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# Banks' asset and liability valuation in the new regulatory environment: a game theory perspective

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**Abstract** In the aftermath of the global financial crisis, US regulators have required banks to disclose more details regarding the valuation techniques of their traded assets and liabilities. Using data from 2013 to 2014 annual reports for nine primary dealers, we examine the determinants of the choice of the valuation techniques in a game theory setup. Consistent with their publicly disclosed shareholder policy, we assume that the banks' objective is to maximize their return on equity. Our key findings are threefold. First, we show that the optimal strategy for the global systemically important banks (G-SIBs) is to select the valuation techniques associated with a lower level of risk. Conversely, the optimal strategy for the non-G-SIBs is to select the valuation techniques associated with a higher level of risk. Finally, we demonstrate that the above optimal strategies are consistent over time. These findings are in line with the regulators' mindset to reduce the balance sheet riskiness of G-SIBs.

**Keywords** Great recession · Game theory · Global systemically important banks · Return on equity · Valuation techniques

**JEL Classification** C72 · D78 · G11 · G23 · G24 · G28

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## Introduction

The global financial crisis prompted US regulators to increase their scrutiny on financial markets and demand more transparency from financial institutions, specifically with regard to the pricing and hedging of financial instruments. For instance, the Basel Committee on Banking Supervision (BCBS) published in 2009 a "consultative document that outlined a comprehensive banking regulation reform package in order to promote a more resilient banking sector and to improve its ability to absorb financial and economic shocks [1]." Another important international response to the great recession was the establishment by the G20, in April of 2009, of the Financial Stability Board (FSB) as a successor to the financial stability forum (FSF). In cooperation with the BCBS, they established a new classification that groups banks into two categories: global systemically important banks (G-SIBs) and non-global systemically important banks (non-G-SIBs). A G-SIB is defined as "a financial institution whose distress or disorderly failure, because of its size, complexity and systemic interconnectedness, would cause significant disruption to the wider financial market and economic activity [2]." In addition, given the global nature of the banking industry, a number of recent studies also advocate for a new international financial architecture that could mitigate the regulatory arbitrage that benefit to multinational banks [3, 4].

This new distinction was mainly introduced to impose a tougher regulatory environment for G-SIB and thus limit the tail risk from the "too big to fail" institutions. Put another, the goal of such classification is to preserve the stability of the financial system in the event that a major institution experiences financial distress without imposing significant negative externalities on the public through a government bailout [5]. Numerous recent studies analyze the impact of the new regulatory environment on large banks' value and performance. Gao et al. [6] find that, in response to the key events of the Dodd–Frank Act, systemically important financial institution (SIFI) experienced more negative abnormal returns. Moreover, Moenninghoff et al. [7] provide evidence on how the new international regulation on G-SIBs affects the market value of large banks. They find that the new regulation negatively affects the value of the newly regulated banks, yet that the official designation of banks as "globally systemically important" itself has a partly offsetting positive impact.

In this paper, we also study one particular aspect of the post-global financial regulatory environment: the increased transparency demanded by US regulators. In March and September 2008, the US Securities and Exchange Commission (SEC) recommended an amendment to the fair value disclosure requirements by investment banks [8]. This amendment would require all public companies to disclose more specific information about the valuation techniques used to determine the fair value of traded financial instruments.

Responding to this recommendation, the Financial Accounting Standards Board (FASB) issued an accounting standards update on May 2011 that defines fair value measurement [9]. This amendment was created to achieve common fair value measurement and disclosure requirements across the US Generally Accepted Accounting Principles (GAAP) and the International Financial Reporting Standards (IFRS). The FASB was very specific in identifying the purpose of the update. This update explained how fair value should be measured, but did not require additional fair value measurements and was not intended to establish valuation standards or affect valuation practices outside of financial reporting. However, more recently, the FASB has been discussing new restrictions with regard to the disclosure requirement of the valuation techniques of certain assets and liabilities. For example, on March 2015, the FASB discussed the opportunity to remove the disclosure requirement on the internal valuation processes for fair value measurements sensitive to uncertainty around unobservable inputs [10]. Then, in September 2015, the Board issued a new accounting standard update, which is intended to promote the use of discretion by reporting entities when evaluating disclosure requirements set forth by the Board [11].

While more restrictions on disclosures could be introduced in the future, accounting data available for the first time in the 2012 annual financial statements do contain valuable and detailed information about the decision-making process of investment banks for the selection of asset and liability valuation techniques. In our paper, we exploit this unique information content to analyze and study the implications of the investment banks' selection process in the context of an uncertain environment.

More specifically, we model the decision-making process of investment banks in a game theory setup. This setup relies on three key assumptions: First, we assume that banks play a simultaneous game of imperfect information, where they simultaneously disclose the valuation techniques they adopted in their respective annual financial statements. Second, consistent with the banks' publicly disclosed shareholder policy, we assume that their goal is to maximize the ROE. Third, we distinguish between two categories of banks: G-SIBs and non-G-SIBs. This distinction allows us to group the investment banks in our sample into two categories, thus modeling the interaction of the game between only two players.

The Nash equilibrium (Nash [12]) of the game suggests that the optimal strategy for the G-SIBs is to select valuation techniques associated with a lower level of risk, and the optimal strategy for the non-G-SIBs is to select valuation techniques associated with a higher level of risk. Finally, we demonstrate that the above optimal strategies are consistent over time. This result is consistent with the regulators' mindset to reduce the balance sheet riskiness of G-SIBs following the global financial crisis.

The rest of this paper is structured as follows. We first describe the game theory setup and define the two groups of players: the strategies and the payoff functions. Second, we discuss our dataset and empirically derive the equilibrium strategies pursued by the banks in our sample. Finally, we conclude by providing some avenues for future research.

## The game theory setup

Following the 2011 accounting standards update, investment banks have been required to disclose more information regarding their fair values measurement [9]. Even though the update explained how fair value measurement should be reported, it did not intend to establish valuation standards or affect valuation practices outside of financial reporting. It essentially required banks to provide details with regard to the assumptions used to evaluate level 3, or illiquid, assets and liabilities and ensure the processes used to measure their fair value are consistent with the fair value framework in US GAAP. These requirements were not without posing some challenges for most public companies.

To better understand the determinants of the choice of the valuation techniques in the new post-global financial crisis regulatory environment, we use a game theory approach. To be more specific, we model the banks' simultaneous move (their choice of valuation techniques) as a static game of complete and imperfect information. This game is of complete information since we assume that all the banks have common knowledge about the possible strategies and payoffs. And since we assume that the banks simultaneously choose their strategies without communication, it is also considered as a game of imperfect information. Another key assumption is that all players behave rationally, i.e., they understand and seek to maximize their own payoffs.

In what follows, we discuss the building blocks behind our game theory setup.

## The players

Following the investment banks classification recommended by the FSB [13], we group the banks in our sample into G-SIBs and non-G-SIBs. These two groups define the players in our model, where G-SIBs are Player 1 and non-G-SIBs are Player 2.

G-SIBS are evaluated based on different criteria given the global nature of the classification. The BCBS [14] focused on four indicators:

- The first indicator of G-SIBs is cross-jurisdictional activity. This means that G-SIBs should have "non-domestic revenue as a proportion of total revenue … (and) cross-jurisdictional claims and liabilities as a proportion of total assets and liabilities." Put simply, this implies the bank is globally diversified, doing a substantial amount of work outside of its own country.
- The second ingredient that is required to classify a bank as G-SIB is its size. The bank's size is measured based on gross or net revenue as well as the equity market capitalization.
- The third ingredient is substitutability, which looks at the "degree of market participation." This includes gross mark-to-market value of the bank's repo, reverse repo and securities lending transactions in addition to gross mark-to-market over-the-counter derivatives transactions. Mark-to-market accounting essentially implies pricing goods at their current cost rather than their historical cost and therefore captures the current values of the assets in the company and thus their ability to be substituted by another firm.
- The fourth ingredient is complexity. This indicator observes the number of jurisdictions in which the firm acts. The more complex the bank is, the stronger are the systemic implications of potential financial distress.

As of November 2013, the list of G-SIBs contains 29 banks. These banks are allocated to five buckets depending on the required level of additional loss absorbency. These levels are 3.5, 2.5, 2, 1.5 and 1%. The list shows that bucket 5, which has a 3.5% additional loss absorbency level, is empty. Bucket 4 at 2.5% includes HSBC and JP Morgan Chase. Bucket 3 at 2.0% includes Barclays, BNP Paribas, Citigroup and Deutsche Bank, bucket 2 at 1.5% includes Bank of America, Credit Suisse, Goldman Sachs and Morgan Stanley, and finally, bucket 1 at 1.0% includes Mizuho FG, Royal Bank of Scotland and UBS [15]. Non-G-SIBs include dealers such as Jefferies and Nomura.

## The strategies

With the above classification in mind, we now turn to the strategies followed by each player in choosing the valuation technique of their assets and liabilities. To do so, we rank the valuation techniques reported by banks according to their riskiness and bucket them into two categories: HRI valuation techniques and LRI valuation techniques. These two buckets define the strategies that are available to each group of banks.

In defining the riskiness of the valuation techniques, we exploit a key change made to the accounting standards in 2012. This change required companies to disclose the following three items:

- The first is quantitative information with regard to the (significant) unobservable inputs used in determining the fair value.
- The second includes a description of the valuation processes a company has in place. This may include information about the group within the company that is responsible for the valuation policies and procedures, the methods and frequency of the procedures in place for validating pricing models, the processes for analyzing changes in fair value measurements from period to period and how information from brokers or pricing services is evaluated.
- The third includes a description of the sensitivity of fair value measurements to changes in the unobservable inputs. It is important to note that these requirements only apply to assets and liabilities whose fair values cannot be determined by observable inputs, such as market values.

Aside from the above three requirements, the new accounting standard does not provide specific guidance on what quantitative information should be disclosed to meet the requirement described in the first item above.

The above requirements provide valuable information about the valuation techniques used by each bank as well as the unobservable inputs to these techniques. Our priority is that the range of the disclosed unobservable inputs is a reasonable proxy for bank's perception of risk: The wider the range, the higher is the bank's risk perception toward the asset to be valued and vice versa. Consider two banks that use the same valuation technique for a given asset, but one of them discloses a higher range of the unobservable input. The use of a wider range of unobservable inputs likely indicates a different risk perception toward the asset. Put differently, the fact that one bank reports on a wider range of unobservable inputs relative to the other reflects lower confidence toward the fair value of the asset and thus a higher risk perception.

With this intuition in mind, we build a risk index variable by group of banks or players, denoted by $\mathrm{RI}_p$ where $p = \{1, 2\}$. Each player $p$ has therefore two strategies available:

Strategy 1: choose a high risk index ($\mathrm{HRI}_p$) valuation technique, where $p$ represents the player, and $p = \{1, 2\}$.
Strategy 2: choose a low risk index ($\mathrm{LRI}_p$) valuation technique, where $p$ represents the player, and $p = \{1, 2\}$.

More details on how these strategies are defined and calculated are presented later in the paper.

## The game

We model the interaction between G-SIBs and non-G-SIBs as a static game of imperfect information. This means that the players choose strategies simultaneously and without communication. Each player $p$, $p = \{1, 2\}$, will decide whether to choose from these two strategies: techniques that reflect a $\mathrm{HRI}_p$ or those that reflect a $\mathrm{LRI}_p$.

The payoffs function consists in maximizing the ROE, a longstanding goal for the vast majority of investment banks and a key performance metric closely followed by both analysts and investors. The ROE is defined as the ratio of post-tax profit to the value of equity. The denominator is typically calculated as the average common shareholder equity over the reporting period. With the exception of a few banks in our sample, we use the market value of equity in order to calculate the ROE. We would note that in the wake of the global financial crisis, regulators have required banks to increase the levels of equity capital and balance sheet liquidity, which has depressed the banks' ROE to substantially lower levels relative to the pre-crisis period.

Table 1 provides the normal form representation of the game. It shows that both players, i.e., G-SIBs (Player 1) and non-G-SIBs (Player 2), simultaneously and without communicating decide whether they are choosing HRI or LRI techniques. Each player's objective is to maximize its ROE. Our goal is to find a Nash equilibrium to this simultaneous game.

This table shows the outcomes of a negotiation game at the end of any given years. Both players, i.e., G-SIBs (Player 1) and non-G-SIBs (Player 2), simultaneously and without communicating decide whether they are choosing a HRI valuation technique (HRI) or a LRI valuation technique (LRI). Each player's objective is to maximize its ROE.

**Table 1** Normal form representation of the game

| | Non-G-SIBs (Player 2) | |
|---|---|---|
| | $\mathrm{HRI}_2$ | $\mathrm{LRI}_2$ |
| G-SIBs (Player 1) | | |
| $\mathrm{HRI}_1$ | $\mathrm{ROE}(\mathrm{HRI}_1), \mathrm{ROE}(\mathrm{HRI}_2)$ | $\mathrm{ROE}(\mathrm{HRI}_1), \mathrm{ROE}(\mathrm{LRI}_2)$ |
| $\mathrm{LRI}_1$ | $\mathrm{ROE}(\mathrm{LRI}_1), \mathrm{ROE}(\mathrm{HRI}_2)$ | $\mathrm{ROE}(\mathrm{LRI}_1), \mathrm{ROE}(\mathrm{LRI}_2)$ |

## Equilibrium analysis

The interaction between G-SIBs and non-G-SIBs is defined by a two-player normal form game, where each player has two strategies: $S_1 = \{\mathrm{HRI}_1, \mathrm{LRI}_1\}$ and $S_1 = \{\mathrm{HRI}_2, \mathrm{LRI}_2\}$. Let $s_p$ denote an arbitrary strategy for each player $p$, and $(s_1, s_2)$ denote a combination of strategies, one for each player. The payoff for each player is defined by ROE. Since both players simultaneously disclose in their annual financial reports their strategies, i.e., their choice of valuation techniques as categorized into HRI and LRI, then we define the Nash Equilibrium of this game as follows [16]:

**Definition** In the two-player normal form game $G = \{S_1, S_2; \mathrm{ROE}_1, \mathrm{ROE}_2\}$, the strategies $(s_1^*, s_2^*)$ are a Nash equilibrium if, for each player $p$, $s_p^*$ is (at least tied for) player $p$'s best response to the strategies specified by the other player.

For Player 1 in our game, this implies that for every feasible strategy $s_1$ in $S_1$; that is, $s_1^*$ solves $\max_{s_1 \in S_1} \mathrm{ROE}_1(s_1, s_2^*)$. The same solution concept applies to Player 2 where $s_2^*$ solves $\max_{s_2 \in S_2} \mathrm{ROE}_2(s_1, s_2^*)$.

To be more concrete, the Nash equilibrium solution concept will lead to the following possible equilibria:

Equilibrium 1: $(s_1^*, s_2^*) = (\mathrm{HRI}_1, \mathrm{HRI}_2)$

This equilibrium would indicate that the new regulation that imposed tougher regulatory requirements on G-SIBs did not affect the behavior of these banks in terms of risk taking. That equilibrium would be in line with the findings of Moshirian (3,4) that is advocating for a new international financial structure.

Equilibrium 2: $(s_1^*, s_2^*) = (\mathrm{HRI}_1, \mathrm{LRI}_2)$

This equilibrium would prove that the distinction between G-SIBs and non-G-SIBs had an opposite effect on the behavior of these two categories of banks. In fact, this would point out to the failure of the new legislation since the big banks are taking more risk, exacerbating the too big to fail idea.

Equilibrium 3: $(s_1^*, s_2^*) = (\mathrm{LRI}_1, \mathrm{HRI}_2)$

This equilibrium would prove that the legislator succeeded in not only curbing the big banks' risk taking, but also left room for the smaller banks to seek higher returns. That is also in line with results of Moeninghoff et al. [8]

Equilibrium 4: $(s_1^*, s_2^*) = (\mathrm{LRI}_1, \mathrm{LRI}_2)$

This equilibrium would signal that tougher regulation designed for big banks had a spillover effect on the whole industry.

## Empirical results

### Data collection

We start by selecting the entire population of US primary dealers as of 2013, and we obtain a sample of 21 primary dealers in total [17]. For each selected dealer, we then examine the 10-K and 20-F annual reports for the 2013 and 2014 fiscal years and only retain dealers that disclose both the quantitative data and the range and average of the unobservable inputs utilized in the valuation techniques. For instance, dealers that did provide a "quantitative" sensitivity analysis of the unobservable inputs (e.g., BMO Capital Markets) or did not disclose the valuation techniques used to price the financial instruments (e.g., SG Americas Securities) were removed from our initial screen. These criteria reduce the size of our sample to eight dealers.[1]

In a second step, we classify dealers into G-SIBs and non-G-SIBs based on the FSB list [15]. The G-SIBs in our sample are Bank of America, Citibank, Credit Suisse, Goldman Sachs, JPMorgan Chase Bank and Morgan Stanley, while the non-G-SIBs are Jefferies and Nomura Group.

In a third step, to quantify the players' strategies and game outcome, we collect all the qualitative and quantitative information relative to traded assets and liabilities, as well the valuation techniques used to price them. Because of the large number of assets and liabilities evaluated by the banks (roughly 20), we bucket them into four groups: structured products, corporate equity, corporate debt and derivatives. This classification, which is shown in Table 2, makes the model more tractable while keeping the categories of instruments granular enough.

We display the different assets and liabilities traded by the investment banks in our sample, as well as the four different categories that we created to group them.

The fourth ingredient needed to perform our analysis is to categorize the set of valuation techniques as well as the unobservable inputs. Starting with the valuation techniques, we define seven distinct categories: comparable bond price, discounted cash flow, correlation model, net asset value, market approach, corporate loan model and option model. Each of these categories requires the use of at least one unobservable input. As for the unobservable inputs, we define seven categories: correlation (e.g., equity-exchange rate correlation, cross-commodity correlation), price (e.g., comparable loan price, comparable bond price), rate (recovery rate, discount rate), severity (e.g., loss severity), spread (e.g., credit spreads, cash synthetic spread), volatility (e.g., commodity volatility, inflation volatility) and yield.

One challenge with the above classification is that the unobservable inputs have different units that range from years (e.g., bonds duration), basis points (e.g., spreads), percentages (e.g., volatility and correlation) and dollars (e.g., price per megawatt hour of power). To address this issue, for each bank $i$ in our sample $i = \{1, \ldots, 8\}$, valuation technique $j$ used by each bank ($j = \{1, \ldots, 7\}$), to price each financial instrument $k$ ($k = \{1, \ldots, 7\}$), we use the following risk index (RI) standardized measure for each year $n = \{2013, 2014\}$:

$$\mathrm{RI}_{i,n} = \sum_{j=1}^{7} \sum_{k=1}^{7} \sqrt{\frac{\left(H_{i,j,k,n} - A_{i,j,k,n}\right)^2 + \left(L_{i,j,k,n} - A_{i,j,k,n}\right)^2}{2}} \tag{1}$$

where $H$ and $L$ represent, respectively, the highest and lowest range values for the unobservable input. Moreover, $A$ represents the average range values for the unobservable input. This measure allows us to rank the dealers in terms of their risk perception, as measured by the range in the unobservable inputs.

The final ingredient that we need is the bank's ROE as well as the total assets as of December 31, 2013 and 2014. This information is summarized in Table 3. Asset values for Credit Suisse and Nomura Group were reported, respectively, in Swiss Franc and Japanese Yen. These numbers were converted into US dollars using the closing exchange rate on December 31 for each year. The ROE is measured at its book value, as of December 31. ROE for all the banks in our sample is collected from Ycharts.com, a financial data research platform.[2] One exception is Jefferies

[1] Only eight investments banks have disclosed fair value measurements in 2012. These banks are: Bank of America, Citibank, Credit Suisse, Goldman Sachs, JP Morgan, Morgan Stanley, Jefferies and Nomura.

[2] Source: www.ychart.com.

**Table 2** Grouping of assets and liabilities

| Category | Trading assets and liabilities |
|---|---|
| Structured products | Asset-backed securities (ABS), auction rate securities (ARS), collateralized debt obligations (CDO), collateralized loan obligations (CLO), commercial mortgage-backed securities (CMBS), mortgage-backed securities (MBS), Residential mortgage-backed securities (RMBS), structured notes (SN) |
| Corporate equity | Private equity investments, corporate equity |
| Corporate debt | Corporate loans, commercial loans, municipal, foreign, government and corporate debt securities |
| Derivatives | Currency derivatives, commodity derivatives, credit derivatives, equity derivatives, interest rate derivatives, derivatives with monolines |

**Table 3** 2013–2014 ROE and total assets for investment banks in our sample

| | 2013 | | 2014 | |
|---|---|---|---|---|
| | ROE (%) | Assets ($ millions) | ROE (%) | Assets ($ millions) |
| Bank of America | 4.61 | 2,102,273 | 1.71 | 2,104,534 |
| Citibank | 7.02 | 1,880,382 | 3.37 | 1,842,530 |
| Credit Suisse | 4.81 | 515,763 | 4.33 | 548,137 |
| Goldman Sachs | 10.98 | 816,400 | 11.15 | 971,000 |
| Jefferies | 5.52 | 40,177 | 6.55 | 44,764 |
| JPMorgan Chase Bank | 8.40 | 1,945,467 | 9.75 | 2,074,952 |
| Morgan Stanley | 4.31 | 493,526 | 4.94 | 448,526 |
| Nomura Group | 9.99 | 402,957 | 8.06 | 367,954 |

Group, Inc. 2014 data. Jefferies merged with Leucadia National Corporation on March 1, 2013. To collect data for this company for 2013, we rely on data released by Jefferies on October 2014.

We report the 2013 and 2014 return on equity, as well as the total assets, for each bank in our sample. The total asset is effective as of December 31 and collected from 10-K and 20-F reports.

## The Nash equilibria

We model the decision-making process of investment banks in the selection of valuation techniques by a simultaneous, non-cooperative game, between two groups of banks: G-SIBs and non-G-SIBs.

We first start by characterizing the strategies of each player and identify within each group of banks, which ones have high risk index and which ones have a low one. To do so, we rank the investment banks based on an average return index (RI). Within each category of banks, i.e., G-SIBs and non-G-SIBs, we calculate the average RI and identify high risk index banks as those who have a risk index above the average. Conversely, we identify low risk index banks as those who have a risk index below the average. For instance, Table 4 represents the classification of the banks in our sample following two criteria: G-SIBs versus non-G-SIBs, and high risk versus low risk index. We also find that this list does not change over the period 2013–2014.

This table represents banks grouping following two criteria. We first distinguish between G-SIBs and non-G-SIBs. Second, within each group of banks, we distinguish between banks that have high risk index and those that have low risk index. The calculation of RI is based on 2013 data.

For each group of G-SIBs, we also calculate an average ROE weighted by the assets. Using these results, we calibrate our data and obtain the following game outcomes:

This table represents the 2013 outcomes of the simultaneous game between G-SIBs and non-G-SIBs. Both players want to maximize their ROE. The optimal outcome for G-SIBs is to choose a strategy LRI, which indicates

**Table 4** Classification of banks in our sample

| Low risk index (LRI) | | High risk index (HRI) | |
|---|---|---|---|
| Dealer | Risk index | Dealer | Risk index |
| G-SIBs (Player 1) | | | |
| Bank of America | 4.1 | Citibank | 9.1 |
| JP Morgan | 2.4 | Credit Suisse | 4.3 |
| Morgan Stanley | 1.6 | Goldman Sachs | 5.7 |
| Non-G-SIBs (Player 2) | | | |
| Jefferies | 1.3 | Nomura | 10.8 |

**Table 5** The 2013 game outcome

| | Non-G-SIBs (Player 2) | |
|---|---|---|
| | $HRI_2$ (%) | $LRI_2$ (%) |
| G-SIBs (Player 1) | | |
| $HRI_1$ | 3.18, **9.99** | 3.18, 5.52 |
| $LRI_1$ | **3.63**, **9.99** | **3.63**, 5.52 |

Values in this table represent a weighted average Return on Equity (ROE). Each entry in the table corresponds to an average ROE by group of banks (G-SIBs *vs.* Non G-SIBs) and category of valuation techniques (HRI *vs.* LRI). These values are weighted by the banks total balance as of December 31st. For instance, 3.18 represents a weighted avergae ROE for G-SIBs that adopted a HRI valuation techniques. The values in bold represent dominant strategies in the Nash equilibria game

**Table 6** The 2014 game outcome

| | Non-G-SIBs (Player 2) | |
|---|---|---|
| | $HRI_2$ (%) | $LRI_2$ (%) |
| G-SIBs (Player 1) | | |
| $HRI_1$ | 2.43, **8.06** | 2.43, 6.55 |
| $LRI_1$ | **3.26**, **8.06** | **3.26**, 6.55 |

Values in this table represent a weighted average Return on Equity (ROE). Each entry in the table corresponds to an average ROE by group of banks (G-SIBs *vs.* Non G-SIBs) and category of valuation techniques (HRI *vs.* LRI). These values are weighted by the banks total balance as of December 31st. For instance, 3.18 represents a weighted avergae ROE for G-SIBs that adopted a HRI valuation techniques. The values in bold represent dominant strategies in the Nash equilibria game

adopting valuation techniques associated with low risk index. The optimal outcome for non-G-SIBs is to choose a strategy HRI, which indicates adopting valuation techniques associated with high risk index.

We derive the solution by iterated elimination of strictly dominated strategies. Indeed, "rational players do not play strictly dominated strategies, because there is no belief that a player could hold (about the strategies the other players will choose) such that it would be optimal to play such a strategy [10]". Thus, in our game, a rational Player 1 (or G-SIBs bank) chooses a LRI valuation technique that strictly dominates HRI valuation techniques, and Player 2 (Non G-SIBs) chooses a HRI valuation technique that strictly dominates LRI valuation techniques.

Table 5 shows the 2013 outcomes of the simultaneous game between G-SIBs and non-G-SIBs. The Nash equilibrium of this game corresponds to Equilibria 3 described in the equilibrium analysis section. This equilibrium is interpreted as follows: In order to maximize its return on equity, the optimal strategy for the G-SIBs is to select valuation techniques associated with a lower level of risk, and the optimal strategy for the non-G-SIBs is to select valuation techniques associated with a higher level of risk.

This table represents the 2014 outcomes of the simultaneous game between G-SIBs and non-G-SIBs. Both players want to maximize their ROE. The optimal outcome for G-SIBs is to choose a strategy LRI, which indicates adopting valuation techniques associated with low risk index. The optimal outcome for non-G-SIBs is to choose a strategy HRI, which indicates adopting valuation techniques associated with high risk index.

Table 6 also shows that this behavior is consistent over time as the 2014 outcomes of the simultaneous game between G-SIBs and non-G-SIBs indicate the same outcomes as those inferred from the 2013 fiscal year.

## Summary and conclusions

Following the global financial crisis, global regulators have significantly increased their scrutiny on banks in an attempt to better control their strategies and business models. The main paradigm shift for banks has been the significant increase in the levels of equity capital and balance sheet liquidity. In addition, enhanced transparency and disclosure have also become a key pillar of the new regulatory environment. In this paper, we zoom in on this particular aspect looking at the way US primary dealers have responded to the recent changes in the fair value disclosure requirements by investment banks.

Starting with the assumption that the banks' objective is to maximize their ROE, we find that the optimal strategy for the G-SIBs is to select the valuation techniques associated with a lower level of risk. Conversely, the optimal strategy for the non-G-SIBs is to select the valuation techniques associated with a higher level of risk. Both of these results appear to be consistent over time. These findings are in line with the regulators' mindset to reduce the balance sheet riskiness of G-SIBs.

Several extensions to our analysis can be applied. Firstly, a time series approach will be possible once 2016 and 2017 data are collected and disclosed, respectively. This approach would imply two changes to the analysis. Firstly, we would be able to extend our model as a sequential game to study herd behavior and demonstrate whether non-G-SIBs would be tempted to imitate large banks in their choice of valuation techniques. Further, we could conduct a time series analysis with the quantitative methods of inferential statistics. This would also allow us to determine whether herd behavior is taking place among the banks, but also to study the time effects of the variables.

Another extension of the current paper is to conduct a survey among investment bankers that would allow for a more profound understanding of their decision-making processes. More specifically, it would allow us to deepen our comprehension of the relationship between the risk index and performance. Such a survey may prove extremely useful.

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