The Heterogeneity of Stock Prices Responses to Policy Shocks: Evidence From International Data

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In the aftermath of a shock in an economy, stock prices tend to be subject to adjustments. We observe heterogeneous responses to shocks to nominal interest policy rates across firms differing by the degree of financial leverage and by the expanse of financing frictions that managers encounter when accessing external finance. We find that a unit shock to nominal interest rates decreases stock prices of firms with high debt to asset ratios whereas it increases stock prices of firms with low debt to asset ratios. We provide puzzling evidence that stock prices are positively related to nominal interest policy rates in case of low and zero leverage firms. This fact represents an anomaly which we purport to explain.

Keywords: stock prices, investment analysis, financial leverage, financing frictions, panel vector autoregressive model, interest rates, impulse response functions

INTRODUCTION

The financial decision-making process subsumes two separate types of decisions - investment decisions and financing decisions (Tobin, 1958). Although such process is endogenous to firms, managers cannot overlook exogenous factors that have consequences on shareholders' wealth. Changes to policy, resulting in movements in the level of interest rates, for instance, might have long lasting effects on stock prices (Chen, 1986). In fact, interest rates affect the cost of capital and the net present value of investments, thereby having implications for both the liability side and asset side of the balance sheet. The persistence of stock prices responses to shocks to interest rates, or even their sign, might be heterogeneous across firms with different degrees of financial leverage and might depend on the expanse of financing frictions encountered by firms.

The debate about a prospective connection between stock returns and financial leverage has divided scholars into two groups. This debate has counter-posed those who support the view that returns increase with leverage (Hamada, 1972 and Bhandari, 1988) with those who advocate a negative relationship between stock returns and financial leverage (Hall and Weiss, 1967; Dimitrov and Jain, 2008; Korteweg, 2010; Muradoglu and Sivaprasad, 2012). The sign of stock returns depends on the role that financial leverage is playing. Provided that investors are risk adverse, theoretically, during negative market conditions, financial leverage acts as a negative multiplier, whereas, during good times, financial leverage can spur positive returns.

Although the connection between stock prices and financial leverage has been extensively studied, less is known about the connection between financial leverage and macroeconomic variables. The topic of the paper is multidisciplinary, moving itself along the boundary between macroeconomics and corporate finance. The intent of the paper is singular, notably helping people in decision making. We try to narrate how we reached our conclusion by starting from explaining the initial reasoning that guided us to the results.

Our goal was originally that of empirically disentangling the interrelation between leverage and interest rates by analyzing the persistence of stock prices' responses to shocks to interest rates under varying degrees of capital structure and asset tangibility.

The bottom line is that shocks to interest rates might be amplified by corporate leverage for companies with significant financial distress risk, thereby becoming more durable. Likewise, stock prices of constrained firms – which face frictions when trying to obtain funding – might be more persistently affected by shocks to interest rates. We tested the persistence and the effect - in terms of sign and of magnitude - of unit shocks to interest rates on series of stock prices.

The methodology subsumes a Panel Vector Autoregression that enables us to derive impulse response functions. By means of impulse response functions, we could check whether stock prices reach the steady state after a timeframe that is dependent on the degree of financial leverage and on the degree of financing frictions – represented by asset tangibility – characterizing the firms under scrutiny. To this end, we compute the median value of leverage for the full sample. We then split the sample into two subsamples constituted by firms featuring above median financial leverage and firms featuring below median financial leverage. Finally, we derive impulse response function for the two subsamples.

The paper distinguishes then between high and low leverage firms based on the median value of financial leverage. While wishing to provide evidence on whether the sensitivity to shocks could be measured in terms of the persistence of the shock itself, we serendipitously found that the main variables used in the literature (Chen et al., 1986) were significant for low leverage firms but not for high leverage ones and, interestingly, that a unit shock to nominal interest rates decreases stock prices of firms with high debt to asset ratios whereas it increases stock prices of firms with low debt to asset ratios.

Firstly, we surmise that responses in stock prices to shocks to interest rates last longer in case of high leverage firms. A greater persistence of shocks, showing itself as longer responses of stock prices in the aftermath of a shock, might be due to the lack of financial slack and concomitant presence of financial constraints characterizing firms with high corporate leverage. Similarly, longer responses of stock prices before reaching the steady state after an impulse to interest rates, might be due to the degree of firms' asset tangibility because of the difficulty of such firms to adjust their capital structure towards the optimal level. Hence, we hypothesize that responses in stock prices to shocks to interest rates are more durable in case of more constrained firms. Then we carry out a multitude of robustness checks. We investigate the consequences of shocks for different subsamples, and we add a new explanatory variable – the market index.

The difference in terms of shocks' persistence is sizeable between highly leverage firms and low leverage ones. Interestingly, we find that the former firms are affected by shocks in an opposite manner compared to the latter. That is, a unit shock to interest rates determines an increase in the stock price of low leverage firms whereas it brings about a decrease in the stock price of highly leveraged firms. Hence, the consequences of shocks are heterogeneous for the two typologies of firms, as we hypothesized. This heterogeneity manifests itself in terms of sign of the responses of stock prices to shocks as well as in terms of its persistence and magnitude.

These puzzling findings led us to delve further into the topic. Indeed, the inverse relationship between interest rates and stock prices represents a paradigm which our results would seem to confute. Therefore, we decide to investigate the temporal dimension in order to understand if this anomaly is due to the peculiar behavior of market actors during periods of financial distress. The existence of an intertemporal relationship between stock prices and the discount factor should be out of discussion, by tautology. The relevance of macroeconomic factors in determining movements in the stock market is well established in the literature (Blanchard, 1981; Fama, 1981; Fama, 1990; Geske and Roll, 1983; Kaul, 1987; Barro, 1990; McQueen and Roley, 1993; Campbell and Ammer, 1993; Boyd et al., 2005; Jensen and Johnson, 1995).

Again, we split the sample into two additional subsamples covering respectively the period that goes from 2001 to 2006 and the period that goes from 2011 to 2019. This way, we exclude from our sample three periods that are commonly qualified as crises, notably the Dot Com Bubble (2000), the Global

Financial Crisis (2007-2010) and the Covid-19 outbreak (2019). For robustness, we decompose the panel of stock prices into their underlying components – the cyclical one and trend one – by means of the Christiano and Fitzgerald Filter (Christiano and Fitzgerald, 2003).

We find that the anomaly in the form of a positive relationship between stock prices and interest rates disappears. We conclude that periods of financial distress are the main drivers of the aforementioned anomaly.

The key implications of this paper are then twofold. Firstly, the different sign with which shocks affect stock prices for the subsample of high leverage firms compared to low leverage ones might pave the way for an investment strategy opportunity. Rational investors could try to anticipate the resulting market adjustments of a decrease in interest rates, thus reaping some profits by moving their equity investments from high leverage firms to low leverage ones during periods of financial distress.

Secondly, when investigating the market behavior of the first two decades of the second millennium, particular attention should be paid to Crises because prices can depart from their fundamental values as already suggested by many scholars (Shiller, 1989; Staumbaugh, 2012; Jiang et al., 2019) and this fact is more likely to happen in times of hardship when sentiment is high (Garcia, 2013).

Nations vary in their industrial composition and have industries that are inherently more or less volatile or characterized by different average degrees of financial leverage (Roll, 1992). Therefore, we decide to rely on a dataset composed by firms spread over seven countries. This way, we avoid making generalizations about phenomena that are country specific.

The implementation of a VAR approach dates to Lee (1992), Thorbecke (1997), Patelis (1997), Jensen and Mercer (2002), Bernanke and Kuttner (2005). However, such approach is still commonly used within the field of macroeconomics (Lakdawala, 2019; Jarocinski and Karadi, 2020; Cieslak and Pang, 2021). Jensen and Johnson find that after including a broad measure of monetary stringency, business conditions explain future stock returns only in expansive monetary policy periods, and only the dividend yield and the default premium are significant (Jensen and Johnson, 1995).

The main contribution is then represented by the originality through which we tackle the matter of the heterogeneity in terms of response of stock prices under varying degree of financial leverage and asset tangibility. To date, that represents a quasi-unexplored topic that lacks of empirical evidence. The results are interesting as the only variable that does not seem to be a key determinant of stock prices is industrial production whilst inflation, unemployment and, more interestingly interest rates, exhibit positive and significant coefficients.

The paper is organized as follows: Section II describes the data and the methodology while striving to bring insight into the underlying reasoning framing the analysis; section III reports the empirical results; section IV presents empirical results by considering two sub-periods (2002-2006; 2011-2018) with the aim of overriding the effects of the Crises (i.e. Dot.Com Bubble, Global Financial Crisis); section V concludes.

DATA AND METHODOLOGY

To empirically document the relationship between interest rates and stock prices under varying degrees of capital structure and asset tangibility, we focus on a multitude of firms of G7 countries over the period from 2000 to 2020. Data come from Thomson Reuters Database whence I collect accounting and financial information, including stock prices, financial leverage, and the amount of tangible assets. The dataset consists of 4849 firms.

The model takes the following form:

$$Y_{i,t} = Y_{i,t-1} A_p + X_{j,t} B + u_i + e_{it}$$

where $Y_{i,t}$ is a (K x 1) vector of endogenous variables for each ith cross sectional unit (firm) at time t, $Y_{i,t-1}$ is a (K x K) matrix of lagged endogenous variables. X_t is a (M x 1) vector of predetermined and exogenous variables for each of the jth country. A is a (K x K) matrix and B is a (M x K) matrix of parameters to be estimated.

The idiosyncratic error vector (K x 1) e_{it} is assumed to be independent from both the regressors and the individual error component u_{it}, and identically distributed for all i and t with E [e_{it}] = 0 and var [e_{it}] = ΣΛΣ, positive and semidefinite. Critical assumption to ensure covariance stationarity is that the eigenvalues of the PVAR polynomial are less than 1.

The estimation technique is based upon GMM (Hansen, 1982) which accommodates the expected serial correlation and heteroscedasticity of the errors that may be induced by leverage (Doshi et al., 2019). Moreover, in a dynamic model, estimation by GMM does not necessarily entail a decrease in the efficiency of the estimated parameters under individual aggregation (Veredas and Petkovic, 2010).

The technique uses additional moment conditions based upon differenced values. Such conditions can be summarized in the following way:

$$\begin{aligned} &E[\Delta{*}e_{i,t}\ y_{i,j}^{T}]= 0\ j \in \{1,...,T{-}2\}\ and\ t \in T_{\Delta *}, \\ &E[\Delta{*}e_{i,t}\ x_{i,j}^{T}]= 0\ j \in \{1,...,T{-}1\}\ and\ t \in T_{\Delta *}, \\ &E[\Delta{*}e_{i,t}, t\Delta{*}u\ _{i,t}^{T}] = 0\ t \in T_{\Delta *} \end{aligned} \tag{1}$$

The dimension of these matrices are the following: $\Delta *\ \varepsilon i,t$ is $m \times 1$, yi, j is $m \times 1$, xi, j is $k\times 1$ and $\Delta * si,t$ is $n\times 1$.

The estimation technique aims at defining the true value θ_0 of an unknown parameter vector $\theta \subseteq R^p$. Let f[$x_i\theta$] be a set of q population moments and $\mathfrak{f}_n$ the corresponding sample counterparts. The GMM estimator of θ_0 is defined as that value that minimize the criterion function $Q_n(\theta) = \mathfrak{f}_n\ \theta^T W_n \mathfrak{f}_n \theta$, whereby W_n, the weighting matrix, converges to a positive definite matrix W, as the number of observations grows large. In plain English, GMM of θ_0 finds the minimum of the quadratic form: $\mathfrak{f}_n\ \theta^T W_n \mathfrak{f}_n \theta$, notably the quadratic form of moment conditions.

Following Holtz-Eakin, Newey and Rosen (1988), we assume that the cross-sectional units share the same underlying data generating process, with the reduced-form parameters $A_1, A_2, \dots, A_{p-1}, A_p$, and B to be common among them. Systematic cross-sectional heterogeneity is modeled as panel-specific fixed effects. Instead of using deviations from past realizations, we remove the fixed effects by subtracting the average of all available future observations (forward orthogonal transformation) (Abrigo and Love, 2016). Since the panel is unbalanced and missing values are widespread, we preferred to avoid including numerous lags of the dependent variables, aware of the efficiency gains that their inclusion would have brought about, notwithstanding. Assuming that the instruments are uncorrelated with the errors, in the spirit of Holtz-Eakin, Newey and Rosen (1988), the formers are created using available data and missing values are substituted by zero while observations with no valid instruments are excluded.

Overfitting might remain an issue and, hence, as a mitigating element, the number of lags reduced to minimum (only one). A limitation is that seasonality might be overlooked in our case of quarterly data.

The model presents itself as follows:

$$\begin{aligned} Price_{i,t} = {} & \beta_1\ price_{i,t-1} + \beta_2 Interest\ rate_{j,t-1} + \beta_3 lnCPI_{j,t} + \beta_4\ Industrial\ Production_{j,t} \\ & + \beta_5 Unemployment_{j,t} + u_i + e_{it} \end{aligned} \tag{2}$$

$$\begin{aligned} Interest\ rate_{j,t} = {} & \alpha_1 Interest\ rate_{j,t-1} + \alpha_2\ price_{i,t-1} + \alpha_3 lnCPI_{j,t} + \alpha_4 Industrial\ Production_{j,t} \\ & + \alpha_5\ Unemployment_{j,t} + v_{j,t} \end{aligned} \tag{3}$$

The panel VAR model can capture both dynamic and static interdependencies. The choice is driven by the wish to conduct impulse response analyses while harnessing the informative potential of a panel dataset incorporating both the time and the cross-sectional dimension. Financial integration determines an increased synchronization in business cycles across the G7 economies (Hardouvelis, 2006), whence the need to capture these interdependencies arises. Classical OLS-based regression methods cannot be applied because of the Nickell bias (Nickell, 1981) that does not disappear asymptotically if N → ∞ and T is fixed. Main drawbacks of such procedure are well known and described in detail in previous works. (See e.g. Cooley and Le Roy, 1985; Cooley and Dweyer, 1998; Chari et al., 2008). In a nutshell, when disposing of a restricted set of observations, degrees of freedom may not be sufficient, implying poor model efficiency, resulting in wide confidence intervals for model coefficients.

$Y_{i,t}$ are stock prices and the level of interest rates of randomly picked companies, whereas the control variables $X_{j,t}$ are the rate of unemployment, the inflation rate, and the level of industrial production. The choice of the control variables roots in Chen et al. (1986) who remind us that stock prices are influenced by those forces that impact expected cash-flows or the discount factor appearing in the denominator to take into consideration the time value of money under uncertainty. Firstly, variation on the expected level of real industrial production should impact stock prices by virtue of their influence on cash flows. The rate of unemployment is a general indicator of economic conditions. Nominal interest rates that are assumed to capture the state of the investment opportunity set. Nominal interest rates, in turn, are influenced by changes in the inflation rate.

We run two VAR regressions by filtering observations on the median value of financial book leverage. After filtering, we obtain two separate datasets. One is constituted by above median leverage firms whereas the other one is made of below median financial leverage firms. We limit our attention to the largest economies wherein data are sufficient to make insightful comparisons, thus focusing on G7 economies. In our analysis, we compute book leverage as the ratio of total debt over total assets, whereas we express tangibility as the amount of property plant and equipment divided by total assets.

The datasets consist of quarterly stock prices of aforementioned firms and of quarterly values of aforementioned macroeconomic variables. The dataset excludes potential errors, which are identified as firms with asset value equal to zero. Stock prices are Winsorized at levels 1st and 99th percentiles and leverage truncated as to exclude values above 1.

With the aim of explaining the matter of stability, we can start considering a simplified form of our model: a VAR (1). In fact, any VAR (p) can be rewritten as a VAR (1). To form a VAR (1) from the general model we define: e'_t = [e'_t, 0,...,0], Y_t' t = [Y_t', Y'_{t-1}', Y'_{t-p+1}]

$$A = \begin{pmatrix} A_1 & A_2 & \dots & A_{p-1} & A_p \\ I & 0 & \dots & 0 & 0 \\ 0 & I & & \vdots & \vdots \\ \vdots & & I & & \\ 0 & & & I & 0 \end{pmatrix} \tag{4}$$

Therefore, we can rewrite the VAR (p) as a VAR (1) $Y_t = AY_{t-1} + e_t$. This is also known as the companion form of the VAR(p).

A VAR [p] process is considered stable if its reverse characteristic polynomial has no roots in or on the complex unit circle. Formally, a stochastic process X is weakly stationary if its first and second moments (mean and covariance) do not change with time. Equivalently, the process X at time t is stable if all eigenvalues of companion matrix **A** have modulus less than 1 (Lütkepohl, 2006).

Suppose that we have a unit shock in e_t, the marginal effect on y, s periods ahead is equal to:

$$\frac{\partial y_{t+s}}{\partial e_t} = \psi_s. \tag{5}$$

That is, the row i, column j element of ψ_s identifies the consequences of a standard deviation increase in the jth variable's innovation at date t ($e_{j,t}$) for the value of the ith variable at time $t + s$ (y_{t+s}) holding constant all other innovations at all dates.

In fact, a VAR can always be written as a MA (∞) in the following way:

$$y_t = \mu + e_t + \psi\, e_{t-1} + \psi\, e_{t-2} + \ldots \tag{6}$$

The impulse responses are based on decomposing the original VAR innovations ($e_{i,t}$) into a set of uncorrelated components ($v_{i,t}$) and on calculating the consequences for y_{t+s} of a unit impulse in $v_{i,t}$.

Since the paradigm whereby nominal policy rates should be negatively related to stock prices seem to be confuted by our results, we split the sample into two additional subsamples in an effort to shed light on this anomaly. The first one covers the period going from 2002 to 2006 whereas the second one covers the period from 2011 to 2019. This way, we can determine if the heterogeneity in terms of response of stock price to shocks is due to what are commonly defined as Crises (i.e. 2000, Dot Com Bubble; 2007-2010 Global Financial Crisis).

On the one side, when the economy slows down central banks tend to decrease interest rates to reinvigorate such economy. On the other side, during such periods, market operators and analysts become more active (Loh and Stulz, 2018), thus increasing the number of transactions. The increment in number of transactions determines room for disagreement among agents, thereby originating volatility (Cujean and Hasler, 2017). As volatility and attention increase, people tend to overreact to innovations, but prices become less informative (Peng and Xiong, 2006), and the general tendency is to shift from risky stocks to less risky ones such as stocks of firms with low book leverage. Hence, during periods of financial distress the demand for risky stocks moves downwards and stocks prices fall, determining negative stock returns. This phenomenon is commonly known among investors as flight to quality.

With the aim of identifying recessions, we draw on the Christiano and Fitzgerald (2003) Filter to decompose the time-series of stock prices into its main components. We can use such filter as a robustness check in order to verify whether those periods that we qualified as crises (i.e. 2000, 2001, from 2007 to 2010 and 2020) show a negative growth component and higher volatility.

The Filter provides us with handy procedure through which we can decompose stock prices into a growth component and a cyclical component. Provided that our time-series does not feature a seasonal component, this procedure is suited for immediate application, regardless of the order of integration characterizing the series. We can safely assume that stock prices investigated at the aggregate level are already deprived of the seasonal component as different countries are characterized by different seasonal components that we assume on average offset each other. To visualize the trend component graphically we draw on Lowess Smoothing where the weights are the "tricube" as specified by Cleveland (1979).

EMPIRICAL RESULTS

Table 1 presents descriptive statistics for a sample of G7 firms over the period (2nd quarter 2000, 2nd quarter 2020) drawn from Thomson Reuters Eikon DataStream. Panel A describe the mean, 1st quartile, median, 3rd quartile for the full sample.

Considerable insight can be obtained just by observing descriptive statistics (table 1). The mean value of our panel of stock prices is equal to 28.655 whereas the median value is considerably lower (3.12). The mean book leverage of our full sample is equal to 0.211 whilst the median value is slightly lower (0.172). Tangibility is computed as the ratio of property plant and equipment to total assets; its mean value is equal to 0.269 while the median value is equal to 0.219. Also relevant to our analysis are the first quartile of book leverage - equal to 0.026 - and the third quartile (0.343). Finally, the first quartile of asset tangibility is equal to 0.074 whereas the third quartile is equal to 0.407.

We need to make sure that the choice not to use log returns does not undermine our analysis. To this effect, a sufficient and indispensable condition is that all eigenvalues of the reduced form parameter A fall within the unit circle (Binder et al., 2005). When considering both datasets (below leverage and above leverage firms) we find that this condition is fulfilled, thus implying that the Panel VAR is stable. That is, the VAR is covariance stationary and shocks to v_t eventually fade out. Therefore, the impulse response functions converge. However, for robustness we carry out Fisher type tests devised by Choi (2001).

These tests consist in implementing an Augmented Dickey Fuller Test (Dickey and Fuller, 1979) on each time series composing the panel and then combining the p-values.

We find strong evidence against the null hypothesis that all series contain a unit root for each of the variables considered in our model except for the case of the Consumer Price Index (CPI) which we needed to make stationary by taking the natural logarithms.

Figure 1 and Figure 2 display impulse response functions respectively for below median leverage firms and above median leverage firms. Table 2 reports the regression output.

Because the innovations e_{it} and v_t are correlated, a shock on one variable is likely to be accompanied by shocks to other variables. Moving to the persistence analysis, we can note, in the figures above, that a unit shock is more persistent for low leverage firms than for highly levered ones.

In fact, the shock disappears after about a bit more than 50 steps in the case of below median leverage firms and after 25 steps in the case of highly leverage firms. Operating leverage – which should be negatively associated with financial leverage (Van Horne, 2005) – seems to play a major role in rendering price responses more persistent for below median leverage observations than for above median ones.

Imagine now a shock hits the economy (e.g. one unit increase in interest rate or an earthquake). This innovation may reduce demand for goods. Firm A is strongly constrained whereas firm B has low operating leverage. After the shock arises, Firm A risks to end up with negative NVP projects that need to be dismissed, and this operation is likely to take time, thus determining durable responses in stock prices. Firm B variable production can instead adjust according to the lower demand.

Interestingly, a shock to the base rate has a positive effect on stock price for below median leverage firms whereas the opposite arises for high leverage firms. Moreover, low leverage firms are less strongly affected by shocks to the base rate than high leverage firms. We explain this phenomenon in the following way.

Let us start from the assumption that a firm's stock price is determined as the sum of all its future dividend payments discounted back to their present value according to the weighted average cost of capital (WACC). For the sake of simplicity, let us assume that the company is funded only by debt and equity. A one standard deviation positive innovation to the interest rates, in case it is associated with an increase in the interest rate, determines both a higher cost of debt and a higher cost of equity capital.

The direct consequence would be a higher WACC, an increased discount factor and a lower stock price value. Having said that, low leverage firms' value would benefit from a positive shock, translating in an increase in the base rate. In fact, if we assume that the cost of equity is equally affected by the shock to interest rates across all firms, low leverage firms have a lower increase in the cost of debt and demand moves from highly leverage firms to low leverage firms. This fact determines a higher stock value. In other words, investors reshape their portfolios according to movements in the interest rates and move their money from firms with high leverage to firms with low leverage in the aftermath of an increase in the base rate.

The next question we would like to linger on concerns the validity of the Market Efficiency Hypothesis (MEH) (Fama, 1970) within this framework. The underlying theory is that prices follow a random walk (Fama, 1970) and, according to the semi-strong version of this theory, they embed all public information, whether historical or forecasted. Nevertheless, when testing the series of stock prices for the presence of a unit root, we could reject the null hypothesis of all panels containing a unit root. This fact leads us to question the validity of the Market Efficiency Hypothesis, albeit an organic treatise of the matter is beyond the scope of this paper.

Determining whether shocks are more enduring for highly levered firms can be instrumental to the definition of optimal leverage. In light of the findings, firms may decide to de-leverage as to render their business more resilient to shocks, especially in the case of negative market condition when leverage is acting as a negative multiplier. Moreover, the contribution of the paper goes beyond that, helping to explain the existence of zero leverage firms. Those firms that do not adjust their leverage over time assume that shocks can arise suddenly and, hence, accept a super-precautionary policy, which is sub-optimal in normal periods. The effect of macroeconomic conditions on the leverage and tangibility decisions has been studied recently by Chang (2019).

From the perspective of investors these results might also be more interesting than from the managers' perspective. In fact, if our reasoning is valid, whereby an innovation (unit increase) in the error term of our interest rate equation is accompanied by an increase in interest rates, then once an increase of interest rates is announced, rational investors might decide to reshuffle their portfolios with the aim of anticipating the market. They might move their equity investments from highly leveraged firms to lowly leveraged ones as to forestall the market.

This process, if properly and rapidly implemented, might lead investors to obtain profits so long as the new information is not reflected on prices yet. That is, investors can beat the market in the aftermath of an increase of interest rates by adopting an active strategy.

To understand if those firms that face more frictions bear an additional opportunity cost after a policy change to the interest rate level, we split the sample into two groups: constrained firms and unconstrained ones.

In the spirit of Braun and Larrain (2005), we define constrained firms as those which are characterized by lower degree of tangibility. Tangibility is expressed as net property plant and equipment over total assets. Tangible assets can serve as collateral, thus enabling firms to easily access credit when they need to. More constrained firms, which are characterized by low tangibility, can be subject to more enduring shocks**.**

We then carry out the vector auto-regression with the model specified as previously but this time we filter observations by the median value of the tangibility ratio. This median is equal to 0.211 as table 1 shows. We produce the impulse response function as to check whether shock durability depends on the degree of a firm tangibility, thereby obtaining the following results. Figure 3 and figure 4 display the outcome of an impulse to the base rate in the form of a stock price response. Table 3 reports the regression output.

Results are not counterintuitive. The persistence of a shock to interest rates in terms of price response is a function of the degree of tangibility of a firm's assets. If their assets are tangible to a great extent, firms face less difficulties when trying to adjust their capital structure. Hence, they take less time to recover after a shock hits the level of interest rates. As a result, those firms that are more constrained should pay higher attention to macroeconomic policy changes to the level of interest rates. In addition, the magnitude of the shock is higher for more constrained firms suggesting that the market is aware of the aforementioned difficulties to adjust their capital structure. An implication of such results is that managers might need stronger incentives to invest in intangible assets.

For the sake of completeness, we run a fixed-effects estimator with robust standard error clustered at the firm level of the variable price on a binary variable which distinguishes between below median leverage and above median leverage (Table 7).

Our regression produces a significant dummy with a negative coefficient when controlling for other macro-determinants of stock prices and main market indices. The implications of such prospective findings would digress the boundaries of the asset pricing literature as the degree of financial leverage would enter the equation of pricing models as a driver that pushes prices downwards. A negative dummy can be interpreted as the average additional discount on stock prices.

Our results are puzzling on many dimensions. Firstly, we would have expected a negative relationship between stock prices and interest rates as the latter appears in the denominator of discounted cash flow models. Secondly, the vector autoregressive regressions produce significant relationships almost exclusively when investigating firms with low leverage. Let us try then to shed light on the first anomaly. The positive coefficient on interest rate for below median leverage firms might be the result of the presence of financial crises (e.g. 2007-2010 Global Financial Crisis) in our sample. Therefore, after conducting robustness checks on sub-samples of the full sample, we identify and exclude periods of financial distress.

ROBUSTNESS CHECKS

This section aims at solving some issues characterizing the sample. Firstly, by splitting the sample into two parts according to median values of financial leverage, the heterogeneous consequences of shocks to interest rates cannot be well decrypted at a granular level. That is, there are a handful of firms which feature leverage levels gravitating around the boundary of the median level of financial leverage of the full sample. These firms have some observations that enter the sample of below median leverage firms during certain years, while, during other years, they are included in the sample of above median leverage firms. Therefore, an easy approach to solve this issue would be that of considering two subsamples, focusing only on those firms which exhibit below first quartile leverage values and above third quartile leverage values.

When we take into consideration the two abovementioned different subsamples, represented by below first quartile leverage firms (figure 5) and by above third quartile leverage firms (figure 6), we obtain consistent result (Table 4). Indeed, *a fortiori*, we note that below first quartile leverage firms are positively affected by shocks in terms of their stock price response whereas above third quartile leverage firms are negatively affected.

Again, unemployment and inflation are positivily related to stock prices, whereas industrial production is negatively related to stock prices in case of firms with zero or very low degree of financial leverage. For firms with very high leverage there is no evidence of a relationship between stock prices and the prospective macrodeterminants.

The magnitude of the response to shocks is considerably different between the two sub-samples. Those firms that are characterized by very high financial leverage and, therefore, potentially by low operating leverage are softly affected by shocks in terms of both magnitude and persistence. Differently, a shock determines a large increase in stock prices for firms with very low financial leverage.

When comparing firms with a very low amount of tangible assets to total assets (below first quartile tangibility) to the previous subsample consituted by firms with low ratio of tangible assets to total assets (below median tangibility), it is a different story as we can see by paralleling figure 8 and figure 4. Yet, the explanation is straightforward and the findings further corroborate our results.

Figure 8 features opposite sign compared to that in the previous section figure 4. Yet, if you are willing to accept that leverage is positively associated with tangibility as showed by Hall (2012), then these results should not come as a surprise. In fact, above third quartile tangibility firms' subsample would be constituted by high leverage firms. Table 4 exhibits the regression's results.

In order to control for the state of the market we add the main indices as additional explanatory variables to our system of equations. The model becomes:

$$Price_{i,t} = \beta_1\, price_{it-1} + \beta_2 Interest\ rate_{j,t-1} + \beta_3 lnCPI_{j,t} + \beta_4\, Industrial\ Production_{j,t} + \beta_5\, Unemployment_{j,t} + \beta 6\, Index_{j,t} + u_i + e_{it} \quad (7)$$

$$Interest\ rate_{j,t} = \alpha_1 Interest\ rate_{j,t-1} + \alpha_2\, price_{it} + \alpha_3 lnCPI_{j,t} + \alpha_4 Industrial\ Production_{j,t} + \alpha_5 Unemployment_{j,t} + \beta_6 Index_{j,t} + v_t \quad (8)$$

Results are robust to the addition of the stock market index variable. With the aim of checking whether the periods we tend to call recessions are, in fact, characterized by higher volatility and decreasing stock prices on average, we apply the CF Filters. We can identify the business cycles and the trends by applying the Filters on the panel of stock prices.

IDENTIFYING AND EXCLUDING THE CRISIS FROM THE SAMPLE

Firstly, we investigate the business cycle component at an aggregate level for the G7 countries after filtering the stock prices data through the CF Filter. At an aggregate level (figure 11), the Global Financial Crisis (GFC) manifests itself clearly, as highlighted by the higher volatility and by below average values.

Other hypothesized Crises are not so evident. We then investigate the business cycle component and the trend component at country level (figures 12-18).

The countries that were most strongly affected by the GFC are Canada, US and Japan, followed by the European countries. China does not show evidence of a strong impact of the GFC, perhaps because the channels for crisis transmission were more obstructed.

The graphs purposely feature equal scale, thus enabling us to make valid comparisons across countries. We can note that Canada (figure 12), Japan (figure 16) and USA (figure 18) present higher volatility levels than the other countries under scrutiny.

We can now move to investigate the second output of the Filter (i.e. the Trend). The trend-line that we obtain by decomposing the panel of time series through the CF Filter has undergone a smoothing procedure (i.e. Local Weighted Regression as known as Lowess Smoothing). This technique can be used to detect a trend in the presence of noisy data when the underlying distribution is unknown. The main advantage resides in the fact that it makes no assumption on the underlying data patterns. We run line least squares smoothing where the bandwidth is set at 0.8, meaning that 80 % of the data are used in smoothing each point. That is, given a focal point, which corresponds to the central point, we run a set of weighted regression where the focal point slides. The focal point is the one receiving more weight, whereas the other points receive less and less weight, the further they are situated from the focal point.

In general, we can note a negative trend throughout the first decade of the sample period and a recovery during the second decade of the sample period. This tendency means that the equity market of G7 countries has gone through a tough period during the middle phase (2009-2010) of the interval period under consideration when prices stabilize themselves on lower levels. China and Canada (figure 19-20) represent exceptions as the trend is imperceptible.

We conclude that our firms have undergone two major crises – Dot Com Bubble and Global Financial Crisis - with the GFC being the most prominent one. In fact, the first decade of the second millennium turns out to be more turbulent than the second decade. Price volatility stabilizes itself on higher levels while prices exhibit a negative trend component during the first decade followed by a positive trend during the second decade.

Given our results, we can proceed by considering sub-periods characterized by relative calm within the market where the mechanism leading to the anomaly of a positive relationship between stock prices and interest rates possibly does not actualize. To this effect, we divide the sample in such a way as to consider the period that goes from 2002 to 2006 and the period that goes from 2011 to 2019. This way, we omit prospective anomalies that are due to effects of Crises on stock prices.

We observe in the graphs below that the anomaly disappears in the case of the two sub-periods that we consider at this stage of the analysis. The relationship between stock prices and nominal interest policy rates turns negative for both the sub-periods and it is robust across different subsamples varying by degree of financial leverage. In particular, all responses to shocks to interest rates in the first sub-period (i.e. 2002-2006) are negative and feature similar magnitude (i.e. figures 26-29); likewise, all responses to shocks to interest rates in the second sub-period (i.e. 2012-2019) manifest themselves as decreases in stock prices, albeit the magnitude varies across subsamples.

CONCLUSION

The paper is structured in two parts which gravitate around the concepts of financial leverage and asset tangibility and share the same estimation technique, the Generalized Method of Moments, along with the same model, a Panel Vector Autoregression. By investigating a sample consisting of approximately 5000 firms, we started by testing if unit shocks to interest rates are more enduring for those firms that we define as highly levered ones. In fact, the whole sample is divided into two parts, firstly by subsampling on the basis of the median value of financial leverage, then on the basis of the median value of asset tangibility, as above defined.

We demonstrate, by means of impulse-response functions, that above median and below median financial leverage firms are heterogeneously affected by shocks in terms of both shocks' duration and sign as well as magnitude when considering the full sample period. That is, on the one side, stock price responses of above median leverage firms are negative before reaching the steady state when unchaining an impulse; on the other side, below median leverage firms, undergoing the same shock, are characterized by positive stock price responses.

Evidence shows that both low and zero leverage firms benefit from a unit shock to interest rates possibly thanks to fact that, if the cost of equity is equally affected by the shock to interest rates across both firms' classes, low leverage firms, however, have a lower increase in the cost of debt and demand moves from highly leverage firms to low leverage firms. This phenomenon determines a higher stock value. Aware of the fact that a positive relationship between interest rates and stock prices goes against common sense, we investigate the matter more deeply, thereby identifying the Crises (Dot.com Bubble and Global Financial Crisis) as the major driver of this anomaly.

With the aim of empirically isolating periods of financial distress, we rely on the Cristiano and Fitzgerald Filter. Such Filter enables us to decompose the panel of stock prices into its main component – cyclical and trend component. The Filter leads us to conclude that there is evidence of turbulence across the G7 countries during the periods going from 2000 to 2001 and from 2007 to 2009 as well as in 2020. Hence, we exclude such period in our second stage analysis and we get rid of the anomaly that we had spotted: the relationship between stock prices and interest rate no longer appears as positive but rather stock prices are negatively related to interest rates for all subsamples.

When shifting our focus to the degree of constraints that firms face, we empirically prove that more constrained firms – which are represented by the subsample of firms with low asset tangibility – tend to take longer to see their stock prices return stable. The reason for this phenomenon might reside in the fact that they encounter more frictions to obtain funding for positive Net Present Value projects. Therefore, the market spends more time on ascribing prices to such firms in the aftermath of a shock to interest rates.

A suggestion for future research might be that of approaching such results by extending this work theoretically, building a new asset pricing model that accounts for the dynamics of the connection between stock prices, volatility (i.e. shocks) and leverage. Alternatively, different macro-variables can be investigated as prospective determinants of stock prices under varying degrees of financial leverage. The presence of periods of financial distress can help explain other phenomena such as the leverage effect.

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APPENDIX

FIGURE 1
BELOW MEDIAN LEVERAGE

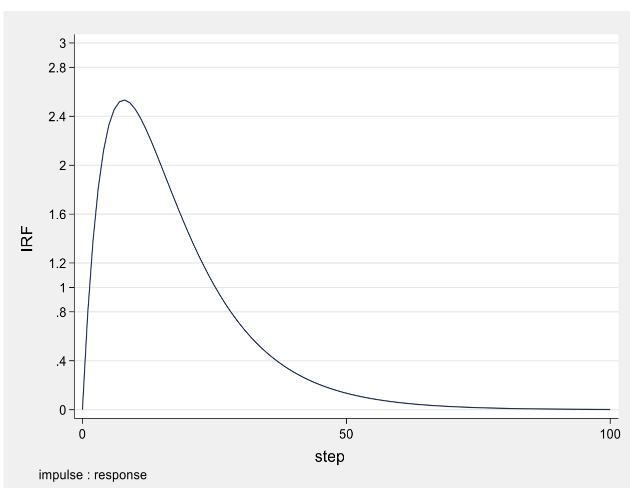

FIGURE 2
ABOVE MEDIAN LEVERAGE

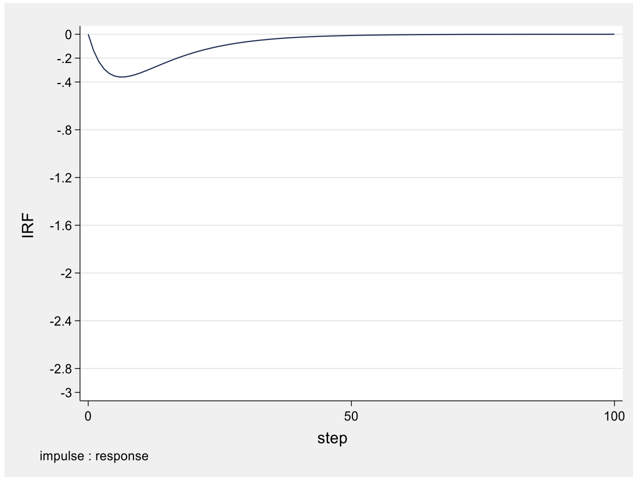

FIGURE 3
BELOW MEDIAN TANGIBILITY

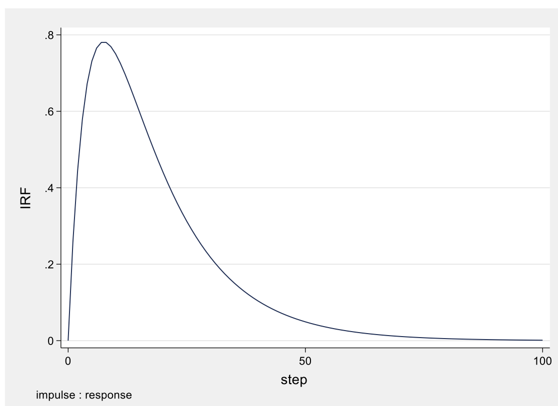

FIGURE 4
ABOVE MEDIAN TANGIBILITY

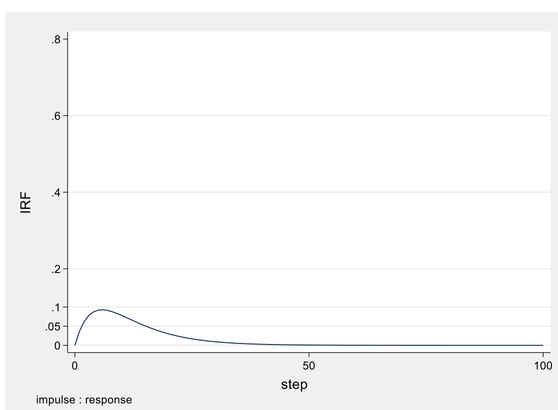

FIGURE 5
BELOW FIRST QUARTILE LEVERAGE

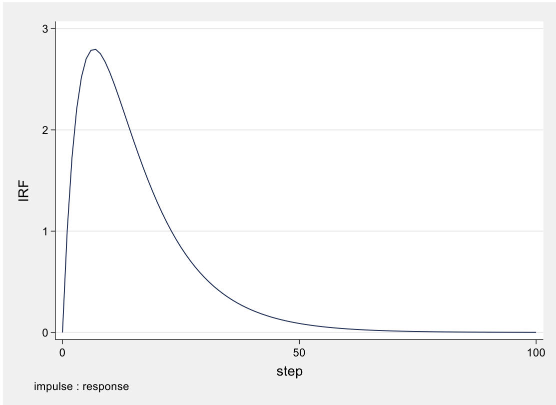

FIGURE 6
ABOVE THIRD QUARTILE LEVERAGE

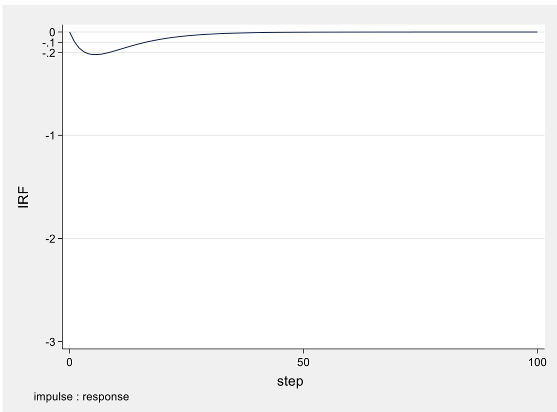

FIGURE 7
BELOW FIRST QUARTILE TANGIBILITY

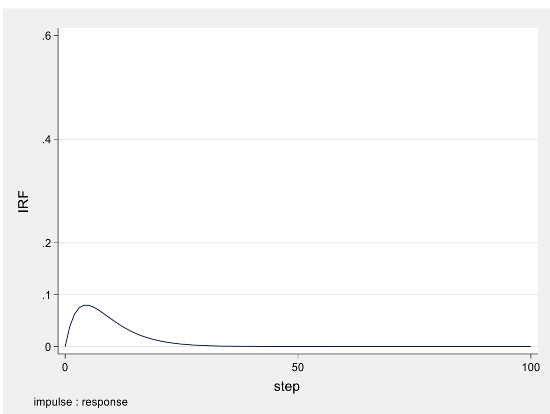

FIGURE 8
ABOVE THIRD QUARTILE TANGIBILITY

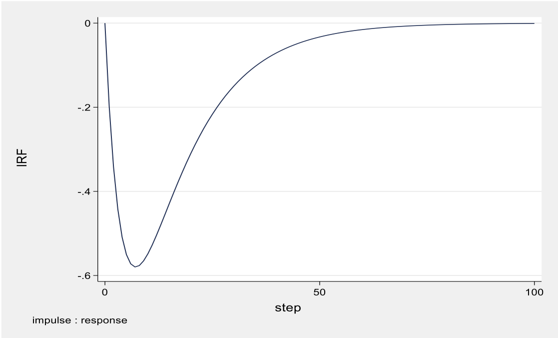

FIGURE 9
BELOW MEDIAN LEVERAGE WITH INDEX

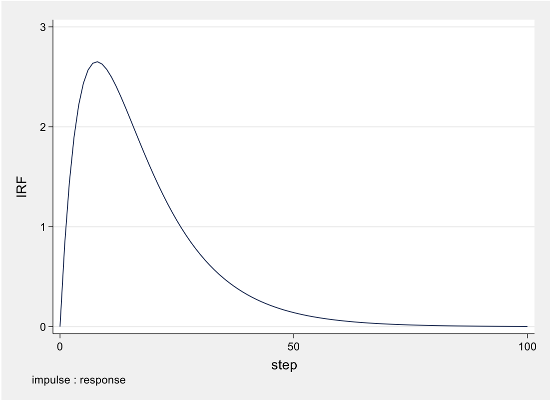

FIGURE 10
ABOVE MEDIAN LEVERAGE WITH INDEX

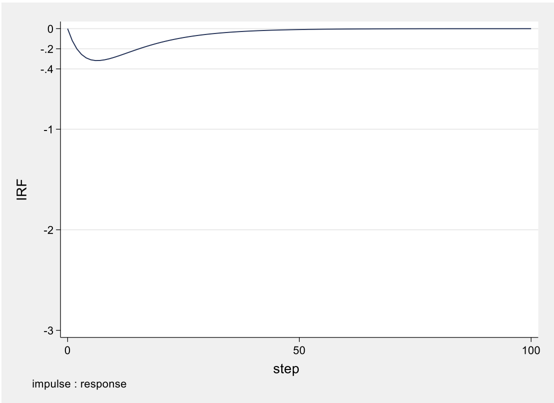

FIGURE 11
CYCLICAL COMPONENT AGGREGATE

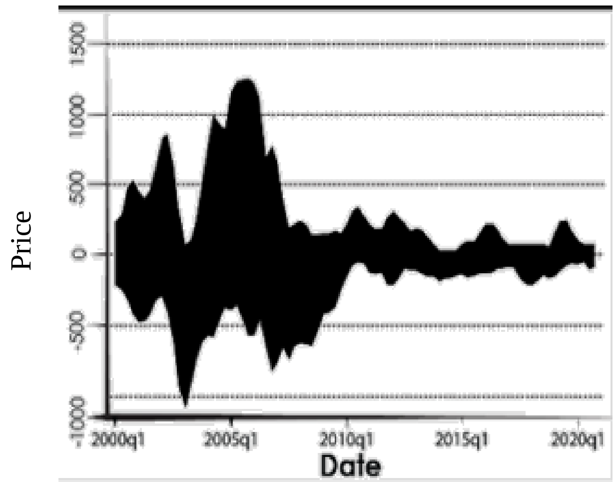

FIGURE 12
CYCLICAL COMPONENT: CANADA

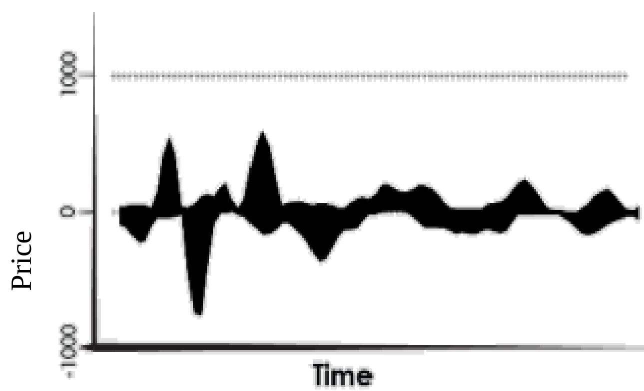

FIGURE 13
CYCLICAL COMPONENT: GERMANY

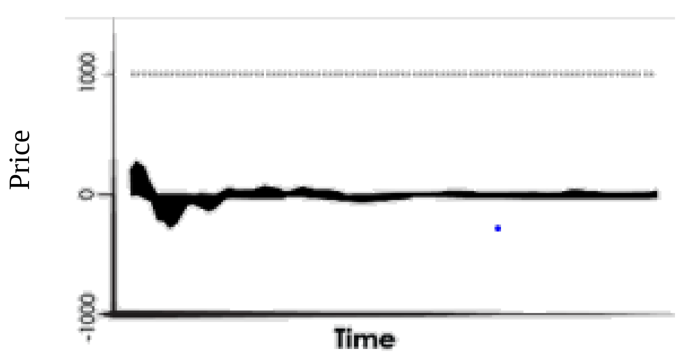

FIGURE 14
CYCLICAL COMPONENT: CHINA

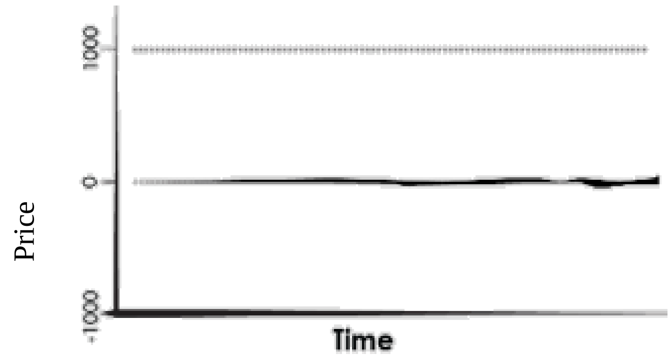

FIGURE 15
CYCLICAL COMPONENT: FRANCE

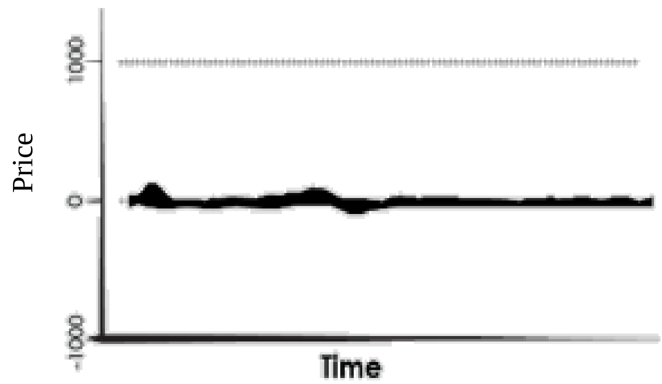

FIGURE 16
CYCLICAL COMPONENT: JAPAN

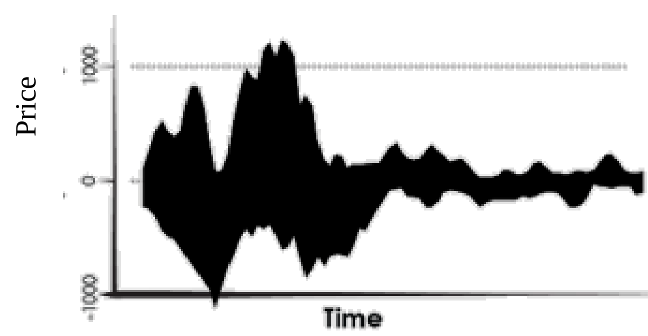

FIGURE 17
CYCLICAL COMPONENT: UK

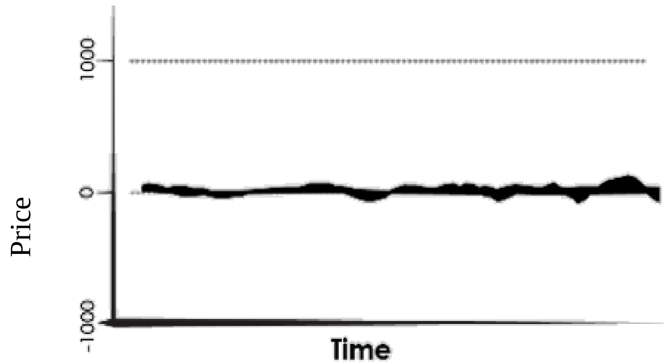

FIGURE 18
CYCLICAL COMPONENT: USA

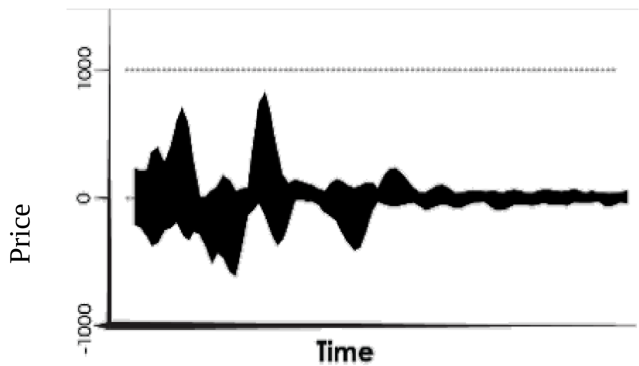

FIGURE 19
TREND COMPONENT: CANADA

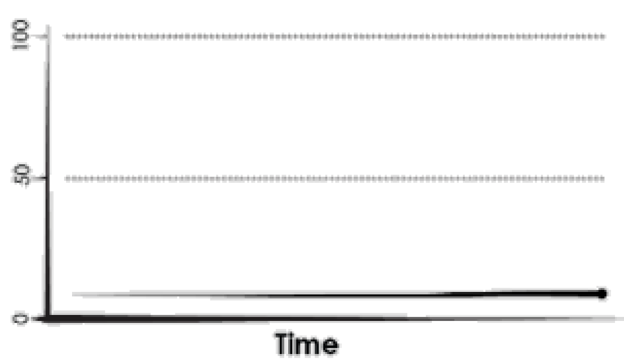

FIGURE 20
TREND COMPONENT: CHINA

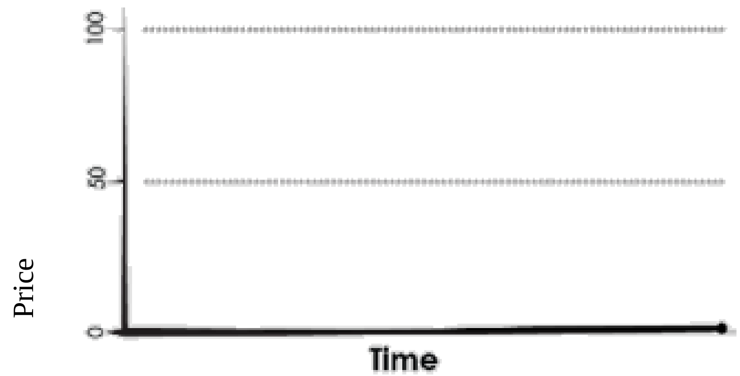

FIGURE 21
TREND COMPONENT: GERMANY

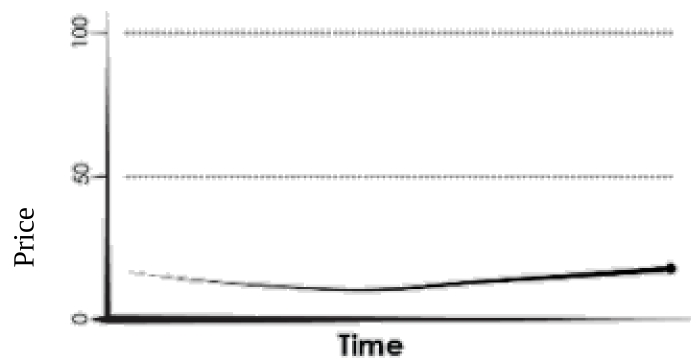

FIGURE 22
TREND COMPONENT: FRANCE

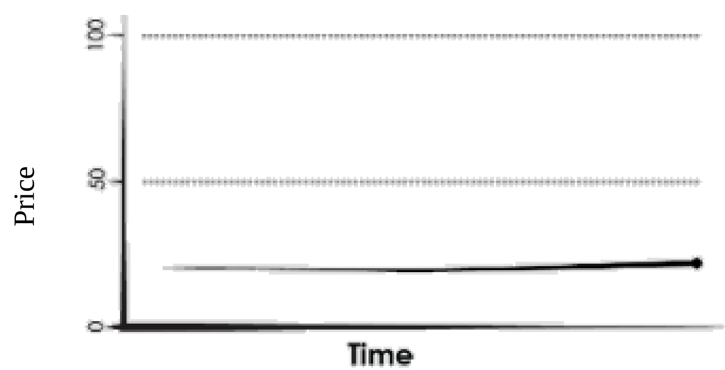

FIGURE 23
TREND COMPONENT: JAPAN

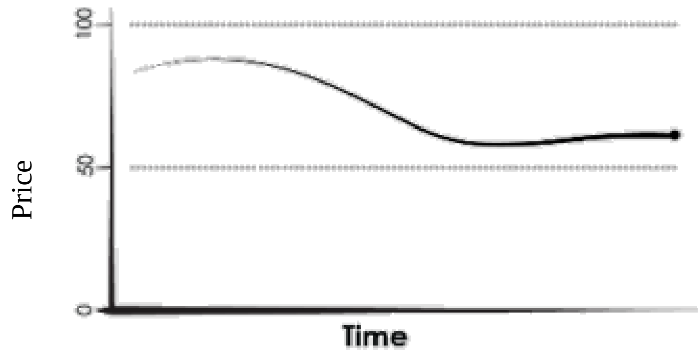

FIGURE 24
TREND COMPONENT: UK

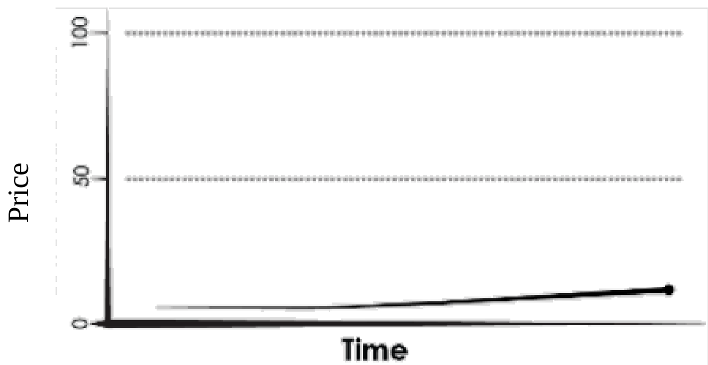

FIGURE 25
TREND COMPONENT: USA

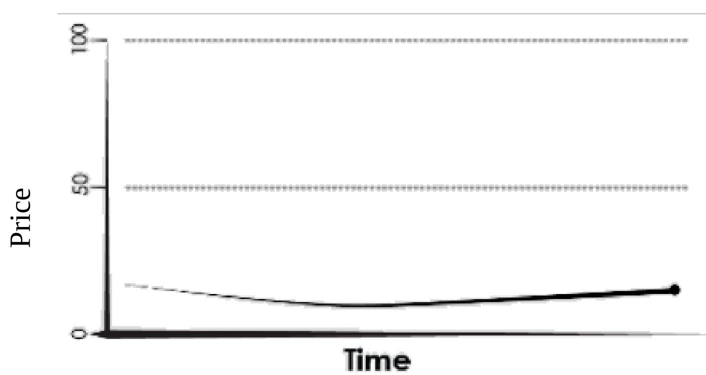

FIGURE 26
BELOW MEDIAN LEVERAGE (2002-2006)

Price

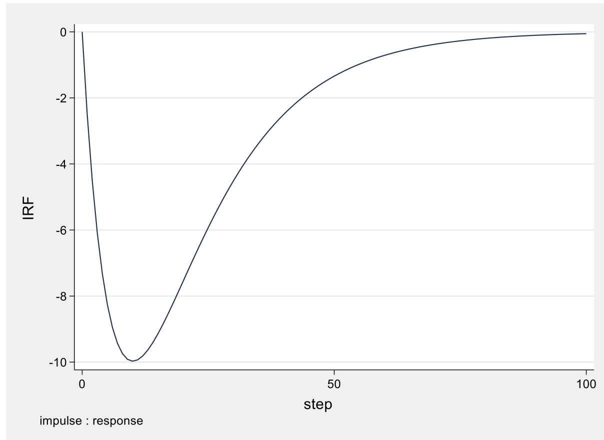

FIGURE 27
ABOVE MEDIAN LEVERAGE (2002-2006)

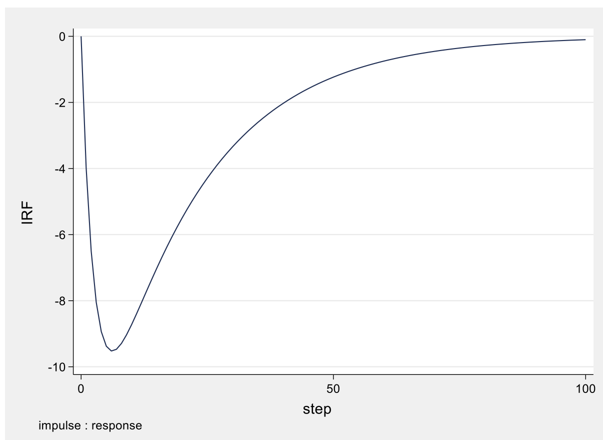

FIGURE 28
BELOW FIRST QUARTILE LEVERAGE (2002-2006)

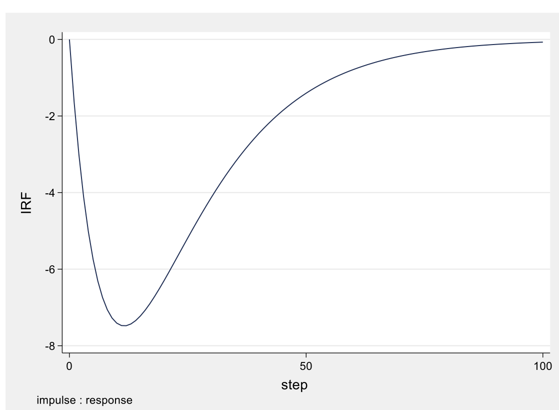

FIGURE 29
ABOVE THIRD QUARTILE LEVERAGE (2002-2006)

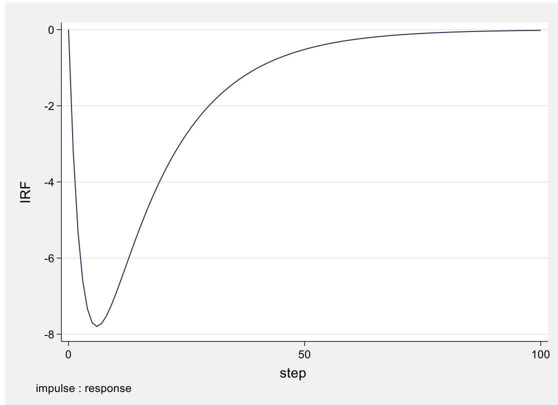

FIGURE 30
BELOW MEDIAN LEVERAGE (2011-2018)

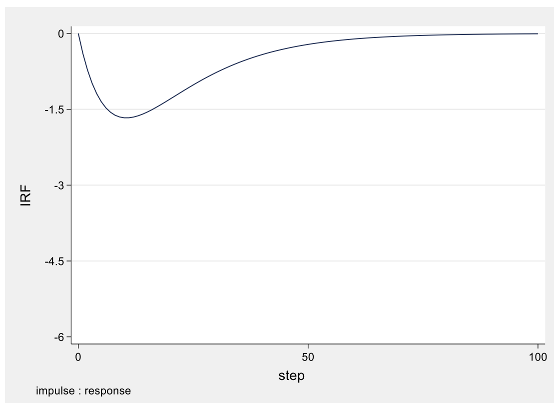

FIGURE 31
ABOVE MEDIAN LEVERAGE (2011-2018)

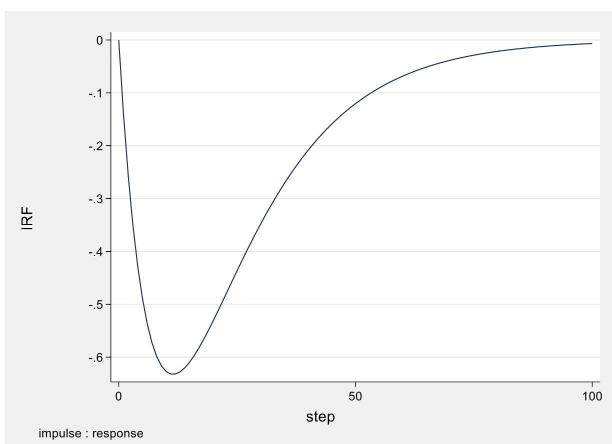

FIGURE 32
BELOW FIRST QUARTILE LEVERAGE (2011-2018)

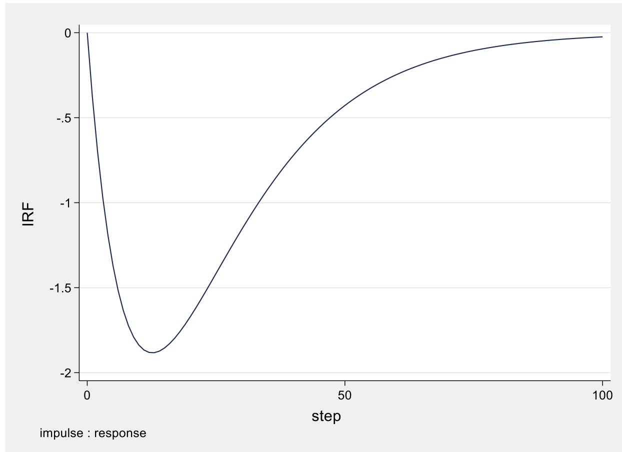

FIGURE 33
ABOVE THIRD QUARTILE LEVERAGE (2011-2018)

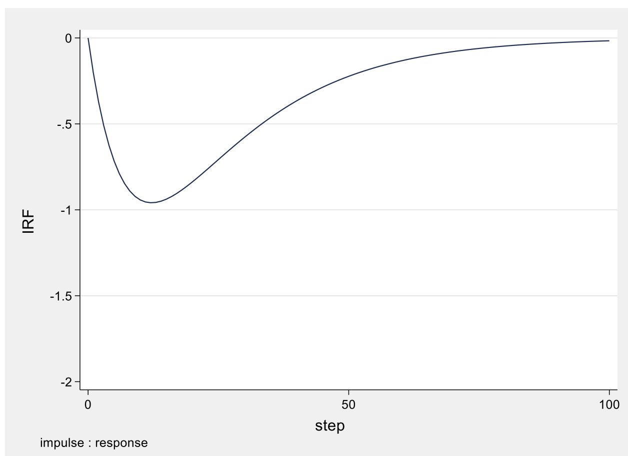

Table 1 presents descriptive statistics for a sample of G7 firms over the period (2nd quarter 2000, 2nd quarter 2020) drawn from Thomson Reuters Eikon Datastream. Panel A describe the mean, 1st quartile, median, 3rd quartile for the full sample.

TABLE 1
SUMMARY STATISTICS

Panel A: full sample					
	Obs.	Mean	1st Quartile	Median	3rd Quartile
Price	383568	28.655	0.74	3.12	9.96
Total Debt	256541	788603	1922	21838	98732

Total Assets	257930	3408760	58396	160008	487626
Tangible Assets	251096	413406.8	6971.5	33473.5	114255
Leverage	254058	0.211	0.026	0.172	0.343
Tangibility	251024	0.269	0.074	0.219	0.407

Table 2 presents results using two subsamples obtained by filtering observations according to the median leverage of the full sample. Data frequency is quarterly. The dependent variable is price. See appendix for variable definitions and sources. Standard errors are reported in parentheses below coefficient estimates. Statistical significance at the 0.01***, 0.05** and 0.1* level is designated by asterisks.

TABLE 2
STOCK PRICE RESPONSE FOR VARYING DEGREES OF FINANCIAL LEVERAGE: BELOW AND ABOVE MEDIAN

Dependent Variable: Price		
	Below Median Leverage	Above Median Leverage
Lag1 Price	0.921***	0.910***
	(0.016)	(0.125)
Lag1 Base rate	0.787***	- 0.134
	(0.280)	(0.087)
Consumer price index	17.240***	- 2.371
	(5.616)	(1.503)
Industrial production	- 0.063**	0.017
	(0.033)	(0.018)
unemployment	0.694***	0.091***
	(0.227)	(0.060)
Dependent variable: Base rate		
Lag1 Price	- 0.000***	- 0.0003***
	(0.000)	(0.0000)
Lag1 Base Rate	0.830***	0.782***
	(0.005)	(0.002)
Consumer price index	- 1.592***	- 2.211***
	(0.090)	(0.030)
Industrial production	0.021***	0.028***
	(0.000)	(0.000)
unemployment	0.032***	-0.023***
	(0.004)	(0.0018)
No. of observations	117,163	239,879
Ave. no. of T	35.397	51.631

Table 3 presents results using two subsamples obtained by splitting observations based on the median tangibility ratio of the full sample. Data frequency is quarterly. The dependent variable is price. See appendix for variable definitions and sources. Standard errors are reported in parentheses below coefficient estimates. Statistical significance at the 0.01***, 0.05** and 0.1* level is designated by asterisks.

TABLE 3
STOCK PRICE RESPONSE FOR VARYING DEGREES OF ASSET TANGIBILITY: BELOW AND ABOVE MEDIAN

Dependent Variable: Price		
	Below Median Tangibility	Above Median Tangibility
Lag1 Price	0.928***	0.883***
	(0.011)	(0.021)
Lag1 Base rate	0.257*	0.037
	(0.262)	(0.084)
Consumer price index	6.836*	1.539
	(5.184)	(1.550)
Industrial production	0.003	- 0.020*
	(0.037)	(0.015)
unemployment	0.705*	0.047
	(0.212)	(0.062)
Dependent variable: Base rate		
Lag1 Price	- 0.000***	- 0.001***
	(0.000)	(0.000)
Lag1 Base Rate	0.805***	0.792***
	(0.005)	(0.002)
Consumer price index	- 1.947***	- 2.125***
	(0.086)	(0.032)
Industrial production	0.024***	0.027***
	(0.000)	(0.000)
unemployment	0.024***	- 0.021***
	(0.004)	(0.002)
No. of observations	115,475	241,567
Ave. no. of T	37.59	52.20

Table 4 presents results using two subsamples obtained by filtering observations as to consider only those values below the first quartile of the sample's leverage and those above the third quartile of the ratio. Data frequency is quarterly. The dependent variable is price. Standard errors are reported in parentheses below coefficient estimates. Statistical significance at the 0.01***, 0.05** and 0.1* level is designated by asterisks.

TABLE 4
STOCK PRICE RESPONSE FOR VARYING DEGREES OF FINANCIAL LEVERAGE: 1ST QUARTILE AND ABOVE 3RD QUARTILE

Dependent Variable: Price	Below First Quartile Leverage	Above Third Quartile Leverage
Lag1 Price	0.915***	0.886***
	(0.020)	0.014
Lag1 Base rate	1.008***	- 0.093
	(0.343)	0.088
Consumer price index	19.385***	- 1.686
	(6.298)	1.431
Industrial production	- 0.068*	0.011
	(0.045)	0.020
unemployment	0.750***	0.091*
	(0.252)	0.063
Dependent variable: Base rate		
Lag1 Price	- 0.000***	- 0.000***
	(0.000)	(0.000)
Lag1 Base Rate	0.792***	0.767***
	(0.006)	(0.002)
Consumer price index	- 2.179***	- 2.272***
	(0.100)	(0.030)
Industrial production	0.025***	0.030***
	(0.001)	(0.000)
unemployment	0.017***	- 0.028***
	(0.005)	(0.002)
No. of observations	59530	183786
Ave. no. of T	27.421	39.971

Table 5 presents results using two subsamples obtained by filtering observations as to consider only those values below the first quartile of the sample's ratio given by property, plant and equipment to total assets and those above the third quartile of the ratio. Data frequency is quarterly.

TABLE 5
STOCK PRICE RESPONSE FOR VARYING DEGREES OF ASSET TANGIBILITY: 1ST QUARTILE AND ABOVE 3RD QUARTILE

Dependent Variable: Price		
	Below First Quartile Tangibility	Above Third Quartile Tangibility
Lag1 Price	0.926 ***	0.822 ***
	(0.013)	(0.032)
Lag1 Base rate	- 0.199	0.039
	(0.432)	(0.078)
Consumer price index	- 4.840	1.956
	(5.616)	(1.427)
Industrial production	0.099	- 0.025
	(0.061)	(0.016)
unemployment	0.443	0.015
	(0.334)	(0.057)
Dependent variable: Base rate		
Lag1 Price	- 0.000 ***	- 0.001 ***
	(0.000)	(0.000)
Lag1 Base Rate	0.793 ***	0.777 ***
	(0.006)	(0.002)
Consumer price index	- 2.310 ***	- 2.227 ***
	(0.114)	(0.030)
Industrial production	0.026 ***	0.030 ***
	(0.001)	(0.000)
unemployment	0.003	- 0.025 ***
	(0.006)	(0.002)
No. of observations	58,245	185,965
Ave. no. of T	30.336	40.684

Table 6 presents results using two subsamples by filtering data at the median leverage level as two produce two subsamples. We add another variable – index returns – represented by log returns of main stock market indices of G7 countries under investigation. Data frequency is quarterly. The dependent variable is price.

TABLE 6
CONTROLLING FOR THE MARKET INDEX

Dependent Variable: Price		
	Below Median Leverage	Above Median Leverage
Lag1 Price.	0.921***	0.911
	(0.016)	(0.013)
Lag1 Base rate	0.823***	- 0.119
	(0.281)	(0.087)
Consumer Price Index	16.352***	- 3.104**
	(5.597)	(1.499)
Industrial Production	- 0.048	0.023
	(0.032)	(0.018)
Unemployment	0.607***	0.025
	(0.227)	(0.061)
Index Returns	9.150***	4.733***
	(0.828)	(0.504)
Dependent variable: Base Rate		
Lag1 Price	- 0.000***	- 0.000***
	(0.000)	(0.000)
Lag1 Base Rate	0.831***	0.784***
	(0.005)	(0.002)
Consumer Price Index	- 1.602***	- 2.256***
	(0.090)	(0.030)
Industrial Production	0.021***	0.029***
	(0.000)	(0.000)
Unemployment	0.031***	- 0.027***
	(0.004)	(0.002)
Index Returns	0.096***	0.282***
	(0.009)	(0.282)
No. of observations	117,163	239,879
Ave. no. of T	35.397	51.631

Table 7 reports the regression output of the fixed-effects estimation of stock prices on the dummy variable which identifies above median leverage firms while controlling for the state of the economy and for the market index. The full sample is considered.

TABLE 7
THE LEVERAGE DUMMY

Dependent Variable Price:	
Leverage Dummy	- 9.080***
	(1.862)
Base Rate	1.514***
	(0.16)
Consumer Price Index	12.929 ***
	(3.871)
Index Log Returns	10.933 ***
	(1.201)
_cons	- 28.940
	(18.185)