).$$

[14] Biondi et al. (2012) further analyse a specific evolution of interacting individual opinions by allowing α^j_t to vary across periods t according to the Galam model of social opinion dynamics.

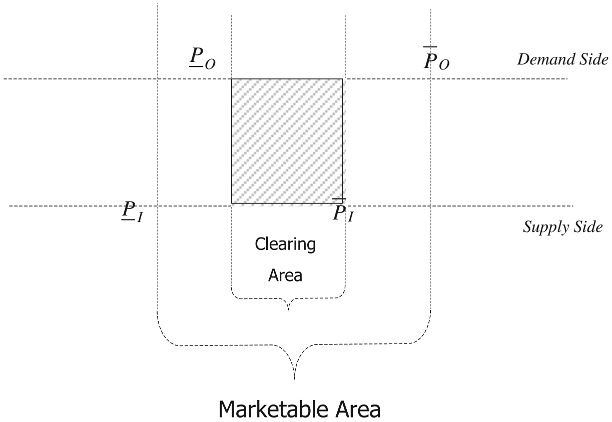

Fig. 5 Aggregate potential demand and supply when clearing is possible according to extreme investors' focal pricing

Extreme values of $\varphi_i = 0, 1$ define four extreme investors: two with $\varphi_i = 0$, which are "pure speculators" (either inside $j = S$ or outside $j = D$ the market) and do not care of fundamental signal $F_t(\cdot)$; and two with $\varphi_i = 1$, which are "pure fundamentalists" (either inside or outside the market, that is, $j = S$ or $j = D$) and attribute full confidence to fundamental signal $F_t(\cdot)$ inferred by fundamental analysis. Since time $t = 0$ when share-issuing entity k offers its shares on the primary market, aggregate demand and supply depend on these four focal prices with $i = 0$ and $i = 1 \ \forall j = S, D$ (shareholding/potential fundamentalist and shareholding/potential speculator), defined as follows:

$$\overline{P_t^j} \equiv \max \arg \left[E_t(p_{t+1})|_{i=0}^{j} ; \ E_t(p_{t+1})|_{i=1}^{j} \right]$$

$$\underline{P_t^j} \equiv \min \arg \left[E_t(p_{t+1})|_{i=0}^{j} ; \ E_t(p_{t+1})|_{i=1}^{j} \right].$$

All together, these focal prices determine a "marketable area" (that could not exist) where share exchanges are *wished* by some shareholding and potential investors (Fig. 6). Inside and outside the share market, investors observe the aggregate share market price p_t and the fundamental signal $F_t(\cdot)$ of business firm k. According to their own expectations on p_{t+1}, they decide then whether change their position through selling or buying, or simply wait until the next period.

Share market design defines how trades may be eventually performed within the "clearing area" (Fig. 5). This design decides how orders passed by investors are satisfied within this clearing area. This area denotes the width of the share market possible pricing at period t. By assuming linear distribution of investors for both potential demand side and potential supply side of the share market, aggregate supply x_{t+1}^S and demand x_{t+1}^Dintegrate individual bids as follows:

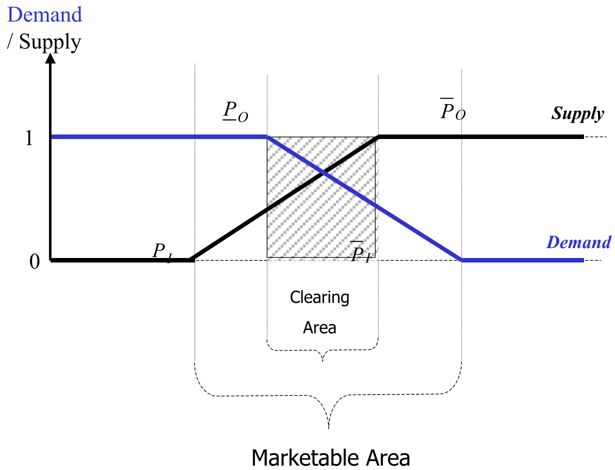

Fig. 6 Aggregate potential demand and potential supply when clearing is possible

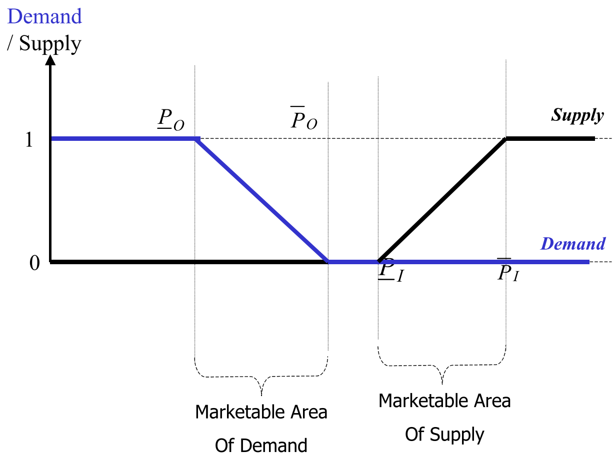

Fig. 7 Aggregate potential demand and potential supply when clearing is impossible

$$\begin{cases} x_{t+1}^{S} = \int_{\underline{P}_t^S}^{p_{t+1}^*} \frac{1}{\overline{P}_t^S - \underline{P}_t^S} dx \\ x_{t+1}^{D} = \int_{p_{t+1}^*}^{\overline{P}_t^D} \frac{1}{\overline{P}_t^D - \underline{P}_t^D} dx. \end{cases} \tag{7}$$

On this basis, aggregate clearing price arises from matching demand with supply ($x_{t+1}^S = x_{t+1}^D$):

$$x_{t+1}^S = x_{t+1}^D \Longrightarrow \begin{cases} \frac{p_{t+1}^* - \underline{P}_{S,t}}{\overline{P}_{S,t} - \underline{P}_{S,t}} = \frac{\overline{P}_{D,t} - p_{t+1}^*}{\overline{P}_{D,t} - \underline{P}_{D,t}} \\ \text{if } \max \arg\left(\underline{P}_{S,t}; \underline{P}_{D,t}\right) < p_{t+1}^* < \min \arg\left(\overline{P}_{S,t}; \overline{P}_{D,t}\right) \\ \text{never otherwise.} \end{cases} \tag{8}$$

Figures 6 and 7 show this matching between aggregate demand and supply. In particular, Fig. 5 shows the case when aggregate clearing price exists.

Figure 7 shows the case when aggregate clearing price does not. In the latter case, no share exchanges occur. Aggregate clearing price is then settled by some institutional market-making rule.

Please refer to Biondi et al. (2012) for full analytical development of this approach.

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