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Time-varying causality between stock prices and macroeconomic fundamentals: Connection or disconnection?

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ABSTRACT

This study investigates the connection/disconnection between the stock market and macroeconomic fundamentals in the United States from January 1960 to December 2021. Using a recent time-varying Granger causality framework, tests revealed asymmetric bidirectionnal causality. The lead-lag relationships between stock prices and key macroeconomic indicators are more prevalent during recession phases. However, the significance and intensity of the causal relationships during the Covid crisis varied greatly; which could indicate a possible disconnection.

1. Introduction

The connection/deconnection between macroeconomic variables and the stock market is a central question for academics, policymakers, investors or fund-managers. Many studies[1] focus on the interactions between real economy and the stock market, by analyzing the spillover effects or the predictability of stock returns using macrovariables. Beginning with Chen et al. (1986), the literature considers a large set of macro variables (inflation, industrial production, interest rates, money supply, consumption, unemployment), in developed and developing countries, to assess the impact on financial markets. Changes in stock prices will be related to macroeconomic changes occurring or being anticipated by the market (Peiro, 2016). On the one hand, stock markets can be considered as a leading indicator, since security prices should reflect a company's expected earnings (Stock & Watson, 1990). Stock market can be an indicator of how economic activity will act in the future, and increased stock market returns can point to future variations in the macroeconomic variables (Fromentin, 2021b).

The bidirectional causality between real macroeconomic variables and stock market has been difficult to establish, perhaps because their relationships are not linear nor time invariant (Flannery and Protopapadakis, 2002), which may be the case during the Covid crisis.

In this article, in order to extend the existing literature, we propose to study the bicausal relationship between the stock market and five macroeconomic variables in the United States between January 1960 and December 2021. Our paper aims to contribute to the literature in four key ways.

First, we applied a newly developed time-varying Granger causality approach of Shi et al. (2018, 2020) to explore the bidirectional causal relationship between S&P500 and macroeconomic variables. This new approach allows unknown change points in the causal relationships and also accommodates potential heteroscedasticity. It is also possible to determine the origination and termination dates

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[1] We can refer to Camilleri et al. (2019) or Bhuiyan and Chowdhury (2020) for a literature review.

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for any episode of Granger causality. In complement, this methodology does not require detrending or differencing the data.

Second, we investigated the bidirectional causality between macroeconomic factors and the stock market (like Camilleri et al., 2019 for example). Indeed, most studies focus on a unidirectional relationship. However, we believe that analyzing a double causality to assess the connection/disconnection and lead-lag effects is more relevant, especially during periods of recession or uncertainty, such as the Covid crisis. It is likely that the intensity and direction of causality may vary according to periods and macroeconomic variables.

Third, this study incorporates the most recent data in order to judge the singularity (or not) of the health crisis concerning the interactions between stock market activity and macroeconomic indicators. Indeed, despite some jolts, the stock market presents a high level of performance; contrary to certain macroeconomic indicators. In consequence, it is difficult to see a relationship between the health crisis and the reactions of stock markets (Capelle-Blancard and Desroziers, 2020).

Fourth, we integrated the "unemployment" variable in the VAR model. This variable is very little used in articles studying the interrelationships between macroeconomic variables and the stock market. However, we believe that the integration of this variable is interesting in several respects: it reflects the economic situation of a country, particularly during phases of recession; the work of Phelps (1994); Hoon and Phelps (1992); Phelps and Zoega (2001); Farmer (2010) and Feldmann (2011) explain the link between the stock market and unemployment rates through arguments based on the expected profits and the impact on employment; this allows different markets to be integrated into a VAR model (like Abdullah and Hayworth (1993) for example): the money market with an interest rate and money supply, the goods market with inflation and IP and the labor market with unemployment.

In summary, this article complements the existing literature by analyzing the existence and intensity of bidirectional time-varying causality between the stock market and five macroeconomic variables (with a labor market variable), while taking into account the singularity of the Covid period.

The rest of the paper is organized as follows. The next section review the existing literature that contextualizes our paper. The Section 3 presents the data. The Section 4 summarizes the methodology, with a focus on the recursive evolving window procedure. The Section 5 explains the econometric procedure and expose the results. The Section 6 concludes.

2. Literature review

From a theoretical point of view, these hypothetical connections can be explained in several ways. The efficient market hypothesis (Fama, 1970) suggests that all relevant information about changes in macroeconomic factors is fully reflected in current stock prices. In this case, investors would not earn abnormal profits in these markets and economic changes will be unable to have an influence on stock market. Obviously, this argument has been critically examined by subsequent studies (Fama and Schwert (1977) for example). They demonstrate that macroeconomic variables influence and help predict stock prices. In this line, Arbitrage Pricing Theory (APT) provides a theoretical framework to explain the relationship between stock prices and macroeconomic fundamentals. Economic changes affect discount rates, and concomitantly, macroeconomic variables become part of the risk factors in equity markets (Ross, 1976; Chen et al., 1986).

On the other hand, stock markets can also be lagging indicators, reacting to macroeconomic data (Stock & Watson, 1990). For example, Ratanapakorn and Sharma (2007) show that “the improvement in the profit outlook increases the aggregate demand and, consequently, investment and finally raises the interest rate”. In complement, stock prices can be related to expected future production through effects on the discounted value of changes in cash flows and dividends (Cochrane, 1991). Mcmillan (2005) showed that a positive demand shock that increases industrial production expected future and hence cash flow, will drive stock prices higher today. Equity returns thus enable and can predict future industrial production. results of Mcmillan (2005) support time variation in the relationship between stock markets and macroeconomic variables.

However, the literature does not present consensual results, depending on the country and the periods used. The conclusions diverge from one study to another sometimes (Camilleri et al., 2019). For example, Binswanger (2000) showed that stock returns do not seem to lead real activity and predictable return variations as a response to business conditions cannot be detected for certain periods.

In addition, the singularity of Covid health crisis can also upset the preliminary conclusions. Several studies conducted their research to investigate the link between the macroeconomic variables and the worldwide crisis over time, ending with the last health crisis that we experienced, “Covid-19″. For example, Roghani and Panahi (2021) examined the linkage between unemployment and the Covid-19 vaccine rate in the United States and found a positive linear association between them, which means a higher rate of unemployment is likely to lead to a higher tendency of seeking the vaccination against Covid-19. Rouatbi et al., (2021) conducted a study on 66 countries to find out whether or not the vaccination of Covid-19 has an impact on stock market volatility. They found that the vaccination helps to stabilize stock markets around the world. Also, Capelle-Blancard and Desroziers (2020) conducted a study on 74 countries to find out the influence of Covid on stock markets worldwide.

However, to our knowledge, no study analyzes the relationship between macroeconomic fundamentals and the stock market during the health crisis.

3. Data

In this paper, we used monthly data between January 1960 and December 2021 for stock market and macroeconomic variables. The sample includes 744 observations.

In details, like the previous studies, we retained the four most used macroeconomic variables: industrial production (IP) (Source: Federal Reserve Economic Data (FRED) - Bank of St. Louis), inflation (CPI) (Source: FRED), money supply (M1) (Source: FRED) and

long-term government bond rate (LIR) – Benchmark 10-year government bond rate (Source: FRED). Following Humpe and Macmillan (2009) and Bhuiyan and Chowdhury (2020), seasonally adjusted data for industrial production are used to correct the strong seasonality. In complement, we took into account the unemployment rate (U) (Source: FRED) (like Chen (2009), Farmer (2015) or more recently, Fromentin (2021b)). The stock market variable is S&P500 (Source: FactSet). The stock market composite is based on the closing price of the indices on the last business day of each month. All the series are expressed in natural logarithmic form (for more details, see Tables A1 and A2, Fig. A3 and Fig. A4).

Finally, the model incorporated industrial production, money supply, inflation (with CPI like proxy), long-term bond rate, unemployment and S&P500 to capture respectively the real economic activity, monetary politics, the evolution of prices, long-term interest rate, labor market and stock market activity.

4. Methodology

To investigate the time-varying causal relationship between the stock market and the macroeconomic variables, we proposed to implement the recent causality procedure from Shi et al., (2018, 2020). They revisited the notion of time variation in testing for Granger causality by showing it is possible to assess stability of causal relationships over time, with a stationary VAR model (Shi et al., 2018) or with a lag-augmented VAR (LA-VAR) model to make non-stationary variables in the VAR model possible (Shi et al., 2020).

They considered time dynamics to detect periods of instability in the causal relationship with three time-varying causality algorithms: forward recursive causality, rolling causality and recursive evolving causality. The method is based on intensive recursive calculation of Wald test statistics from a VAR model:

$$y_{1t} = \varnothing_0^{(1)} + \sum_{k=1}^{m} \varnothing_{1k}^{(1)} y_{1\ t-k} + \sum_{k=1}^{m} \varnothing_{2k}^{(1)} y_{2\ t-k} + \varepsilon_{1t} \tag{1}$$

$$y_{2t} = \varnothing_0^{(2)} + \sum_{k=1}^{m} \varnothing_{1k}^{(2)} y_{2\ t-k} + \sum_{k=1}^{m} \varnothing_{2k}^{(2)} y_{2\ t-k} + \varepsilon_{2t} \tag{2}$$

where y_{1t} and y_{2t} represent respectively the stock market and the macroeconomic variables.

In this context, the null hypothesis of no Granger causality from y_1 to y_2 is verified by testing the joint significance of $\varnothing_{1k}^{(2)}$ $(k = 1, \ldots, m)$ by means of a Wald test. Shi et al., (2018, 2020) compare different statistics with a sequence of test statistics of Granger causality, one for each time period of interest. They then conclude in favor of a rolling window estimation of the traditional Wald statistics. That is a real-time-varying test based on the supremum (sup) Wald statistic sequences using a forward recursive (Thoma, 1994), a rolling window (Swanson, 1998; Arora and Shi, 2016) and recursive evolving algorithms (Phillips et al., 2015a, 2015b).

Shi et al., (2020) suggested that the recursive evolving window procedure yields the best results. We will therefore focus our attention on this algorithm in this analysis. In this procedure, Wald statistics over $[f_1, f_2]$ with a sample size fraction of $f_w = f_2 - f_1 \geq f_0$ is noted by $Wf_2(f_1)$ and the sup Wald statistics is expressed as follows[2]:

$$SW_f(f_0) = \frac{sup}{(f_1, f_2) \in \widehat{0}, f_2 = f} \{w_{f_2}(f_1)\} \tag{3}$$

where $\widehat{0} = \{(f_1, f_2) : 0 < f_0 + f_1 \leq f_2 \leq 1, \ and\ 0 \leq f_1 \leq 1 - f_0\}$

In this context, it is possible to determine $\widehat{f}_e$ and $\widehat{f}_f$ which are the first estimated chronological observations whose test statistics respectively exceeds or falls below the critical values for the origination and termination points in the causal relationship.

$$\widehat{f}_e = \frac{inf}{f \epsilon [f_0, 1]} \{f : SW_f(f_0) > scv\}$$

and

$$\widehat{f}_f = \frac{inf}{f \epsilon [\widehat{f}_e, 1]} \{f : SW_f(f_0) > scv\} \tag{4}$$

where scv is the corresponding critical values of SW_f statistics.

In view of the superiority of the recursive evolving window procedure, we investigated the potential causal relationship between the stock market and the macroeconomic variables using this procedure in this paper.

5. Empirical analysis and results

To estimate the bivariate VAR and to conduct the dynamic granger causality tests, we used the TGVC Stata module (Otero et al.,

[2] See Hammoudehet et al. (2020)

Table 1
Unit root test results.

	Level		First Difference		Conclusion
	Intercept	Intercept and trend	Intercept	Intercept and trend	
ADF Test					
SP500	0.46	-1.97	-26.15***	-26.16***	I(1)
IP	-2.46	-1.53	-20.51***	-20.67***	I(1)
CPI	-1.44	-1.15	-3.46***	-3.66**	I(1)
M1	2.35	1.43	-25.45***	-25.61***	I(1)
LIR	-1.33	-2.10	-24.52***	-24.55***	I(1)
U	-3.03**	-2.99	-24.40***	-24.40***	I(0)

Notes: ***, **, and * denote a significance of 1%, 5%, and 10%, respectively. Phillips-Perron results are not shown to save space. We obtain substantially the same results.

Table A1
Description of the variables.

	LNSP500	LIR	LNIP	LNU	LNCPI	LNM1
Mean	5.932298	5.883406	4.115979	1.753538	4.661116	6.561972
Median	5.885052	5.615000	4.131973	1.740466	4.901191	6.469250
Maximum	8.469300	15.84000	4.645985	2.687847	5.635475	8.900467
Minimum	3.977623	0.539600	3.100471	1.223775	3.379974	6.128178
Std. Dev.	1.299525	2.978207	0.436802	0.268666	0.733532	0.487275
Skewness	0.123162	0.697563	-0.496670	0.192871	-0.507580	2.934104
Kurtosis	1.535055	3.302562	2.153801	2.640438	1.805137	13.43632
Jarque-Bera	68.40889	63.17547	52.78606	8.620542	76.20564	4443.934
Probability	0.000000	0.000000	0.000000	0.013430	0.000000	0.000000
Sum	4413.630	4377.254	3062.289	1304.632	3467.870	4882.107
Sum Sq. Dev.	1254.754	6590.199	141.7615	53.63099	399.7856	176.4157
Observations	744	744	744	744	744	744

Table A2
Variables, names and sources.

Variables	Names of the variables	Source
Industrial Production	IP	FRED
Inflation	CPI	FRED
Money supply	M1	FRED
Long-term government bond rate	LIR	FRED
Unemployment	U	FRED
Stock market	S&P500	Factset

2021). We followed different steps: the determination of the order of integration, the choice of the VAR model, causality tests for full sample, and time-varying causality tests.

This methodology does not require pre-filtering of data. However, it is necessary to estimate the order of integration of the series. We implemented Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests. The results of ADT tests are reported in the table 1. They concluded that all variables are stationary for the first difference, except unemployment. Since there are variables I(1) in the VAR model under consideration, the time-varying causality is obtained from a LA-VAR model where $d = 1$. Like Shi et al., (2020), lag orders are selected using BIC with a maximum length of 12.

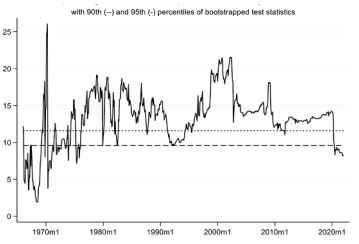
For the full sample, we can reject the null hypothesis of no Granger causality from all the macroeconomic variables to the stock market variable. Specifically, between January 1960 and December 2021, the Max Wald recursive evolving are 26.06 (LIR→SP500), 56.19 (IP→SP500), 39.84 (U→SP500), 22.98 (CPI→SP500) and 40.97 (M1→SP500). We also obtained significant results for reverse causation: 38.39 (SP500→LIR), 45.91 (SP500→IP), 28.27 (SP500→U), 44.91 (SP500→CPI) and 23.24 (SP500→M1).

The time-varying Wald test statistics are presented in Fig. A1 with their bootstrapped critical values (90th and 95th percentiles), from macroeconomic variables to SP500. The inverse causality are shown in Fig. A2. In general, we found that Granger causal relationships are very dynamic and that stock market activity and the macroeconomic variables are closely related. This is particularly true during recession phases[3] (1969–12–01, 1970–11–01 / 1973–11–01, 1975–03–01 / 1980–01–01, 1980–07–01 / 1981–07–01, 1982–11–01 / 1990–07–01, 1991–03–01 / 2001–03–01, 2001–11–01 / 2007–12–01, 2009–06–01 / 2020–02–01, 2020–04–01).

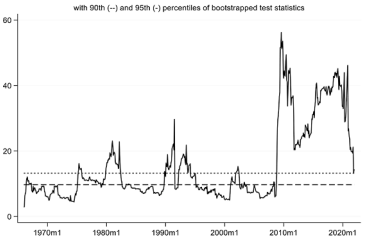
The causality from LIR to SP500 is constantly significant from the mid-1970s until today, except during the health crisis linked to Covid. The degree of significance increases during periods of recession. These results are in agreement with the theory of finance, as

[3] Source: https://fredhelp.stlouisfed.org/fred/data/understanding-the-data/recession-bars/

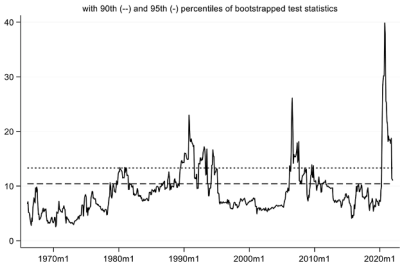
(a) Recursive Evolving-Heteroskedasticity LIR→SP500



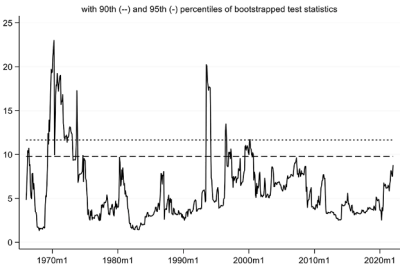
(b) Recursive Evolving-Heteroskedasticity IP→SP500



(c) Recursive Evolving-Heteroskedasticity U→SP500



(d) Recursive Evolving-Heteroskedasticity CPI→SP500



(e) Recursive Evolving-Heteroskedasticity M1→SP500

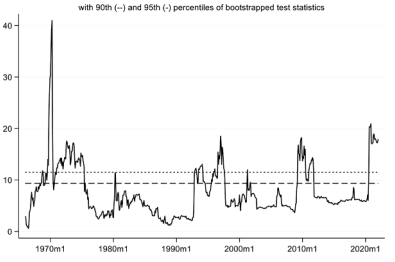


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Fig. A1. Time-varying causality from LIR, IP, U, CPI, M1 to SP500. a) Recursive Evolving-Heteroskedasticity LIR→SP500. b) ursive Evolving-Heteroskedasticity IP→SP500. c)Recursive Evolving-Heteroskedasticity U→SP500. d)Recursive Evolving-Heteroskedasticity CPI→SP500. f)Recursive Evolving-Heteroskedasticity M1→SP500.

demonstrated by R Jammazi et al. (2017). Interest rates have a direct impact: on the discount rate used in standard equity valuation models; on the capital costs of financing corporations, thus impacting expected future corporate cash flows; on the investor diversification strategy, with a portfolio of bonds and stocks. Concerning the time-varying Granger causality from SP500 to LIR, the relationships are significant from 1980, with a greater amplitude during the phases of recession, except during the Covid crisis. Indeed, a sharp increase (decrease) in the forward-looking stock prices can be interpreted as a signal of optimism (pessimism) about future economic developments, which may eventually lead to a growth (reduction) in interest rates. These results about a bidirectional causality between interest rates and the stock market are in line with the work of Moya-Martínez et al., (2015) or R. Jammazi et al. (2017).

Concerning the causality IP→SP500, it has an asymmetrical character with regard to its significance during specific phases. This significance becomes particularly important during the 2008 financial crisis and the Covid crisis. Reverse causality, on the other hand, has a less marked asymmetric character. It becomes systematically significant in the early 1980s. It should be noted that the Covid crisis marks a significant drop in the level of significance. This relationship even becomes insignificant, with an invalidity of the predictive nature of the stock market. Variation in industrial production (as a proxy for real economic activity) impacts the corporate earnings enhancing the present value of the firm (Fama, 1990) and hence it leads to modify the investment in the stock market (see Pramod Kumar and Puja (2012) for example). The level of output affects the profitability of a firm which finally affects SP500. In reverse logic, returns on firms' stocks lead growth rates in industrial production (like Geske and Roll (1983), Chang and Pinegar (1989) or Sadorsky (1999)), in link with Fama's (1981) assertion of market efficiency. The stock market is also a leading indicator of real economic activity, which varies in intensity depending on the period, especially during the Covid crisis.

Unemployment clearly seems to cause stock market activity asymmetrically, during periods of recession. Its degree of significance also reached a very high level during the Covid crisis. In an inverse logic, the predictability of the stock market on unemployment is also verified, especially after periods of crisis (oil shock, internet bubble and financial crisis of 2008 in particular). It is important to note that SP500 did not cause unemployment during the health crisis, which testifies a certain disconnection (unlike U→SP500). Time-varying Granger causality tests revealed that lagged realizations of the SP500 have predictive power regarding unemployment, and vice versa (like Fromentin, 2021b). However, the Covid crisis is singular in terms of existence of unidirectional causality. Hoon and Phelps (1992), Feldmann (2011) or Fromentin (2021a) explained the relationship between the stock market and unemployment rates through arguments based on the expected profits and the impact on employment. Reciprocally, unemployment news can feature information on growth expectations and/or the equity risk premium in the current business cycle phase (Chen, 2009). It should be noted that the "unemployment" variable is very little used in articles studying interrelationships between macroeconomic variables and the stock market; however, Chen (2009) and R Jammazi et al. (2017) "indirectly" used this variable. Moreover, as a robustness check, estimating the VAR model without unemployment leads to almost similar results.[4]

Causality from CPI to SP500 is more erratic. Indeed, the time-varying Wald test statistics are significant during the 1970s and 1990s. From the 2000s, CPI no longer seems to predict stock market activity. Regarding the reverse causality, stock market variable seems to cause CPI during the 1980s, especially from 2010; during relatively "stable" periods, with an increase in money supply. It should be noted that this causality is substantially reduced with the health crisis. In this study, inflation reflects the general state of the economy. As Bhattacharya and Mukherjee (2006), our results suggest a sporadic bidirectional causality between CPI and SP500. This is explained by the fact that nominal long-term returns of assets should contain an inflation premium. Stock prices can reflect the discounted value of expected dividend. Mukherjee and Naka (1995) showed that an increase in inflation increases the nominal risk-free rate, raising the discount rate in the valuation model. Dhakal et al., (1993) assert that an increase in money supply (which is the case from 2010) could lead to unanticipated increase in inflation, which may impact stock prices.

To finish, the results suggest an asymmetric bidirectional causality between M1 and SP500 during or after the recession phases. This observation is confirmed during the Covid crisis. This result is in line with the majority of studies focused on the links between changes in the money supply and the stock market (see Bhuiyan and Chowdhury (2020) for a review). Indeed, causality can be exercised through different transmission channels (see Kumar et al., 2012, for example): an increase in the money supply can modify the investment strategy from non-interest bearing money assets to financial assets like stock; money creation can stimulate the economy, and therefore increase corporate profits, which should increase stock prices; and the increase in the money supply can cause inflation, and therefore an increase in the discount rate, which reduces stock prices.

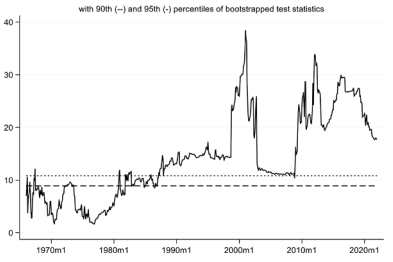
6. Conclusion

In this paper, the bidirectionnal causality between the stock market and macroeconomic fundamentals in the United States between 1960 and 2021 are investigated with newly developed time-varying Granger causality approach. This issue is of central importance to academic finance literature, investors and policy makers, particularly during phases of economic recession, such as the Covid crisis.

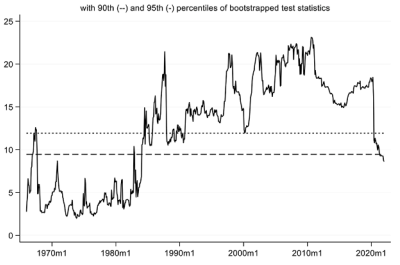
The empirical results revealed that the causality is bidirectionnal and support time variation in the relationship, particularly during

[4] The results are available on request from the author.

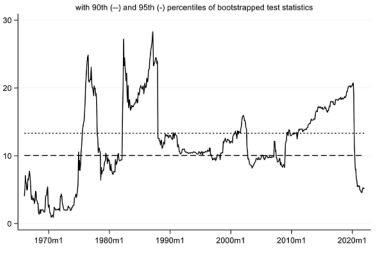
(a) Recursive Evolving-Heteroskedasticity SP500→LIR



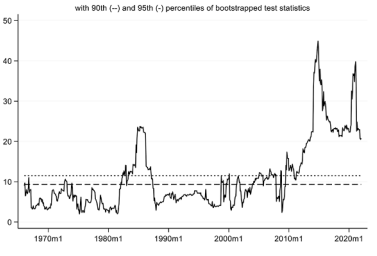
(b) Recursive Evolving-Heteroskedasticity SP500→IP



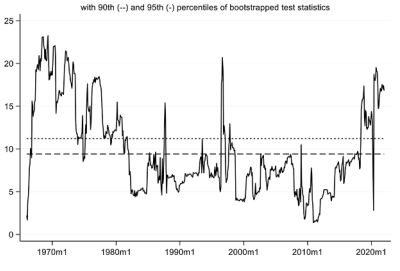
(c) Recursive Evolving-Heteroskedasticity SP500→U



(d) Recursive Evolving-Heteroskedasticity SP500→CPI



(e) Recursive Evolving-Heteroskedasticity SP500→M1



(caption on next page)

Fig. A2. Time-varying causality from SP500 to LIR, IP, U, CPI, M1. Recursive Evolving-Heteroskedasticity SP500→LIR. a)Recursive Evolving-Heteroskedasticity SP500→IP Recursive Evolving-Heteroskedasticity SP500→U. c)Recursive Evolving-Heteroskedasticity SP500→CPI. d)Recursive Evolving-Heteroskedasticity SP500→M1.

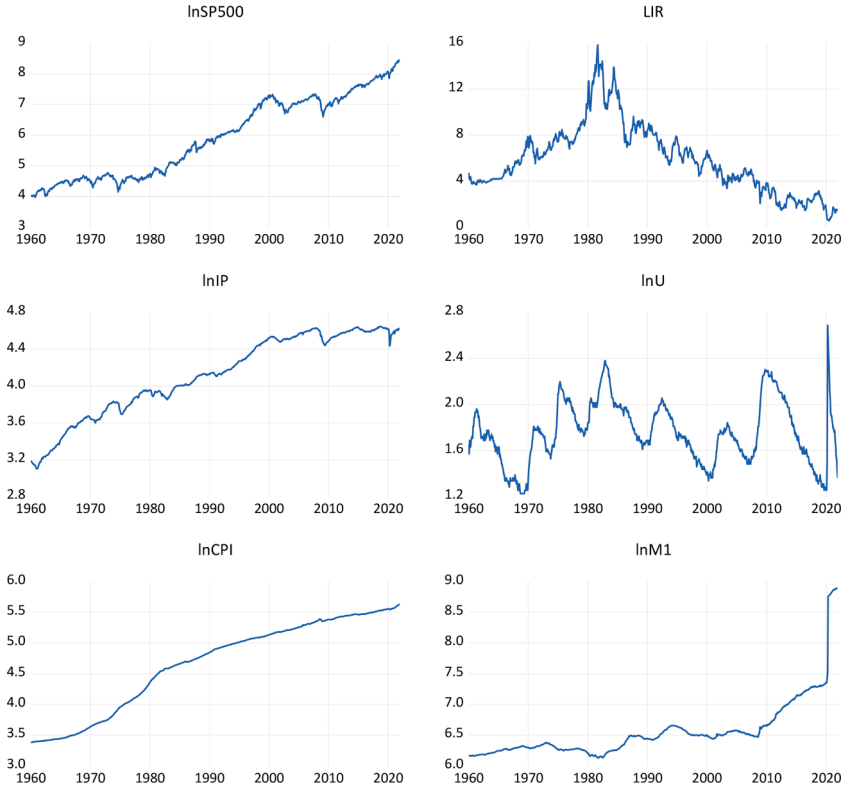


Fig. A3. Evolution of the stock market and macroeconomic variables between 1960 and 2021.

economic or financial crises. The boom and bust cycle is key to understand the spillover of information between fundamentals and the stock market. During the health crisis, this observation is less valid, which could testify to a disconnection between the fundamentals and stock market activity. The recent stock price movements cannot be explained by all fundamental factors (except unemployment and M1) from 2020. Covid crisis might have altered economic relationship. We could be in the presence of irrational exuberance or speculative bubbles (Binswanger, 1999 or Shiller, 2000). The presence of time variation can indicate the presence in the stock market of noise traders and speculators. In parallel, lagged realizations of the stock market seem to have the ability to predict macroeconomic variables asymmetrically. This is particularly true for LIR, CPI and M1 during the Covid crisis in the United States.

These results are in line with the literature about the information spillover between finance markets and real-life economy, with changes of causality and intensity across time. This conclusion must be qualified during the health crisis. The Covid crisis might have altered economic relationships.

This study could be extended by incorporating stock market and macro-economic sectoral variables, by conducting the analysis in other countries (in Europe for example), and by taking into account the transmission mechanisms (between official interest rates and money-market interest rates for example).

CRediT authorship contribution statement

Vincent Fromentin: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Writing – review & editing, Visualization, Supervision, Funding acquisition, Data curation.

Appendix A

none

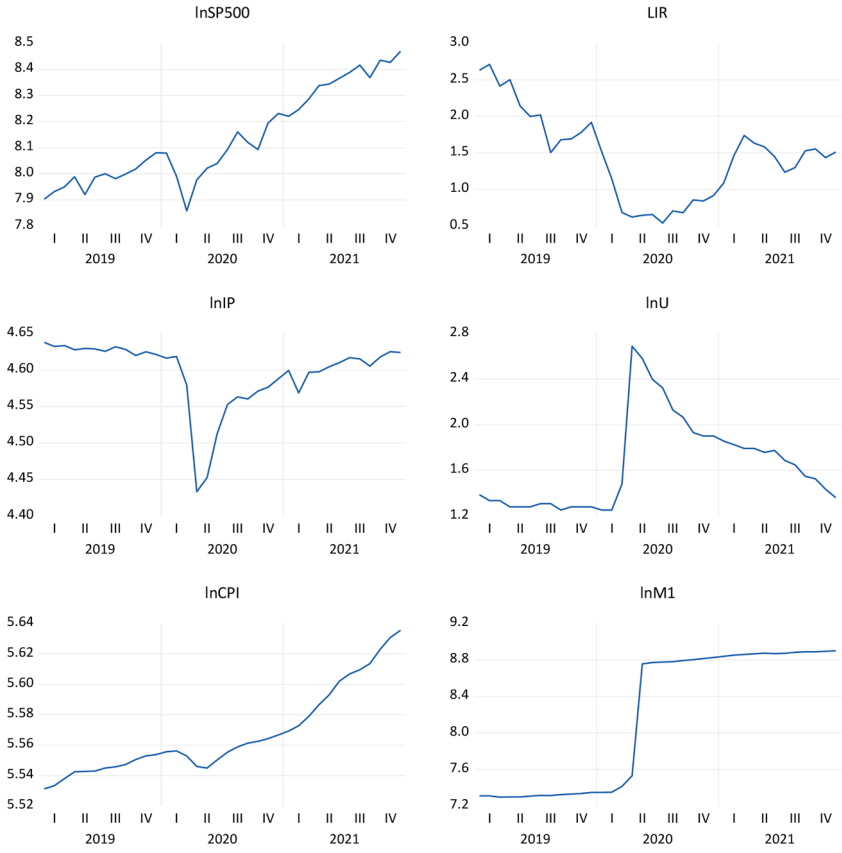


Fig. A4. Evolution of the stock market and macroeconomic variables between 2019 and 2021.

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