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Adaptive markets hypothesis and economic-institutional environment: a cross-country analysis

Marco Aurélio dos Santos
Business Administration Department – EAESP/FGV, Sao Paulo, Brazil and Business Administration and Accounting Department, Universidade de Marília, Marilia, Brazil
Luiz Paulo Lopes Fávero
Business and Accounting Department, School of Economics, University of Sao Paulo, Sao Paulo, Brazil
Talles Vianna Brugni
Department of Accounting and Finance, Fucape Business School, Vitória, Brazil, and
Ricardo Goulart Serra
Business Administration Department – FECAP and INSPER, Sao Paulo, Brazil

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Abstract

Purpose – This study's goal was to identify how several markets have developed over time and what determinants have influenced this process, based on adaptive markets hypothesis (AMH). In this regard, the authors consider that agents are driven by the seeking for abnormal returns to stay "alive" and their environment could somehow modify their decision-making processes, as well as influence the degree of efficiency of the market.

Design/methodology/approach – The authors collected the daily closing-of-the-market index from 50 countries, between 1990 and 2022. The sample includes emerging countries, developed countries and frontier markets. Then, the authors ran multilevel modeling using Hurst exponent as an informational efficiency metric estimated by two different moving windows: 500 and 1,250 observations (approximately 2 and 5 years).

Findings – The results indicate that the efficiency of the markets is not constant over time. The authors also have identified that markets follow a cyclical pattern of efficiency/inefficiency, and they are currently in a period of convergence to efficiency, possibly explained by the increase in computational capacity and speed of the available information to agents. In addition, this study identified that country characteristics are associated with market efficiency, considering institutional factors.

Originality/value – Studies of this nature contribute to the literature, considering the importance of better comprehension of market efficiency dynamics and their determinants, specially observing other theories on the relationship between information and markets (like AMH), which work with other investor assumptions than those used by efficient market hypothesis.

Keywords Adaptive markets hypothesis, Efficient market hypothesis, Market efficiency, Multilevel modeling

Paper type Research paper

JEL Classification — B26, B27, D5, E44

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1. Introduction

Despite the undeniable contribution of the efficient markets hypothesis (EMH), literature has shown that market features are more complex than the axioms that Fama (1970) presupposes (Campbell, Lo, & Mackinlay, 1997; Barberis & Thaler, 2003; Lo, 2005). In this regard, behavioral finance constitutes an alternative area in which individual decision-making presents cognitive biases and non-rational behaviors, bringing additional explanations to the behavior of markets themselves (Tversky & Kahneman, 1974, 1979, 1991; Thaler, 1985; Shiller, 2003).

Considering theories of behavioral finance and the link to the evolutionary concept of markets, adaptive markets hypothesis (AMH) proposed by Lo (2004, 2005) can be considered an evolution of EMH. In that theory, a non-optimal investor decision may be associated with an optimal decision of the market, throughout observation in an intertemporal process. Competition for scarce abnormal returns by market agents tends to direct which decision frameworks are best to be adopted in each period.

Therefore, AMH does not discuss the effect of environment in market efficiency shaping the market dynamics over time. That point is important to comprehend that different markets have different degrees of inefficiency at the same time. Previous studies on AMH worked in identifying the cyclical behavior stated in Lo (2004, 2005) works, but they have not analyzed this aspect.

In this sense, our main objective was to verify whether the economic-institutional environment of the country affects its degree of efficiency. In addition, we verify whether the markets present “cyclical” behavior in their degree of informational efficiency, determined by variations in the economic scenarios of each country. Our proposal goes beyond testing and making a remissive on AMH within the scope of market efficiency: our hypothesis suggests that just as these agents are driven by the search for abnormal returns to stay “alive” in the market, their environment forges and interferes in their decision-making processes, as well as influences the degree of efficiency of the market as a whole. The proposed discussion can strengthen AMH, showing that agents are not only adaptive “animals,” but furthermore they are adaptive according to the environment they are in.

To seek our objectives, we ran multilevel modeling to consider intragroup heterogeneity and differentiate heterogeneity between groups and environments from 50 countries. In this regard, our findings suggest that the efficiency of the markets is not constant over time, and from a general perspective, the environment of the agents influences their decision-making processes over time. Such environmental characteristics are both variable over time, such as cycles and economic shocks, as well as invariable (or with low variation) over time, such as the economic and institutional environment.

Studies of this nature contribute to the literature, considering the importance of a better comprehension of market efficiency dynamics and their determinants, especially observing other theories on the relationship between information and markets (like AMH) that work with different investor assumptions than those in EMH. Identifying how institutional characteristics affect the market dynamics and their evolution is important for regulators to improve policies, aiming at better institutional environment for financial markets. For investors, understanding how markets evolve considering different “species” of market agents could create a better analysis on market scenarios and whether times of predictability are pronounced or not, considering their investment strategies. Additionally, it is important to understand the role of the external environment in the financial decision-making process. For regulators, our study contributes for the understanding on how institutions (like law characteristics) and country characteristics can shape market behavior and informational efficiency of markets, improving actions to create a better environment for stock markets in each country.

2. Theoretical platform

2.1 Market efficiency: neoclassical concept

One of the main fields of study in finance is informational efficiency. Discussed since the utility theory of Von Neumann and Morgenstern (1947), market efficiency is still a current topic to this day. The pioneers in the theory of market information and behavior of returns are Samuelson (1965), Roberts (1967) and Fama (1970), observing the time series of prices and if they constitute a martingale or not.

Condensing the studies of market efficiency, a benchmark definition of efficient market is given by the statement: "A market is efficient when prices fully reflect and quickly adjust to new information" (Fama, Fischer, Jensen, & Roll, 1969; Fama, 1970). Fama (1970) adds some considerations about market efficiency, splitting empirical evidence tests in three forms of market efficiency (strong, semi-strong and weak). In this setting, Shleifer (2000) presents three assumptions on which EMH is structured: (1) the unlimited rationality of the investor, who can logically assess assets in the emergence of new information in the market; (2) arbitrage, for the withdrawal of non-rational investors from the market, and (3) collective rationality, meaning that mistakes made by non-rational investors can be cancelled if they trade at random.

Except for the weak form, there is no consensus on EMH, since several authors indicate the existence of anomalies (e.g. size and momentum), in addition to questioning the rationality of the agents because not all agents will make the same decisions in the face of the same stimulus (news), which generates different results depending on each market/time/event (Titan, 2015). Furthermore, EMH (1) does not explain why markets can switch from efficiency periods to non-efficiency ones (Urquhart, 2013; Okorie & Lin, 2021) and (2) does not predict the existence of the so-called noise traders and their decision-making biases (Ramiah, Xu, & Moosa, 2015; Munir, Sukor, & Shaharuddin, 2022). On the other hand, it is important to consider that this evidence does not invalidate EMH but only highlights how these anomalies affect market efficiency. Conversely, the concepts of behavioral finance and AMH consider such aspects.

2.2 Adaptive markets hypothesis (AMH)

AMH approach suggests that agents can adapt their heuristics in decision-making to achieve greater rewards, but not in a 100% rational way, due to their own cognitive limitations and distinct preferences that restrict their ability to process information. If the external environment is stable, then this trend will move to an optimal point. On the other hand, with changes in the external environment, the tendency to adaptive heuristics is not always straightforward, and heuristics that work well in a given scenario may not be the best to be applied in other scenario, thus generating periods of informational inefficiency (Lo, 2005; Mensi, Tiwari, & Al-Yahyaee, 2019).

Lo (2004) states that AMH can be considered a new version of EMH, derived from evolutionary principles of biology. According to him, prices reflect the level of information based on the set of environmental conditions, the number and nature of "species" in the economy. In this regard, AMH can be summarized by the following characteristics: (1) individuals act in their own interests, (2) individuals make mistakes, (3) individuals learn and adapt, (4) competition drives adaptation and innovation, (5) natural selection draws the ecology of the market and (6) evolution determines the dynamics of the market. One of the main findings in empirical studies is the cyclical behavior of inefficiency over time, as stated by Lo (2004, 2005), as a result of a dynamic behavior of agents and market characteristics.

Looking for possible historical clues to explain periods of inefficiency, one can find studies in the US market such as Kim, Shamsuddin, and Lim (2011), Alvarez-Ramirez, Rodriguez, and Espinosa-Paredes (2012), Urquhart and Hudson (2013), Urquhart and McGroarty (2014), and Lin, Lo, and Qiao (2021). Their results suggest that the fundamentals of the US economy and its changes over time (bubbles, crashes, presidential changes, financial and political crises, inflationary and recessionary processes) directly affect the predictability of returns (Kim, Shamsuddin, & Lim, 2011) and that periods with major economic and general changes (e.g. wars) negatively affect market efficiency (Alvarez-Ramirez *et al.*, 2012; Choi, 2021).

Studies conducted in other markets also find support from AMH, such as Popovic, Mugosa, and Durovic (2013), Urquhart and Hudson (2013), Ghazani and Araghi (2014), Dourado and Tabak (2014), Suárez, Duarte, and Ortíz (2015), Verheyden, De Moor, and Bossche (2015), Hiremath and Narayan (2016), Urquhart and McGroarty (2016), Okorie and Lin (2021), and Munir, Sukor, and Shaharuddin (2022). These studies suggest different impacts by macroeconomic and institutional incentives on market efficiency, suggesting that factors other than economic ones may affect market efficiency over time, and differently, depending on the stimulus level and macroeconomic environment.

In this regard, we notice that the degree of efficiency can rely on two factors: (1) level of competition and (2) characteristics of the environment. Such factors are not constant over time. This assertion is supported by Lo (2004, 2005) who showed that the efficiency of the US market had seasonal behavior between 1871 and 2003, precisely due to changes in the economic, technological and institutional environment (ecosystem).

As stated by Rejeb and Boughrara (2013) and according to Wang, Li and Forst (2021), this would tend to increase the periods of informational efficiency in some of these markets. In this regard, we tested the following research hypotheses:

H1a. There is an evolution in the degree of market efficiency over time.

H1b. There are differences in the evolution of the degree of market efficiency between countries.

2.3 Impact of the economic-institutional and sectoral environment on capital markets

Several studies analyze associations between economic and institutional environments and capital market attributes (e.g. efficiency, size and development, ownership concentration and type of agents) in different countries and types of analysis (e.g. Rajan & Zingales, 1995; La Porta, Lopez-de-Silanes, & Shleifer, 1998). Variables commonly used in these studies are: (1) macroeconomic (Dewandaru, Rizvi, Bacha, & Masih, 2014; Peiró, 2015; Dimic, Kiviaho, Piljak, & Äijö, 2016), (2) economic uncertainty (Dimic *et al.*, 2016), (3) monetary policy (Vithessonthi & Techarongrojwong, 2013; Belke & Beckmann, 2015; Shahab, Ntim, Chengang, Ullah, & Fosu, 2018), (4) political uncertainty (Chang, Chen, Gupta, & Nguyen, 2015; Al-Thaqeb, Algharabali, & Alabdulghafour, 2020), (5) business environment (Rejeb & Boughrara, 2013; Blau, Brough, & Thomas, 2014; Chang *et al.*, 2015; Arjoon, 2016; Shahab *et al.*, 2018), (6) institutional framework (Dewandaru *et al.*, 2014; Jain & Xue, 2017) and (7) demographic profile (Quayes & Jamal, 2015; Alda, 2017).

Literature indicates different behaviors between markets in different countries and different behaviors between sectors/indices of the same market, as well as the effect of both intrinsic and extrinsic characteristics to countries, such as the 2008 crisis (Contreras, Hidalgo, & Nuñez, 2017; Deo, Spong, & Varua, 2017). An analysis of the literature allows us to observe the recurrence of studies on impacts of characteristics related to markets' economic policies and legal frameworks. We observed that characteristics related to the legal behavior of regulatory agents have an impact on the informational process of the markets, which may or may not guarantee a fast or slow adaptation of market agents to economic shocks, based on the AMH framework. The economic regulation structure of a country can also determine whether the market has longer periods of inefficiency compared to other countries with a distinct economic framework.

However, it is also important to highlight the cultural effects presented in the literature. Cajueiro and Tabak (2004) suggest that determinants of informational efficiency are associated with the economic environment and the level of market development. However, none of these studies analyze or test the power of those determinants in explaining the variation in the degree of efficiency of these economies over time. Countries that have a stronger investment culture can better shape investor species compared to other markets. In this regard, we observed heterogeneity of behaviors and relationships in research under the AMH framework. Additionally, to understand the functioning of AMH in different economic contexts, it is worth analyzing the different "market ecosystem" of each country, represented by the general economic, institutional, legal and cultural characteristics of the geographic region and its interrelationships with other economic environments.

In view of this scenario, we also tested the following hypotheses:

H2. Institutional changes and economic shocks are related to the variation in the degree of market efficiency over time.

H3. Characteristics of the economic-institutional environment of countries are related to the degree of market efficiency, and there are differences in this relationship across different economies.

3. Methods

3.1 Population and sample

We collected the daily closing of the market index from 50 countries, for the longest period between 1990 and 2022 (some came into existence after 1990). Our sample includes emerging countries (e.g. Latin American market), developed countries (e.g. United States, United Kingdom and Japan), the so-called frontier markets (e.g. Jordan and Pakistan) and two special cases (Hong Kong and Taiwan), with recognized and not recognized autonomy by the Chinese government and international bodies, respectively.

The choice of the period, from 1990 to 2022, considered (1) the need for a long period of time since (a) we study institutional factors that present little variance over time, and (b) the first observations are discarded by the process of estimating the moving windows (estimated at two periodicities, 500 and 1,250 observations) and (2) the existence of few markets with data that could be used efficiently prior to 1990.

3.2 Data collection and variables

The daily prices of stock exchange indices and the daily remuneration of government bonds were collected from Bloomberg, Investing.com and Stooq. Data on the characteristics of the countries and markets were collected from the World Economic Forum and World Bank, on an annual basis. The difference in the periodicity of the data (daily and annual) was addressed through the calculation of the means, which in multilevel models allows capturing its effects on the dependent variable under study.

In order to analyze the behavior of informational efficiency presented by Lo and MacKinlay (1999) and Auer (2016), we used the ARFIMA (p,d,q) estimation model, with d being the differentiation parameter of the long time series. For the purpose of this research, the Hurst exponent has lower and upper limits established at -0.5 and $+0.5$, respectively. The center point indicates the standard efficiency. Values tending to the left (toward -0.5) suggest intermediate memory, and to the right (toward $+0.5$), long memory of the time series (greater predictability).

To test H1a and H1b, we calculated the dependent variable over time using two moving windows, with 500 and 1,250 observations (approximately 2 and 5 years, respectively), as presented by Anagnostinidis, Varsakelis, and Emmanouilides (2016). To test H2, we used two sets of cycle proxies and economic shocks and/or structural changes. The first set refers to yields (daily) on government bonds maturing in 5 (BOND5) and 10 (BOND10) years, which are used directly for verification of association with the behavior of informational efficiency. The second set refers to the spread (daily) of government bonds in relation to the risk-free security, and for the risk-free security, we use the average of the 10-year bonds of the three largest developed economies in the world (Germany, United States and Japan). We also use two lagged variables, one year (SPREADt-1) and two years (SPREADt-2), to identify whether behaviors from previous periods would be able to influence the degree of efficiency of the current period (SPREADt).

We tested H3 using a group of variables representative of the economic-institutional environment of countries that is connected to the relative inefficiency of markets. Thus, we used the variables (constant over time) described in Table 1 (section 3.3), based on previous research that analyzes institutional economic environment.

3.3 Data analysis and estimation of regression models

Our choice of multilevel models was based on the structure in which the database is presented. The database structure has two levels of analysis. At the first level (associated with time), there are observations of each country at each instant of time *t,* varying over time. The second level presented (country) groups all observations, which remain constant over time, refer to the country. We use multilevel modeling because of the capacity of the model to capture latent behavior (as group nonvisible variables). In that case, it is possible to observe the effects of nonvariant country/stock market characteristics in the degree of inefficiency, using the intraclass correlation coefficient (ICC) measure. Considering this structure, we can use the multilevel models to associate how much the latent variables related to time (level 1) and constants in each country (level 2) can explain the behavior of the relative degree of inefficiency of the markets (Raudenbush & Bryk, 2002). In other words, we can verify how institutions (constant factors over time) and other countries' characteristics affect the dynamics of temporal evolution of the efficiency of different markets.

We used the null model (Equation 1) and the growth curve model (Equation 2) to test hypothesis 1 (H1a and H1b):

$$Hurst(500, 1250)_{it} = \gamma_{00} + \tau_{0i} + \varepsilon_{ti} \tag{1}$$

where:

$Hurst(500, 1250)_{ti}$: refers to the *Hurst* variable measured in each period *t* for each of the windows (500 observations: Hurst500_{ti} and 1250 observations: Hurst1250_{ti}) of a given index *I,*

γ_{00}: overall mean of the sample,

τ_{0i}: refers to the error associated with non-variant country characteristics in time

ε_{ti}: refers to the idiosyncratic error related to the variant characteristics over time

$$Hurst(500, 1250)_{ti} = \gamma_{00} + (\gamma_{10} + \tau_{1i}).Time_{ti} + \tau_{0i} + \varepsilon_{ti} \tag{2}$$

where:

$Time_{ti}$: refers to the measurement number in the time sequence *t* of a given index *i*

γ_{10}: average of the slope coefficients of the first level equation (suppressed)

τ_{1i}: error at group *level i* correlated with evolution in time *t;* and other variables as described

Variable		Proxy used	Origin*
Dependent variables			
Hurst500	Market Relative inefficiency index 1	Hurst Exponent – 1/2 (estimation of parameter *d*) calculated by ARFIMA(0,*d*,0) model (Autoregressive Fractionally Integrated Moving Average – with range between −0.5 and +0.5) of daily selected indexes log-returns by rolling windows of 500 observations	A
Hurst1250	Market Relative inefficiency index 2	Hurst Exponent – 1/2 (estimation of parameter *d*) calculated by ARFIMA(0,*d*,0) model (Autoregressive Fractionally Integrated Moving Average – with range between −0.5 and +0.5) of daily selected indexes log-returns by rolling windows of 1,250 observations	A
Country level variables			
Interests and risk metrics			
BOND10	*BondYield (10 years)*	Daily Bond Yield of government bonds maturing in 10 years	INV
BOND5	*BondYield (5 years)*	Daily Bond Yield of government bonds maturing in 5 years	INV
SPREAD	*BondYieldSpread*	Difference between Bond Yield (10 years) – average (BondYield TNote, Bund10, JPBond10)	INV
Economic and institutional environment metrics			
TAX	Total tax rate	Country's tax rate average in the studied period by combining variables Profit Tax (% of profits), labor tax and other contributions (% of profits) and other taxes (% of profits) by the World Economic Forum (WEF)	GCI
GDP	GDP Growth	Country's GDP average growth in the studied period	BM
INFL	Inflation	Country's inflation average index in the studied period	BM
PROP	Property Rights	Average property rights metric as identified by the World Economic Forum's Global Competitiveness Index (WEF-GCI) for each country in the period	GCI
AUDIT	Strength of Auditing and Reporting Standards	Average of metric of Strength of Auditing and Reporting Standards calculated by WEFGCI by country in the period	GCI
INVEST	Strength of Investor Protection Index	Average of WEF-GCI combination of variables Extent of disclosure Index and Ease of shareholder suit index by country in the period	GCI
REG	Capital Market Regulation	Average of Capital Market quality of regulation index by WEF-GCI by country in the period	GCI
LEGAL	Legal Rights Index	Average of Protection of creditors and borrowers in the legal system that eases lending processes by WEF-GCI by country in the períod	GCI

Note(s): *A = Calculated using as databases: Stooq.com, YahooFinance.com, GoogleFinance.com, Investing.com and bloomberg.com; INV = Investing.com; WB = World Bank; GCI = World Economic Forum Global Competitiveness Index
Source(s): Authors

Table 1.
Variables of the study

After the null and growth curve models, we included the explanatory variables at the different levels, in a procedure known as step-up strategy, starting with level 1 variables (associated with time – time variants), Bond Yield and Bond Yield Spread (Snijders, 1996). Through Equation (3), we tested H2.

$$Hurst(500, 1250)_{ti} = \gamma_{00} + (\gamma_{10} + \tau_{1i}).Time_{ti} + \gamma_{20}.BondYield_{ti} + \gamma_{30}.BondYieldSpread_{ti} + \tau_{0i} + \varepsilon_{ti} \quad (3)$$

where:

$BondYield_{ti}$: represents the observations of the yield of the country index bond *i,* in time *t*

γ_{20}: average of the slope coefficients of each observation

$BondYieldSpread_{ti}$: observations of the bond yield spread of the country *index i,* at the time *t*

γ_{30}: average of the slope coefficients of each observation and other variables as described

The last step of the step-up strategy refers to the inclusion of the variables representing the economic and institutional environment, constant over time, which according to Snijders (1996) are associated with the second level (country). Then, we have tested H3 with the model expressed in Equation (4) as follows:

$$\begin{aligned} Hurst(500, 1250)_{ti} = {} & \gamma_{00} + \gamma_{01}(TAX_i) + \gamma_{02}(GDP_i) + \gamma_{03}(INFL_i) + \gamma_{04}(PROP_i) \\ & + \gamma_{05}(AUDIT_i) + \gamma_{06}(INVEST_i) + \gamma_{07}(REG_i) + \gamma_{08}(LEGAL_i) \\ & + (\gamma_{10} + \tau_{1i}).Time_{ti} + \gamma_{20}.BondYield_{ti} + \gamma_{30}.BondYieldSpread_{ti} + \tau_{0i} \\ & + \varepsilon_{ti} \end{aligned} \quad (4)$$

where:

$\gamma_{01}, \gamma_{02}, \gamma_{03}, \gamma_{04}, \gamma_{05}, \gamma_{06}, \gamma_{07}$ and γ_{08} are angular coefficients for the variables TAX_i, GDP_i, $INFL_i$, $PROP_i$, $AUDIT_i$, $INVEST_i$, REG_i and $LEGAL_i$ and explanatories of the first-level equation intercept β_{0i} (suppressed).

Table 1 presents the variables we used in our models and their calculations, which in turn have followed the pattern of the literature on the subject.

4. Results and discussion

4.1 Descriptive analysis of the dependent variable

As shown in Table 2 below, the overall average daily log-return is 0.000, with standard deviation of 0.015. The lowest average in the period is the Italian index with −0.000 and the highest average is the Brazilian index (IBOVESPA Index) with 0.002, signaling great heterogeneity between countries. The largest individual drop occurred on 13 October 2008, due to the collapse of the Icelandic banking system (−1.062) and the highest individual high occurred on 21 May 1992, when the Shanghai Composite Index rose 0.719.

These log-extreme returns have an impact on the measure of relative inefficiency and on the tests of theory. However, we found that the main windows of negative returns are related to periods of economic instability and financial crises, such as 2008 and 2022 crises, and institutional crises in markets such as Brazil (3 August and 13 August 1992), Russia (28 October 1997 – impact of the Asian crisis on emerging markets, lasting until 1998), as well as effects of the 2008 crisis (Russia – 16 September and 6 October 2008; Egypt – 7 October 2008). Based on the inefficiency metrics for rolling samples of 500 (Hurst500), we observed two countries with exponent above +0.10 (alphabetical order): Chile and Egypt. There is no market with exponent below −0.10. We observed that in the range between −0.10 and +0.10, smaller markets tend to have exponents closer to extremes (except for the Malay market, with

Table 2. Descriptive statistics

CODY	Country	Retornolog Mean	SD	Min	Max	H500 Mean	SD	Min	Max	H1250 Mean	SD	Min	Max
ARG	Argentina	0.001017	0.027675	−0.757131	0.261918	0.029700	0.040821	−0.104946	0.135294	0.033462	0.028417	−0.052138	0.095137
AUS	Australia	0.000181	0.009395	−0.100090	0.063548	−0.012232	0.044214	−0.198400	0.138513	−0.011510	0.028372	−0.062030	0.092043
BEL	Belgium	0.000167	0.011638	−0.153276	0.093340	0.030933	0.053278	−0.111913	0.195411	0.038535	0.041733	−0.051574	0.121289
BGR	Bulgaria	0.000364	0.011916	−0.113600	0.083878	0.075307	0.071903	−0.117541	0.236958	0.090504	0.052730	−0.006451	0.198739
BRA	Brazil	0.002078	0.027906	−0.393043	0.341799	−0.021152	0.043051	−0.174161	0.120434	−0.011212	0.032689	−0.070685	0.097294
CAN	Canada	0.000198	0.010117	−0.131761	0.112945	0.035981	0.087717	−0.248284	0.290591	0.024731	0.073820	−0.110926	0.227008
CHE	Switzerland	0.000224	0.011334	−0.101339	0.107876	−0.010381	0.041133	−0.160354	0.130071	−0.002462	0.027637	−0.063718	0.075069
CHL	Chile	0.000427	0.010892	−0.152156	0.118034	0.120740	0.065918	−0.027795	0.313576	0.120216	0.051022	0.027731	0.263604
CHN	China	0.000451	0.021918	−0.179051	0.719152	0.012836	0.032247	−0.100412	0.150163	0.020414	0.018578	−0.027848	0.074526
COL	Colombia	0.000096	0.011689	−0.132812	0.124697	0.086583	0.064422	−0.045468	0.272119	0.105879	0.039186	0.010852	0.218242
CZE	Czech Republic	0.000077	0.012805	−0.161855	0.123641	0.048092	0.088079	−0.144781	0.446246	0.037087	0.044463	−0.026934	0.201156
DEU	Germany	0.000245	0.014080	−0.130549	0.107975	−0.017337	0.035445	−0.110664	0.141410	−0.012715	0.018399	−0.077326	0.056531
EGY	Egypt	0.000384	0.016217	−0.179916	0.183692	0.129114	0.039025	0.011551	0.392280	0.133092	0.024922	0.062994	0.205672
ESP	Spain	0.000124	0.013991	−0.151512	0.134836	−0.000263	0.046106	−0.133777	0.228017	−0.000989	0.038422	−0.073816	0.097258
EST	Estonia	0.000451	0.010460	−0.106025	0.120945	0.084354	0.073295	−0.085280	0.250447	0.093320	0.056844	−0.029599	0.188951
FIN	Finland	0.000254	0.016812	−0.174042	0.145630	0.002967	0.039030	−0.095682	0.192622	0.003193	0.019418	−0.027214	0.086146
FRA	France	0.000142	0.013698	−0.130984	0.105946	−0.033048	0.046853	−0.164912	0.193356	−0.028877	0.032604	−0.095991	0.069995
GBR	United Kingdom	0.000245	0.009702	−0.098202	0.080388	0.092375	0.089441	−0.102117	0.324964	0.098683	0.076527	−0.031173	0.261769
GRC	Greece	0.000083	0.018651	−0.177129	0.137497	0.062893	0.045471	−0.075345	0.251593	0.064613	0.034597	0.005331	0.139744
HKG	Hong-Kong (China)	0.000241	0.015531	−0.147346	0.172470	0.003749	0.031924	−0.079592	0.182672	0.002994	0.024485	−0.049489	0.092135
HUN	Hungary	0.000476	0.015805	−0.180331	0.136157	0.043395	0.104916	−0.097265	0.372688	0.038276	0.070196	−0.037044	0.291935
IDN	Indonesia	0.000364	0.014143	−0.127318	0.131278	0.086428	0.107356	−0.112077	0.352554	0.084949	0.080872	−0.032828	0.322534
IND	India	0.000553	0.016148	−0.141017	0.159900	0.037794	0.043517	−0.135625	0.209305	0.035996	0.028856	−0.026457	0.136119
ISL	Iceland	0.000260	0.015996	−1.062197	0.050632	0.057404	0.096820	−0.117879	0.293393	0.058750	0.065540	−0.056198	0.253631
ISR	Israel	0.000340	0.012654	−0.104634	0.097815	0.016458	0.037885	−0.140339	0.236687	0.024107	0.026450	−0.050170	0.146023
ITA	Italia	−0.000016	0.015467	−0.185411	0.108743	−0.032248	0.035507	−0.146320	0.159946	−0.026175	0.025169	−0.078728	0.020712
JOR	Jordanian	0.000212	0.012888	−0.412833	0.438263	0.076376	0.151745	−0.385165	0.306429	0.029072	0.145753	−0.224999	0.231473
JPN	Japan	−0.000037	0.014879	−0.121110	0.132346	−0.032737	0.036198	−0.132752	0.113633	−0.034155	0.020614	−0.076306	0.035209
KOR	Korea, Rep	0.000119	0.015705	−0.128047	0.112844	0.016703	0.040212	−0.100949	0.232117	0.020640	0.034572	−0.064981	0.151170

(continued)

Table 2.

CODY	Country	Retornolog Mean	SD	Min	Max	H500 Mean	SD	Min	Max	H1250 Mean	SD	Min	Max
LTU	Lithuania	0.000362	0.009240	−0.119378	0.110015	0.065488	0.081277	−0.159787	0.302242	0.081542	0.067225	−0.057838	0.245598
LVA	Latvia	0.000421	0.013669	−0.163346	0.120862	−0.045480	0.109768	−0.326488	0.180686	−0.020210	0.080064	−0.183913	0.150450
MEX	Mexico	0.000458	0.014250	−0.143145	0.121536	0.030365	0.044288	−0.103698	0.188072	0.031319	0.028627	−0.039766	0.115534
MYS	Malaysia	0.000123	0.012239	−0.241534	0.208174	0.074467	0.050482	−0.084779	0.280477	0.071005	0.039761	−0.029467	0.157040
NLD	Netherlands	0.000200	0.012987	−0.113758	0.100283	−0.007616	0.030445	−0.137628	0.180185	−0.005176	0.017368	−0.065387	0.080544
NOR	Norway	0.000358	0.012981	−0.098320	0.091864	0.004962	0.058909	−0.153040	0.139731	0.014082	0.041364	−0.078365	0.095905
NZL	New Zealand	0.000358	0.007358	−0.078902	0.069366	0.037740	0.039350	−0.070330	0.232006	0.042120	0.014648	0.002545	0.152213
PAK	Pakistan	0.000428	0.014351	−0.132133	0.127622	0.088000	0.055514	−0.030995	0.249130	0.093978	0.036735	0.027937	0.177178
PHL	Philippines	0.000225	0.014430	−0.143224	0.161776	0.069643	0.062906	−0.102331	0.210878	0.073331	0.051806	−0.035769	0.178052
PRT	Portugal	0.000098	0.011725	−0.146161	0.120992	0.063591	0.055737	−0.065524	0.301186	0.056331	0.023412	0.005633	0.173880
ROU	Romania	0.000585	0.014577	−0.119018	0.145765	0.051951	0.046843	−0.087901	0.210784	0.053338	0.019745	0.009973	0.120561
RUS	Russian Federation	0.000500	0.024798	−0.404674	0.275005	0.000715	0.053316	−0.131192	0.126680	0.000718	0.037484	−0.091161	0.114845
SAU	Saudi Arabia	0.000317	0.014780	−0.127914	0.163956	0.042452	0.057735	−0.119620	0.231230	0.058924	0.026802	−0.015227	0.124284
SGP	Singapore	0.000096	0.011777	−0.091535	0.128738	0.038586	0.048783	−0.097073	0.320275	0.050320	0.040350	−0.022867	0.227201
SVK	Slovak Republic	0.000109	0.012145	−0.148101	0.118803	−0.077442	0.092444	−0.296169	0.131937	−0.056404	0.079535	−0.178583	0.093938
SWE	Sweden	0.000278	0.014220	−0.111727	0.110228	−0.027932	0.061012	−0.162420	0.154902	−0.026011	0.047034	−0.104901	0.108106
THA	Thailand	0.000078	0.015421	−0.173884	0.113495	0.041194	0.051934	−0.114736	0.203745	0.049299	0.039668	−0.005519	0.168084
TUR	Türkiye	0.001163	0.024269	−0.199783	0.177738	0.026942	0.050604	−0.086137	0.195478	0.027180	0.040786	−0.038299	0.143979
TWN	Taiwan	0.000113	0.013506	−0.099360	0.085198	0.017142	0.028233	−0.078018	0.138392	0.026294	0.016255	−0.009430	0.084023
USA	United States	0.000305	0.011087	−0.138418	0.107643	−0.047695	0.039041	−0.200986	0.047652	−0.049535	0.034080	−0.132991	0.026798
ZAF	South Africa	0.000381	0.013271	−0.142815	0.090570	−0.017083	0.062516	−0.142449	0.274337	−0.011746	0.054045	−0.091905	0.098420

Source(s): Research data

0.074). Based on inefficiency metrics for rolling samples of 1,250 (Hurst1250), almost all results remain the same.

We have identified an average cyclical behavior of exponents (daily average for all countries) of the sample over time, with periods of efficiency growth and decrease, being the 500-day window more volatile and the 1,250-day window more constant over time (Figure 1). One possible explanation for increased volatility in the 500-day window is that it captures changes in behavior trends (efficient vs inefficient) due to discrete external stimuli, while the 1,250-day window ends up smoothing out these changes.

In general, Figure 1 suggests a trend toward a reduction in the degree of information inefficiency over time, despite the cyclical behavior. Comparing three distinct periods (1992–2000, 2001–2010 and 2011–2022), we noticed a sharper reduction in the first period, a decrease with less cyclic behavior in the second period and an again highly cyclic pattern from 2011 on (third period), with negative periods for the exponent with 500 observations (negative long memory). That point is evidenced in the growth curve model (Table 5), shown in section 4.3.

It is possible to identify the impact of large events on the dynamics of inefficiency by analyzing the 1,250-day window. Moreover, it is possible to verify patterns in line with the AMH, including:

(1) An increase in inefficiency during global contagious financial crises (2007–2008 and 2020–2022, respectively) due to initial disorganization, followed by a subsequent fall in inefficiency resulting from the adjustment process.

(2) Between 2001 and 2006, a period marked by a certain stability in efficiency attributed to the existence of abnormal returns. This stability could potentially be explained by a process of expansion in the world economy after a period of high volatility and several regionalized crises with medium impact in the previous decade.

Source(s): Research data

Figure 1. Temporal evolution of the average daily Hurst index for the whole sample

Figure 1 indicates that the daily sample mean has an impact derived from global crises, generating a distance from the optimal point (0.000). However, such behavior is not clear to individual markets, indicating that (1) markets are differently affected by global determinants and/or (2) there may be individual determinants in this process (therefore, the use of multilevel analysis may be indicated). Examples of the latter are the institutional structures of the countries, their degree of openness to internationalization and their processes of internal adjustments (political, economic and legal). These aspects may impact the perception of crisis probability from market agents (which may not be only reactive, but partly predictive and dependent on the effect of learning) that, in turn, interfere in the level of informational inefficiency. This point is in line with Lo (2004, 2005) considering the relationships between agents in terms of optimal decision.

4.2 Descriptive analysis of explanatory variables

Table 3 presents descriptive statistics of explanatory variables. The high level of standard deviation of variables in relation to their respective means indicates a large difference between yields and spreads of developed and developing countries, which in turn corroborate the heterogeneity of the sample. We also noticed a potential disparity between economic variables (especially inflation) and legal aspects (legal guarantees).

4.3 Analysis of multilevel regression models: null model and growth curve model

Through the null model (Equation 1), we check if there is a statistically significant difference between the indices of countries and how much of this difference can be explained by latent characteristics over the time.

Table 4 presents the results of Equation (1). The Likelihood Ratio test indicates that the multilevel model is preferable to the linear model for both regressions. The means of inefficiency estimated for the two windows are close, but with slight superiority when estimated for 1,250 observations (intercept 0.032 vs 0.028 for 500 observations). Through the ICC, we identified that (1) for the 500 observations window, 35.368% of the variance is from the grouping at the country level, and the remainder (64.632%) refers to characteristics associated with a specific country over time; and (2) for the window of 1,250 observations, 48.053% of variance comes from the grouping at the country level, and the remainder (51.947%) refers to characteristics associated with a specific country over time.

In this sense, we understand that a significant part of the variance of inefficiency indices is associated with constant characteristics in time (or at least invariants for long periods of time),

Variables	Obs	Mean	Standard deviation	Variation Coef.
BOND10	236,995	4.643	3.401	0.732
BOND5	247,224	4.290	3.777	0.880
SPREAD	160,314	2.644	3.471	1.312
SPREAD (t−1)				
SPREAD (t−2)				
TAX	357,607	43.734	16.168	0.370
GDP	357,607	2.780	1.783	0.641
INFL	349,575	3.180	2.395	0.753
PROP	364,501	5.062	0.887	0.175
AUDIT	364,501	5.254	0.660	0.126
INVEST	364,501	6.108	1.328	0.217
REG	364,501	4.906	0.678	0.138
LEGAL	364,501	5.948	2.122	0.357

Source(s): Research data

Table 3.
Descriptive statistics of explanatory variable

Inefficiency index (Hurst – 0.50)	500 obs. window		1,250 obs. window	
Groups/observations				
Country/Stock Index	50		50	
Observations	3,39,508		3,02,023	
	Coef.	$P(z)$	Coef.	$P(z)$
Fixed effects				
Intercept	0.028	***	0.032	***
Random Effects (Estimated Variance)				
Country/Stock Index	0.002		0.002	
Observations	0.004		0.002	
Intraclass Correlation Coefficient				
Level 2 (Country/Stock Index)	0.354		0.481	
Level 1 (Time)	0.646		0.519	
Robustness Checks				
Multilevel × Linear model (χ^2)	1.40E+05	***	1.9E+05	***

Note(s): *** sig. 1%. Estimation by restricted maximum likelihood model (REML)
Source(s): Research data

Table 4. Equation 1 results

such as structural characteristics (e.g. institutional characteristics and behavioral structures of agents that require longer adaptation time to new scenarios), as tested in Table 5.

The evidence presented in sections 4.1 through 4.3 does not allow the rejection of the hypotheses H1a and H1b. Therefore, our results suggest that the degree of informational efficiency is cyclical over time and between different exchanges/countries, given its constant

Inefficiency index (Hurst – 0.50)	500 obs. window		1,250 obs. window	
Groups/Observations				
Country/Stock Index	50		50	
Observations	3,39,508		3,02,023	
	Coefficient	$P(z)$	Coefficient	$P(z)$
Fixed effects				
Intercept	0.077	***	0.085	***
Time	0.000	***	0.000	***
Random Effects (Estimated Variance)				
Country/Stock Index	0.002		0.002	
Observations	0.003		0.002	
Intraclass Correlation Coefficient				
Level 2 (Country/Stock Index)	0.384		0.531	
Level 1 (Time)	0.616		0.469	
Robustness Checks				
Multilevel × Linear model (χ^2)	1.06E+05	***	2.20E+05	***
Wald χ^2 (1)	69657.44	***	94776.45	***

Note(s): *** sig. 1%. Estimation by restricted maximum likelihood model (REML) with unstructured parameters of variance/covariance
Source(s): Research data

Table 5. Equation 1 results with constant characteristics in time

characteristics and the dynamics of evolution of the different markets analyzed. That evidence is in line with previous research on AMH that presents evidence of cyclical behavior in the markets and degrees of informational efficiency, as referenced in section 2.2.

4.4 Analysis of multilevel regression models: multilevel model with inclusion of coefficients

First, we analyzed the relationship between economic shocks and the variation of the inefficiency index over time. To this end, we included two sets of cycle proxies and economic shocks and/or structural changes: yield and spread (section 3.2). The estimated model corresponds to Equation (3).

Tables 6 and 7 present the results for the inefficiency index for 500 observations (Hurst500) and for 1,250 observations (Hurst1250), respectively. Considering only yields for both windows (models 1 and 2 of Tables 6 and 7), we noticed that they show positive sign (with one exception, but without statistical significance), indicating that the higher the yield, the higher the inefficiency of the market. We present one possible explanation for this phenomenon: the higher spread indicates a higher probability of default. In that case, AMH would say that higher spreads can show a period of financial crisis or uncertainty in the economy, leading to a higher degree of inefficiency (Lo, 2004, 2005).

The shift in the significance of the yield variable to the spread variable in models and 5 for the 500 and 1,250-day window indicates that the yield variable measures, for longer windows, the increased probability of default (spread) – explaining why the yield variable loses significance being replaced (with the same positive sign) by the spread variable. The accumulation of the variable spread (with positive sign) to the negative effect of the yield variable could be explained by agents' behavior, which is not always consonant to the probability of worsening of the economic scenario. With agents underestimating the worsening, they can imagine having abnormal returns (increased return without the corresponding increased risk increases abnormal return), which makes them less efficient. With the increased probability of default materializing (unexpected or neglected by the agents, at first), there is the escape of the agents and the explanation given to the long window model becomes evident.

Considering the characteristics of the inefficiency index estimation process (through moving windows), as noted earlier, another possible explanation for this phenomenon is associated with short- and long-term trends (variants over time and structural) for the indicator of inefficiency. The 500-day window (2 years), according to Anagnostinidis *et al.* (2016), captures more variant effects over time, not contemplating an economic cycle (which would present estimators who would not be under the effects of general economic change), estimated by authors between 4 and 5 years (1,000–1,250 obs. on average).

The evidence presented up to this point does not allow us to reject the H2 hypothesis. However, we point out that not all agents make decisions or react in the same way to changes reflected in yields and spreads. Therefore, information about the probability of a default or a recession period can be assimilated differently by the pricing framework of each "species" of market agent, as Lo (2004, 2005) and Urquhart and McGroarty (2016) state.

The last stage of modeling includes the variables related to the economic environment (GDP, INFL and TAX) and the institutional environment (PROP, AUDIT, INVEST, REG and LEGAL) in the model, considered invariants in time. The estimated final model corresponds to Equation (4).

Tables 8 and 9 present the results for the inefficiency index for 500 observations (Hurst500) and for 1,250 observations (Hurst1250), respectively. Analyzing Tables 6–9, we observed that the effects of shock variables and economic cycles remain the same in the presence of economic and institutional environment variables. Analyzing Tables 8 and 9, we noticed that the effects of the variables of the economic-institutional environment are practically the same (with small exceptions) for the two windows (500 and 1,250 observations).

Table 6. Results for the inefficiency index for 500 observations (Hurst500)

Inefficiency index (Hurst – 0.50)	500 obs. window									
Models	1		2		3		4		5	
Country/Stock Index	47		47		47		47		47	
Observations	2,33,239		2,42,315		84,864		84,864		84,864	
	Coef.	$P(z)$	Coef.	$P(z)$	Coef.	$P(z)$	Coef.	$P(z)$	Coef.	$P(z)$
Fixed effects										
Intercept	0.042	***	0.046	***	−0.013	*	0.038	***	0.006	
Time	0.000	***	0.000	***	0.000	***	0.000	***	0.000	**
Bond yield 10 years	0.001	***					−0.009	***		
Bond yield 5 years			0.001	***					−0.004	***
Bond yield spread					0.000		0.009	***	0.005	***
Bond yield spread (t−1)					0.001		0.001		0.001	
Bond yield spread (t−2)					0.001		0.001		0.001	
Random Effects (Estimated Variance)										
Country/Stock Index	0.002		0.002		0.002		0.002		0.002	
Observations	0.002		0.002		0.002		0.002		0.002	
Intraclass Correlation Coefficient										
Level 2 (Country/Stock Index)	0.483		0.461		0.532		0.505		0.509	
Level 1 (Time)	0.517		0.539		0.468		0.495		0.491	
Robustness Checks										
Multilevel × Linear model (χ^2)	1.2E+05	***	1.2E+05	***	49493.56	***	45745.65	***	47172.82	***
Wald χ^2	21130.26	***	25331.86	***	503.54	***	1124.22	***	963.93	***

Note(s): * sig. 10%; ** sig. 5%; *** sig. 1%. Estimation by restricted maximum likelihood model (REML)
Source(s): Research data

Table 7.
Results for the inefficiency index for 1,250 observations (Hurst1250)

Inefficiency index (Hurst – 0.50)	1,250 obs. window									
Models	1		2		3		4		5	
Country/Stock Index	47		47		47		47		43	
Observations	2,25,789		2,33,463		84,735		84,735		84,735	
	Coef.	*P(z)*	Coef.	*P(z)*	Coef.	*P(z)*	Coef.	*P(z)*	Coef.	*P(z)*
Fixed effects										
Intercept	0.055	***	0.062	***	0.017	**	−0.001		0.001	***
Time	0.000	***	0.000	***	0.000	***	0.000	***	0.000	***
Bond yield 10 years	0.002	***					0.003	***		
Bond yield 5 years			0.002	***					0.001	***
Bond yield spread					0.000		−0.003	***	−0.001	**
Bond yield spread (t−1)					0.001		0.001		0.001	
Bond yield spread (t−2)					0.001		0.001		0.001	
Random effects (Estimated Variance)										
Country/Stock Index	0.002		0.002		0.002		0.002		0.002	
Observations	0.001		0.001		0.001		0.001		0.001	
Intraclass correlation Coefficient										
Level 2 (Country/Stock Index)	0.594		0.583		0.642		0.652		0.647	
Level 1 (Time)	0.406		0.417		0.358		0.348		0.353	
Robustness checks										
Multilevel × Linear model (χ^2)	1.7E+05	***	1.8E+05	***	72607.29	***	70580.81	***	71239.61	***
Wald χ^2	51817.06	***	58879.74	***	993.3	***	1119.72	***	1027.66	***

Note(s): * sig. 10%; ** sig. 5%; *** sig. 1%. Estimation by restricted maximum likelihood model (REML)
Source(s): Research data

Inefficiency index (Hurst – 0.50)	500 obs. Window					
Models	6		7		8	
Country/Stock Index	48		46		46	
Observations	3,25,581		83,027		83,027	
	Coef.	*P(z)*	Coef.	*P(z)*	Coef.	*P(z)*
Fixed effects						
Intercept	0.091		0.077		0.052	
Time	−0.000	***	−0.000	***	−0.000	
Bond yield 10 years			−0.009	***		
Bond yield 5 years					−0.004	***
Bond yield spread			0.009	***	0.005	***
Bond yield spread (t−1)			0.001		0.001	
Bond yield spread (t−2)			0.001		0.001	
Total Tax Rate (TAX)	−0.001		−0.001		−0.001	
GDP Growth (GDP)	0.006		0.006		0.006	
Inflation (INFL)	0.003		0.003		0.002	
Property Rights (PROP)	−0.002		0.017		0.018	
Strength of Auditing and Reporting (AUDIT)	0.038		0.020		0.025	
Strength of Investor Protection (INVEST)	0.008		0.010	*	0.011	*
Capital Market Regulation (REG)	−0.039		−0.046		−0.053	*
Legal Rights (LEGAL)	−0.010	**	−0.010	**	−0.010	**
Random Effects (Estimated Variance)						
Country/Stock Index	0.002		0.002		0.002	
Observations	0.003		0.002		0.002	
Intraclass Correlation Coefficient						
Level 2 (Country/Stock Index)	0.339		0.461		0.472	
Level 1 (Time)	0.661		0.539		0.528	
Robustness Checks						
Multilevel × Linear model (χ^2)	1.1E+05	***	35828.19	***	37205.55	***
Wald χ^2	68143.01	***	1163.32	***	1014.67	***

Note(s): * sig. 10%; ** sig. 5%; *** sig. 1%. Estimation by restricted maximum likelihood model (REML)
Source(s): Research data

Table 8. Results for the inefficiency index for 500 observations (Hurst500)

The economic environment variables present results expected by AMH: (1) GDP has a positive signal because periods of expansion tend to generate higher abnormal returns, making agents feel more relaxed and therefore less efficient (also consistent with AMH assumptions – Lo, 2004, 2005).

(2) REG and LEGAL presented a negative signal, indicating that a solid institutional environment attracts internal and external investors, making the environment more competitive and with greater demand for agents' efficiency to ensure their survival, in line with Forti, Yen-Tsang, and Peixoto (2011), Rejeb and Boughrara (2013) and Blau, Brough, and Thomas (2014). Better stock market regulation and law enforcement create a better informational environment and incentivize the agents to compete. These results are in line with AMH assumptions by Lo (2004, 2005).

The positive effect of INVEST draw attention. Considering the effect is significant to 10%, the signal is positive. That result is inconsistent with the other institutional variables: REG and LEGAL. This result is consonant to Blau *et al.* (2014), considering the assumption that more investor protection and subsequent regulation of investor relations can be related with

Inefficiency index (Hurst – 0.50)	1,250 obs. window					
Models	6		7		8	
Country/Stock Index	48		46		46	
Observations	2,89,597		82,898		82,898	
	Coef.	*P(z)*	Coef.	*P(z)*	Coef.	*P(z)*
Fixed effects						
Intercept	0.090		0.051		0.063	
Time	−0.000	***	−0.000	***	−0.000	***
Bond yield 10 years			0.003	***		
Bond yield 5 years					0.001	***
Bond yield spread			−0.003	***	−0.001	**
Bond yield spread (t−1)			0.001		0.001	
Bond yield spread (t−2)			0.001		0.001	
Total Tax Rate (TAX)	−0.001		−0.001		−0.001	
GDP Growth (GDP)	0.006	*	0.007	*	0.007	*
Inflation (INFL)	0.003		0.002		0.002	
Property Rights (PROP)	−0.005		0.008		0.009	
Strength of Auditing and Reporting (AUDIT)	0.043		0.032		0.030	
Strength of Investor Protection (INVEST)	0.010	*	0.011	*	0.011	*
Capital Market Regulation (REG)	−0.043		−0.058	**	−0.055	*
Legal Rights (LEGAL)	−0.009	**	−0.008	*	−0.008	*
Random Effects (Estimated Variance)						
Country/Stock Index	0.002		0.002		0.002	
Observations	0.002		0.001		0.001	
Intraclass Correlation Coefficient						
Level 2 (Country/Stock Index)	0.480		0.604		0.597	
Level 1 (Time)	0.520		0.396		0.403	
Robustness Checks						
Multilevel × Linear model (χ^2)	1.5E+05	***	55347.78	***	55771.36	***
Wald χ^2	90537.98	***	1117.48	***	1018.74	***

Note(s): * sig. 10%; ** sig. 5%; *** sig. 1%. Estimation by restricted maximum likelihood model (REML)
Source(s): Research data

Table 9. Results for the inefficiency index for 1,250 observations (Hurst1250)

riskier markets. In AMH perspective, more investor protection can cause control access of agents for specific markets, reducing interaction and competitiveness.

The evidence presented in this section does not allow us to reject the H3 hypothesis. Not only the interaction between agents but also the characteristics to which these agents are subjected interfere with the efficiency of the market and its dynamics over time.

Our findings indicate, from a general perspective, that the environment of the agents (market characteristics) influences their decision-making processes over time. Such characteristics are both variants over time, such as cycles and economic shocks, as well as invariants (or with low variation) over time, such as the economic and institutional environment.

5. Final thoughts

The main objective of this paper was identifying the effect of macroeconomic and institutional characteristics in market efficiency, considering an AMH framework and using multilevel modeling. Considering the results, we identified (1) increase in abnormal returns in periods of expansion are associated with increased inefficiency (convergent with Lo, 2005), indicating that a country's growth can lead to the relaxation of investors in the face of losses due to non-optimal decisions (increased inefficiency); and (2) greater legal certainty is associated with a lower degree of relative inefficiency, which may accredit legal certainty as indicative of the degree of development of capital markets.

Our results strengthen AMH as it shows that not only agents are adaptive "animals", as they are capable of adapting to the environment they are in. Additionally, consistent with previous works, we identified the cyclical behavior of different markets in time, and possible shocks can be related with variations of market efficiency in time.

Our choice to analyze 50 countries has limited our work on two aspects: period (shorter than that used by other studies) and restriction of economic and institutional environment metrics (restricted to available data of each country). We also highlight the impossibility of generalizing the results to time windows different from those used by us for the calculation of the Hurst moving averages (500- and 1,250-day), nor the direct comparison with studies that chose another period.

Considering that AMH is a relatively new concept (2005), there is much to be done on this subject. Future research may (1) test other time windows, (2) use longer periods of time, (3) control relationships by other variables (associated with national cultures and agent profile) or (4) analyze the interaction of agents over time, since the AMH is still a theory under construction (Lo, 2005). In addition, we can observe how markets react in a pandemic shock (COVID-19 context), with economic and financial consequences, considering two grater points: How government actions affect the size of agents in financial markets, and how these agents act after a big shock. For those events, more research is needed on other markets, in addition to how they adapt to new scenarios based in AMH framework.

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Corresponding author
Talles Vianna Brugni can be contacted at: tallesbrugni@fucape.br