Buy-Side and Sell-Side Research: Implications of Separating Equity Research Payment from Brokerage Service

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Abstract

The recent MiFID II regulation in Europe made delegated asset managers' spending on sell-side analyst research more transparent to their clients. This transparency requirement has attracted a lot of media attention and resistance from the industry. We study theoretically the impact of this transparency on asset managers' information production. Focusing on the agency problem between asset managers and their clients, we show that transparency decreases the use of sell-side research but stimulates more buy-side research activities. These results a decrease in the number of sell-side analysts and an increase in buy-side analysts, which is consistent with empirical findings. Our model has additional predictions on managers' performance, liquidity, and social welfare.

JEL Classification: G14, G23, G28.

Keywords: Information Acquisition; Equity Research; Transparency; MiFID II.

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1 Introduction

As households increasingly rely on financial institutions to manage their assets, asset managers nowadays play a central role in financial markets.[1] To the extent that their trades incorporate some fundamental information, they contribute to better price discovery and more efficient capital allocation.

Asset managers may acquire information in several ways. In particular many asset managers purchase sell-side research, e.g., from brokers' analysts. Sell-side research is typically charged by brokers through trading commissions, which are ultimately borne by end-investors. This practice, called bundling, makes it difficult for investors to estimate how much a fund spends on research, raising concerns among regulators. European regulators introduced the Markets in Financial Instruments Directive (MiFID) II in 2018, which forces asset managers to separate payment for research from trading commissions. Abundant anecdotal evidence suggests that, following the regulation, asset management firms spend significantly less on sell-side research. For example, in the UK, the Financial Conduct Authority finds that asset managers have cut their research budgets by around 20 to 30 percent since MiFID II came into force (*Financial Times, Feb. 25, 2019*). Evidence[2] also indicates that analyst coverage decreased significantly, reacting to a lower demand for sell-side research.

Given the central role of sell-side analysts and asset managers in information aggregation, it is important to understand the friction that calls for this unbundling rule, its impacts and whether it benefits investors as the regulators intended. It is not obvious a priori why opacity in sell-side research costs creates a problem. As most investors care only about returns net of all fees, the composition of costs seems irrelevant. If that is so, how can transparency have an impact and benefit investors?

In this paper, we provide a rationale for the unbundling rule and analyze its impact on information acquisition and investor welfare. Just as the rationale for the regulation is not obvious, it is equally not obvious why it should lead to a lower demand for sell-side research. Instead one might expect the opposite: as more information reduces asset managers' scope for opportunistic behavior, investors might encourage their managers to use more sell-side research

[1] Only about 20% of U.S. public equity is directly owned by individuals (Stambaugh, 2014).

[2] See, e.g., Guo and Mota (2019) and Fang et al. (2019). More details are discussed later.

after MiFID II.

One explanation for the decrease is that sell-side research was bundled with and cross-subsidized by brokerage services, thus limiting asset managers' choice on whether to use a broker's research. However, Goldstein et al. (2009) show that asset managers have the discretion on whether to use a broker's premium service, including valuable research. Di Maggio et al. (2019) provide evidence that asset managers value and pay for good quality research. They can continue to purchase it with separate payment after MiFID II. In that case, the unbundling rule shouldn't trigger any change.

Another popular explanation is that asset managers now have to be more selective when purchasing sell-side research. However, due to intense competition in the asset management industry, it is hard to imagine that they were less careful before MiFID II. As one big investment bank puts it "the PM [portfolio manager] will not remunerate higher execution fees for no value added nor will it churn the portfolio, as those fees negatively impact the performance of the portfolio which is against the interest of both the PM and the investor".[3]

Our explanation is based on the agency problem between investors and asset managers. A key observation is that sell-side research has two opposite effects. On the one hand, it benefits the investor by increasing the fund's expected return. On the other hand, it also makes the agency problem more severe. Indeed, in order to incentivize buy-side effort, managers are remunerated only for high returns. If investor-paid sell-side research increases the probability of high returns independently of the managers' effort, it effectively increases the manager's informational rent and thus the cost of incentivizing buy-side effort. This implies that investors need to discourage their managers from using "too much" research when incentivizing buy-side effort. By allowing investors to observe the spending on research, MiFID II offers investors a tool to reduce this amount.

In our model, we assume a competitive brokerage industry and sell-side research industry. An asset manager acquires information by doing buy-side research (private effort, we hereafter use "buy-side research" and "effort" interchangeably) and by purchasing sell-side research (or "research" for brevity) from analysts. Buy-side and sell-side research independently increase

[3] This quote is from the bank's response to ESMA's consultation paper, which and many other responses can be found at `https://www.esma.europa.eu/press-news/consultations/consultation-paper-mifid-iimifir`.

the manager's chance of identifying a good trading strategy. In order to trade, the fund (thus the investor) pays execution fees to a broker. Payment for research is bundled with trading execution fees as trading commissions. When the manager uses more sell-side research, he is also more likely to pay high trading commissions.

Pre-MiFID II, we assume the investor does not observe the amount of research. Thus the use of research is not contractible. The reason is that trading execution fees are affected by other factors that are random and unrelated to research. The manager's trading commission only provides an imperfect signal about the amount of research that he uses. MiFID II brings full transparency on the amount of research, making it directly contractible.

When the use of research is not contractible, as is the case pre-MiFID II, the investor can induce the manager's effort with only one tool – the manager's compensation. If research increases the probability of high return while not increasing trading commissions too much, the manager tend to use more sell-side research than the amount desired by the investor. In an optimal contract, to save payment for good performance unrelated to the manager's effort, even if return is low, the investor also pays the manager if commissions are low. Unfortunately, this increases the manager's temptation to shirk, which is costly to the investor. Thus the investor balances between the cost of compensation payment due to sell-side research and the cost of incentivizing effort.

MiFID II frees investors from such trade-off, as transparency allows them to directly contract on the usage of sell-side research. Nevertheless, they still have to choose between higher expected returns and higher compensation costs due to more sell-side information.

Comparing the optimal contracts in the two cases, we find that MiFID II decreases the use of sell-side research if buy-side research is more cost-efficient than sell-side research. As transparency enables the investor to control sell-side research without increasing the manager's temptation to shirk, less research is used. More effort is supplied as less research implies a lower incentive cost. Nevertheless, the manager is less informed. In a word, transparency serves as a contracting tool and always benefits investors (contracting effect).

The idea that investors decrease the use of research so that they can infer the manager's effort more precisely from return is reminiscent of Holmström and Tirole (1993). In their paper, investors condition their managers' compensation on market information to avoid payment for performance that is unrelated to their managers' effort. In our case, investors actively reduce the likelihood of such exogenous good performance by using less sell-side research.

As asset managers are hired to trade in financial markets, collective transition in their behaviors are likely to introduce market-wide changes with unintended effects, which may affect investors further. To explore the equilibrium effects of the unbundling rules on investors' welfare, market liquidity and price informativeness, we consider an extension of our baseline model that features competitive market making and endogenous liquidity trading a la Biais et al. (2015).

In this extended set-up, MiFID II is welfare improving. As transparency makes managers less informed, market makers face less adverse selection, which improves market liquidity. In our setting, costly information acquisition destroys value as trading only plays a distributional role. Due to lower total information cost and less adverse selection, the return of informed trading and social welfare also improve (equilibrium effect). However, less information is incorporated into the asset prices. This may be undesirable for efficient asset allocation but this point is beyond this paper.

Our model has a number of empirical implications. Since managers' demand for sell-side research decreases, a direct implication is that the number of analysts or analyst coverage should decrease after MiFID II as the research market clears. Another prediction is that that managers supply more effort, implying that the number of buy-side analysts or their research activities should increase. In addition, we show that such impacts are larger for less risky stocks. If the market size of a stock proxies its riskiness well, then analyst coverage of larger stocks decreases more.

Related literature. This paper is related to several strands of literature. First, it is related to a small literature on the organization of the brokerage and research industry, especially the bundling structure. Brennan and Chordia (1993) rationalize the bundling structure as a risk-sharing arrangement between a risk neutral information seller and a risk averse buyer, who is uncertain about the value of the seller's information. The bundling structure allows the buyer to pay for information (through order execution) after observing its value, eliminating the insurance that the buyer would require if he pays ex ante. Transparency has no impact in this model as what matters is the timing of payment. Our model indicates that if bundling research with execution obfuscates the research cost, then it can increase the managers' demand for research.

Second, we contribute to the literature on soft dollar payment, which refers to the arrangement that managers purchase non-execution services from brokers using commissions instead of direct separate payment ("hard dollar"). Conrad et al. (2001) estimate soft-dollar execution costs. Goldstein et al. (2009) find that commissions vary little across different trades and are renegotiated infrequently. Blume (1993) and Bergstresser et al. (2008) investigate empirically some welfare implications of the use of brokers' soft dollar service. Edelen et al. (2012) find that the US mutual funds that bundle distribution fees with brokerage commissions underperform than whose funds that explicitly expense it, suggesting that disclosure can be an effective way to mitigate the agency issue. Di Maggio et al. (2019) estimated that sell-side research cost can be up to 15% of management fees. The most empirically related papers are Guo and Mota (2019) and Fang et al. (2019). Using stocks of US firms as a control group, both papers find a significant decrease in analyst coverage for European stocks. Guo and Mota (2019) also find that the decrease is larger for large stocks. Fang et al. (2019) find evidence that the number of buy-side analysts increases and they participate more in earning conferences. Surprisingly, theoretical analysis in this literature is scarce. Livne and Trueman (2002) study a situation where the conflict of interests between investors and managers arises as brokers privately rebate part of commissions to managers. They find that disclosure of the rebate has no direct impact as investors rationally adjust their fees for the kickback when the rebate is opaque. Our model indicates that if the rebate is information instead of monetary benefits, distortions arise.

Third, we contribute to a large literature in optimal contracting in delegated asset management. Previous literature has studied the limits of affine contracts in incentivizing portfolio managers' effort (Stoughton, 1993, Admati and Pfleiderer, 1997), optimal non-linear contracts (Dybvig et al., 2009 and Li and Tiwari, 2009), and screening the managers' skill (Bhattacharya and Pfleiderer, 1985). Among models that study portfolio delegation in equilibrium, Cuoco and Kaniel (2011) investigate the asset pricing implications of some commonly used compensation contracts. Buffa et al. (2014) endogenize the limit in managers' risk positions. They find risk limit biases prices upward. Embedding linear contracts in the Kyle (1985) model, Kyle et al. (2011) find that the relationship between price informativeness and the amount of noise trading depends on the manager's risk aversion. Huang (2015) studies a similar problem with multiple principal-agent pairs, where the contract is contingent on price forecast. Therefore more informative price increases agents' forecasting accuracy, decreasing the insurance they required. In contrast, focusing on convex performance compensation, Malamud and Petrov (2014) highlight that better information acquisition technology may decrease investors' utility as more revealing price decreases trading return and investors do not internalize this externality. Different from these papers, we focus on the how the agency problem affects the mix of buy-side and sell-side information acquisition. In particular, we obtain a counter-intuitive result that investors may voluntarily constrain managers from obtaining valuable information.

The rest of the paper is organized as follows. We describe our baseline model in section 2. Benchmark cases, post-MiFID II and pre-MiFID II are analyzed in section 3, 4 and 5. In section 6 we study the effect of the unbundling rule on the agency problem, which is extended with endogenous trading in section 7. Empirical implications are discussed in section 8. We conclude with some policy implications in 9.

2 The baseline model

In our baseline model, we consider a static contracting problem between an investor and a manager. Both are risk-neutral. The investor delegates the management of her asset to the manager. The manager's reservation utility is 0. We assume brokers and analysts behave competitively.

Information acquisition. — The manager can acquire information before making his investment decision. In particular, he can do buy-side research $\tau_m \in [0, \bar{\tau}_m]$, and purchase sell-side research from analysts $\tau_a \in [0, \bar{\tau}_a]$. Then the manager finds a trading strategy that generates a good result (high return) R_G with probability $p_G = \frac{1}{2} + \tau_m + \tau_a$, and a bad result (low return) R_B ($\Delta R = R_G - R_B > 0$) with complementary probability p_B. We assume $\bar{\tau}_m + \bar{\tau}_a < \frac{1}{2}$ to avoid corner situations.

Costs. — Buy-side research (τ_m) is non-verifiable, and costs the manager $C_m(\tau_m)$ with $C_m(0) = 0, C_m'(0) = 0, C_m''(\cdot) > 0$.

In order to trade, the fund pays a trading execution fee to a broker. The execution fee is deducted from the fund return directly, i.e., paid by the investor. This captures the realistic feature that investors pay for trading execution. To model the fact that pre-MiFID II, payment for sell-side research (τ_a) was bundled with trading execution fee, we assume that if the manager uses more sell-side research, he is more likely to pay a high execution fee f instead of a low one, which is normalized to 0. More precisely, let $\pi_B(\tau_a)$ ($\pi_G(\tau_a)$) denotes the probability of high (low) execution fee, we assume $\pi_B(\tau_a) = \frac{1}{2} + C_a(\tau_a)$, and $\pi_G(\tau_a) = \frac{1}{2} - C_a(\tau_a)$, with $C_a(0) = 0, C'_a(0) = 0$, $C''_a(\cdot) > 0$. Note that without using any sell-side research, trading execution fee is randomly high or low. In reality this may be because some profitable investment strategies may require more trading than others and the manager finds one randomly. This random nature makes it difficult for investors to disentangle the cost of sell-side research and the cost of trading execution. Our modeling choice is an easy way to capture this feature and the fact that managers pay for research as shown in Di Maggio et al. (2019). Another interpretation is that sell-side analysts provide information that induces more trading, making the manager likely to trade more and pay a high execution fee.

Contracts and MiFID II. — We model the effect of MiFID II as making the usage of sell-side research τ_a transparent and contractible. when τ_a is not contractible (pre-MiFID II), the contract that the investor offers only specifies outcome-contingent transfers to the manager, as summarized in Figure 1 : W_{GG} (high return low fee), W_{GB} (high return high fee), W_{BG} (low return low fee) and W_{BB} (low return high fee). Post-MiFID II, in addition to the transfers, the contract also specifies τ_a directly.

Assumptions. — As we will use the first-order approach in our analysis, we assume the optimization problems in the rest of the paper are concave. In addition, to avoid corner solutions, we make the following assumption.

Assumption 1. *$C'_m(\bar{\tau}_m) >> \Delta R$, $C_a(\bar{\tau}_a) < \frac{1}{2}$ and $C'_a(\bar{\tau}_a)f >> \Delta R$.*

Alternatively, we may assume $C'_m(\bar{\tau}_m) = C'_a(\bar{\tau}_a) = +\infty$, but this excludes some common cost functions, e.g., quadratic cost functions. A further assumption that relates $C_m(\tau_m)$ and $C_a(\tau_a)f$ will be discussed in section 6.

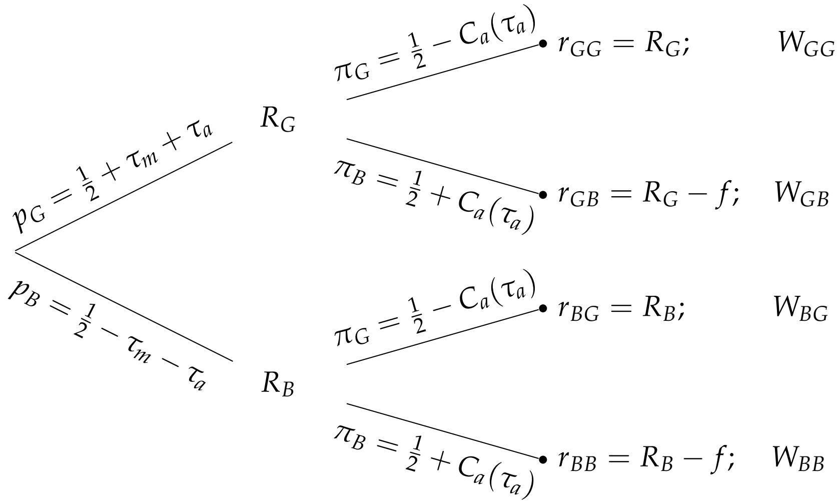

Figure 1: Payoff tree. r is the investor's payoff before paying the manager. W is the manager's compensation.

3 Benchmarks

In this section, we consider two benchmark cases. Both feature no moral hazard: one with full information and one with unobservable sell-side research τ_a

3.1 Full-information benchmark (first-best)

This is first-best situation. As both τ_m and τ_a are contractible and the manager's reservation utility is zero, the investor essentially manages the asset on her own and the manager receives zero utility. The investor's solves the following problem when choosing τ_m and τ_a,

$$\max_{\tau_m, \tau_a} \sum_{i,j \in \{G,B\}} p_i(\tau_m, \tau_a)\pi_j(\tau_a) r_{ij} - C_m(\tau_m) \tag{1}$$

The investor maximizes expected return minus the cost of information, where the cost of sell-side research has been incorporated in r. The solution to this problem is characterized by the following equations:

$$\Delta R - C_m'(\tau_m^*) = 0 \tag{2}$$

$$\Delta R - C_a'(\tau_a^*) f = 0 \tag{3}$$

In the first-best, the investor chooses the amount of buy-side research τ_m^* such that its marginal cost $C_m'(\tau_m^*)$ equals to the marginal value of information ΔR. The amount of sell-side research τ_a^* is determined similarly. An important feature of first-best situation is that τ_m^* and τ_a^* are independently determined. As we'll see later, this is no longer true once there is moral hazard.

3.2 Observable effort but unobservable research

We now consider another benchmark case where effort τ_m is contractible but sell-side research τ_a is not.

With the convention that when the manager is indifferent among different choices, he chooses the one preferred by the investor, it is easy to see that this situation leads to first-best outcomes. Indeed, if the manager is paid $C_m(\tau_m^*)$ for any returns, there is no conflict of interest in choosing τ_a. Then with the convention, first-best outcomes can be achieved.

This result highlights that without moral hazard or agency issue, opacity in the usage of sell-side research does not generate distortion. The investment bank's argument cited in section 1 implicitly refers to this situation.

In the following part, we analyze the situations with moral hazard. We first analyze post-MiFID II situation and then go back in time to analyze the case before MiFID II. The reason for this reverse chronological order is that in this way we add layers of asymmetric information one by one.

4 Post-MiFID II

MiFID II puts the manager's usage of sell-side research under the investor's inspection. The amount of sell-side research τ_a can be directly contracted. The investor chooses monetary transfers W and τ_a to mitigate the agency conflict. In particular, the investor maximizes her expected return minus expected compensation to the manager,

$$\max_{W_{ij},\tau_a} \sum_{i,j\in\{G,B\}} p_i(\tau_m,\tau_a)\pi_j(\tau_a)(r_{ij}-W_{ij}) \tag{4}$$

such that the manager chooses effort to maximizes his utility (incentive compatibility constraint),

$$\tau_m \in \underset{\tau'_m}{argmax} \sum_{i,j \in \{G,B\}} p_i(\tau'_m, \tau_a)\pi_j(\tau_a)W_{ij} - C_m(\tau'_m) \tag{5}$$

and the manager's participation constraint and limited liability constraints are also satisfied.

$$\sum_{i,j \in \{G,B\}} p_i(\tau_m, \tau_a)\pi_j(\tau_a)W_{ij} - C_m(\tau_m) \geq 0$$

$$W_{ij} \geq 0, \quad i,j \in \{G,B\}$$

To gain some intuition of the optimal contract, consider the manager's incentive compatibility constraint (5). It is equivalent to the following first order condition,

$$\pi_G(\tau_a)(W_{GG} - W_{BG}) + \pi_B(\tau_a)(W_{GB} - W_{BB}) = C'_m(\tau_m) \tag{6}$$

Therefore given τ_a, the difference between weighted compensation after high return and low return determines the effort that the manager supplies. The investor optimally sets compensation after low return to zero, $W_{BG} = W_{BB} = 0$.

Ignoring the manager's participation constraint, the investor's problem can then be simplified by substituting (6) and $W_{BG} = W_{BB} = 0$ into (4), leaving us with (6) and

$$\max_{\tau_m,\tau_a} \sum_{i,j \in \{G,B\}} p_i(\tau_m, \tau_a)\pi_j(\tau_a)r_{ij} - p_G(\tau_m, \tau_a)C'_m(\tau_m) \tag{7}$$

τ_m and τ_a are then characterized by associated first order conditions. Comparing (7) with (1), it is immediate to see that moral hazard distorts the choice of τ_m and τ_a, as shown in the following result.

Proposition 1 (Optimal contract with contractible τ_a). *When τ_a is contractible, the investor chooses τ_a^n and the manager's compensation, such that $W_{BG} = W_{BB} = 0$, $(W_{GG}, W_{GB}) \in \mathbb{R}^+ \times \mathbb{R}^+$ satisfy* (6) *with (τ_m^n, τ_a^n), which is determined by the following two equations,*

$$\Delta R - C_m'(\tau_m^n) - (\frac{1}{2} + \tau_m^n + \tau_a^n)C_m''(\tau_m^n) = 0 \tag{8}$$

$$\Delta R - C_a'(\tau_a^n)f - C_m'(\tau_m^n) = 0 \tag{9}$$

The superscript "n" refers to the new situation – post-MiFID II. Note that the manager's compensation W_{GG} and W_{GB} are not fully pinned down. The reason is that trading execution cost does not reveal any information about buy-side research τ_m. Therefore the investor can choose any combination of W_{GG} and W_{GB} as long as their weighted average satisfies the manager's incentive compatibility constraint.

Different from its conterpart in the first-best, (8) has an additional term $(\frac{1}{2} + \tau_m^n + \tau_a^n)C_m''(\tau_m^n)$. This new term arises due to moral hazard problem: to satisfy the manager's incentive compatibility constraint, the investor has to give the manager a compensation higher than the manager's cost of effort. Effectively, from the investor's point of view, this increases the marginal cost of buy-side research.

More interestingly, the choices of τ_m and τ_a are no longer independent as in the first-best case. The reason can be easily seen from (7). The last term $p_G(\tau_m, \tau_a)C_m'(\tau_m)$ is the expected compensation paid by the investor. Recall that $p_G(\tau_m, \tau_a) = \frac{1}{2} + \tau_m + \tau_a$, a larger τ_a leads to a larger compensation to the manager, regardless of his effort. This is because the investor pays the manager only for good return and sell-side research increases the likelihood of a good return independent of the manager's effort. Hence, sell-side research effectively increases the cost of effort.

The investor then faces a trade-off when choosing the amount of research: balancing its effect of return increasing and its effect of cost increasing. As a result, the investor optimally chooses a smaller τ_a to decrease the manager's rent, resulting in $\tau_a^n < \tau_a^*$, since at τ_a^* the marginal effect of return increasing is zero while the marginal effect of cost increasing is positive.

Corollary 1. $\tau_m^n < \tau_m^*$, $\tau_a^n < \tau_a^*$. *Both buy-side research and sell-side research are insufficient compared to first-best post-MiFID II.*

5 Pre-MiFID II

Now we turn to the case where both buy-side research and sell-side research are not contractible. This is the case pre-MiFID II.

As the investor can't observe precisely the amount of research that her manager uses, the contract is only contingent on outcomes. The investor solves a similar problem as in the previous case but with fewer tools. More precisely, she faces the following problem,

$$\max_{W_{ij}} \sum_{i,j\in\{G,B\}} p_i(\tau_m,\tau_a)\pi_j(\tau_a)(r_{ij}-W_{ij}) \tag{10}$$

such that the manager chooses both effort and sell-side research to maximizes his utility. Participation and limited liability constraints are similar.

$$(\tau_m,\tau_a) \in \underset{\tau_m',\tau_a'}{argmax} \sum_{i,j\in\{G,B\}} p_i(\tau_m',\tau_a')\pi_j(\tau_a')W_{ij} - C_m(\tau_m')$$

$$\sum_{i,j\in\{G,B\}} p_i(\tau_m,\tau_a)\pi_j(\tau_a)W_{ij} - C_m(\tau_m) \geq 0$$

$$W_{ij} \geq 0, \quad i,j\in\{G,B\}$$

We assume the first-order approach is applicable. Then the manager chooses τ_m and τ_a such that (6) and the following equation hold,

$$p_G(\tau_m,\tau_a)(W_{GG}-W_{GB}) + p_B(\tau_m,\tau_a)(W_{BG}-W_{BB}) = \frac{C_m'(\tau_m)}{C_a'(\tau_a)} \tag{11}$$

where we already used (6) to simplify the result. As (6) implies that only the wedge between expected compensation after good return and bad return matters for the choice of τ_m, (11) implies that only the wedge between expected compensation after low execution fee, $p_G(\tau_m,\tau_a)W_{GG} + p_B(\tau_m,\tau_a)W_{BG}$, and high execution fee, $p_G(\tau_m,\tau_a)W_{GB} + p_B(\tau_m,\tau_a)W_{BB}$, affects the choice of τ_a.

A reasonable guess of the optimal contract is that the investor sets $W_{BG} = W_{BB} = 0$ and uses the expected compensation after good return $\pi_G W_{GG} + \pi_B W_{GB}$ to induce the manager's effort, while using the difference between W_{GG} (low execution fee) and W_{GB} (high execution fee) to control the usage of research. Indeed, as long as $W_{GB} > 0$, the investor can incentivize the manager to purchase less sell-side research without affecting his effort τ_m by moving some payment of W_{GB} to W_{GG}. Therefore, for a given τ_m, such contract with $W_{GB} = 0$ induces the minimum τ_a.

At this edge case, the manager receives payment only after a good return and low execution fee. When choosing the amount of sell-side research, he maximizes $p_G(\tau_m, \tau_a)\pi_G(\tau_a)W_{GG} - C_m(\tau_m)$. Its first order derivative with respect to τ_a is

$$(\frac{1}{2} - C_a(\tau_a) - (\frac{1}{2} + \tau_m + \tau_a)C'_a(\tau_a))W_{GG} \equiv Q(\tau_m, \tau_a)W_{GG} \tag{12}$$

which is the marginal value of research to the manager. To satisfy the manager's incentive compatibility constraint with respect to τ_a, the marginal probability $Q(\tau_m, \tau_a)$ has to be zero. However, the solution of $Q(\tau_m, \tau_a) = 0$ is not necessarily the pair of (τ_m^o, τ_a^o) that is associated with the solution to the investor's optimization problem (the superscript "o" refers to the old situation pre-MIFID II). If the optimal solution is such that $Q(\tau_m^o, \tau_a^o) > 0$, then the proposed contract is not optimal.

Starting from this edge contract, the investor can then increase W_{GG} further. With a larger W_{GG}, the manager chooses a larger τ_m, decreasing $Q(\tau_m, \tau_a)$. With a large enough W_{GG}, $Q(\tau_m, \tau_a) = 0$, can be restored. The cost is that the manager receives a higher compensation for reasons unrelated to his effort.

An alternative option is to increase W_{BG} above zero, which increases the expected compensation after a low transaction fee, resulting in a smaller τ_a in equilibrium. Unfortunately, this option also increases the manager's expected compensation after a low return, increasing the manager's temptation to shirk.

The investor balances the two costs and combines the two options together in the optimal contract, which is characterized below.

Proposition 2 (Optimal contract with non-contractible τ_a)**.** *When τ_a is not observable, the optimal contract is given by the following,*

(i) If $Q(\tau_m^n, \tau_a^n) \leq 0$, where (τ_m^n, τ_a^n) is the solution to (8) and (9), then the investor sets $W_{GG} = C'_m(\tau_m^n)(1 + \frac{\frac{1}{2} + C_a(\tau_a^n)}{(\frac{1}{2} + \tau_m^n + \tau_a^n)C'_a(\tau_a^n)})$, $W_{GB} = C'_m(\tau_m^n)(1 - \frac{\frac{1}{2} + C_a(\tau_a^n)}{(\frac{1}{2} + \tau_m^n + \tau_a^n)C'_a(\tau_a^n)})$ and $W_{BG} = W_{BB} = 0$.

(ii) If $Q(\tau_m^n, \tau_a^n) > 0$, then the investor sets $W_{GG} = C_m' + \left(W_{BG} - \frac{C_m'}{C_a'}\right)\frac{\pi_G}{p_G}$, $W_{BG} = C_m'\left(\frac{1}{C_a'} - \frac{p_G}{\pi_G}\right)$ and $W_{GB} = W_{BB} = 0$. (τ_m^o, τ_a^o) is determined by

$$\Delta R - C_m'(\tau_m^o) - (\frac{1}{2} + \tau_m^o + \tau_a^o)C_m''(\tau_m^o) + g(\tau_m^o, \tau_a^o) = 0 \tag{13}$$

$$\Delta R - C_a'(\tau_a^o)f - C_m'(\tau_m^o) + h(\tau_m^o, \tau_a^o) = 0 \tag{14}$$

where $g(\tau_m, \tau_a) = C_m'(\tau_m) + p_G(\tau_m, \tau_a) C_m''(\tau_m) - \frac{\pi_G(\tau_a)}{C_a'(\tau_a)} C_m^{(2)}(\tau_m)$,
$h(\tau_m, \tau_a) = C_m'(\tau_m)\left[2 + \frac{\pi_G(\tau_a)}{(C_a'(\tau_a))^2} C_a''(\tau_a)\right]$ *and* $Q(\tau_m, \tau_a) = \pi_G(\tau_a) - p_G(\tau_m, \tau_a) C_a'(\tau_a)$

The superscript "o" refers to the old situation pre-MIFID II. Now we are ready to make a comparison between the pre-MiFID II case and the post-MiFID II case.

6 Comparison

The next result follows directly from proposition 1 and proposition 2.

Corollary 2. *Making sell-side research transparent induces changes if and only if $Q(\tau_m^n, \tau_a^n) > 0$.*

MiFID II is more likely to have an impact when the investor prefers less sell-side research τ_a if she could choose while the manager prefers more research, i.e., the marginal value of research is positive to the manager. This is exactly the case when $Q(\tau_m^n, \tau_a^n) > 0$. Recall that $Q(\tau_m, \tau_a) = \frac{1}{2} - C_a(\tau_a) - (\frac{1}{2} + \tau_m + \tau_a)C_a'(\tau_a)$, it is more likely to be positive when the cost of research is not very high. We will only focus on the interesting case where $Q(\tau_m^n, \tau_a^n) > 0$ throughout the rest of this paper.

Comparing (13) and (14) with (8) and (9), we can see that the asymmetric information about τ_a affects the equilibrium choice of τ_m and τ_a, different from the no moral hazard benchmark case.

Proposition 3 (Impact on information acquisition). *(i) If $C_m^{(3)}(\tau_m) \geq 0$, $\tau_a^n < \tau_a^o$, i.e., transparency decreases the usage of sell-side research. In addition, $\Delta\tau = (\tau_m^n + \tau_a^n) - (\tau_m^o + \tau_a^o) < 0$. The manager is less informed after the MiFID II.*
(ii) If $\forall \tau_a, \tau_m, C_a''(\tau_a)f \leq C_m''(\tau_m)$, then $\tau_m^n > \tau_m^o$ buy-side increases their research activities.

Recall that pre-MiFID II, the investor has to weigh a high cost due to more compensation for effort-independent reasons against a high cost due to higher temptation for the manager to shirk. MiFID II enables investor to directly contract on research τ_a and thus frees the investor from such trade off. As a result, the investor can choose a lower level of sell-side research without paying higher compensation to the manager.

The condition that $\forall \tau_a, \tau_m, C_a''(\tau_a) f \leq C_m''(\tau_m)$ roughly means that information from sell-side analysts is less expensive than internal research. This may be due to the fact that sell-side analysts can exploit the economy of scale while buy-side analysts cannot. Sell-side analysts are able to sell their information to multiple investors at very low marginal cost once the information is produced. Competition among them depresses the price they charge close to the average cost, which is usually smaller than the cost of information production, as in Veldkamp (2006). For the rest of the paper, we maintain this assumption.

Assumption 2. $C_m^{(3)} \geq 0$ *and* $\forall \tau_a, \tau_m, C_a''(\tau_a) f \leq C_m''(\tau_m)$.

Pre-MiFID II, the manager receives positive compensation if trading commissions are low even if return is also low, which makes it more costly to incentivize effort. Smaller cost of inducing effort thus leads to more buy-side research after MiFID II. In addition, it turns out that the increase of buy-side research does not fully compensate the decrease of sell-side information. Thus the manager is less informed after MiFID II.

Since $\tau_m^n < \tau_m^*$, we can conclude that buy-side research is also insufficient when τ_a is not contractible. Unfortunately it is not easy to compare τ_a^o with τ_a^*. Although we are not able to prove that the usage of sell-side research was excessive pre-MiFID II, our model shows that the agency problem can be one of the reasons why this can be the case.

In this setting, the investor always benefits from MiFID II. It is more difficult to draw conclusions on utilitarian welfare of the investor and manager pair. We compute its change below.

$$\begin{aligned}
\Delta U_c &= (U_i^n + U_m^n) - (U_i^o + U_m^o) \\
&= \underbrace{\Delta R \Delta \tau}_{\text{change in raw return}} - \underbrace{(C_m(\tau_m^n) + C_a(\tau_a^n) f - C_m(\tau_m^o) - C_a(\tau_a^o) f)}_{\text{change in total cost}} \qquad (15)
\end{aligned}$$

where U_c is utilitarian utility from contracting, U_i is the investor's utility. Proposition 3 shows $\Delta\tau < 0$. However, total cost is also smaller.

Proposition 4. $(C_m(\tau_m^n) + C_a(\tau_a^n)f - C_m(\tau_m^o) - C_a(\tau_a^o)f) < 0$. *MiFID II saves total costs for investors.*

Therefore, it is difficult to draw a conclusion on utilitarian welfare. The reduction of total cost comes from both that part of sell-side research is substituted by buy-side research, which is more efficient and less information is acquired.

To get more testable implications, we assume quadratic cost functions for the buy-side and sell-side research. Specifically,

Corollary 3. *If* $C_m(\tau_m) = \frac{1}{2}K_m\tau_m^2$, $C_a(\tau_a)f = \frac{1}{2}K_a\tau_a^2$, *then* $\frac{\partial\Delta\tau_a}{\partial\Delta R} > 0$, *where* $\Delta\tau_a = \tau_a^n - \tau_a^o$

This results implies that the decrease in the usage of sell-side research is smaller if the asset is more risky or its related information has higher fundamental value. As small stocks are usually more risky, we expect that managers cut their demand of sell-side research more for large stocks.

Changes in asset managers' information is likely to affect market liquidity. In addition, such changes may in turn affect their trading return, leading to another impact on investors' welfare. In the following, we consider an extension of our model and attempt to analyze the impact of MiFID II on liquidity and investors' welfare. Empirical implications and more discussions come afterwards.

7 Extension: endogenous trading

To explore market-wide impacts, we enrich our contracting model with a trading stage, which is adapted from Biais et al. (2015).

There is one measure of homogeneous investor-manager pairs, one measure of liquidity traders and competitive and uninformed market makers. The managers are hired to trade a risky asset that pays v or $-v$ with equal probability. They receive a signal θ with precision $P(\tilde{v} = v|\theta = v) = P(\tilde{v} = -v|\theta = -v) = \frac{1}{2} + \tau_m + \tau_a$, where τ_m and τ_a have the same interpretation as in our baseline model. The liquidity traders have private valuation over the asset $\tilde{\delta} \sim G[-\bar{\delta}, \bar{\delta}]$, $\bar{\delta} > v$, with the density function g_δ is symmetric around 0. The market makers set the bid and ask prices so that they make zero profits on average.

Timeline. — The game unfolds as follows.

1. Contracts are signed and publicly announced.
2. Managers make information choices τ_m and τ_a and receive their private signals
3. Market makers posts bid-and-ask prices.
4. All traders submit their order.
5. The asset pays off and contracts are settled.

We look for symmetric equilibria. A proper definition of equilibrium is given in appendix. As investor-manager pairs are competitive, they take market liquidity condition as given and do not take the impact of their contracting choice into account. The following result shows that investors face a similar problem as in our baseline model.

Lemma 1. *There is a symmetric equilibrium with $R_G = v - s^*$ and $R_B = -v - s^*$, where s^* is the minimum solution to the following equation,*

$$s^* = \frac{2\tau v}{1 + 2(1 - G(s^*))} \tag{16}$$

$\tau = \tau_m + \tau_a$ and (τ_m, τ_a) is determined by (13) and (14) or (8) and (9), depending on whether τ_a is contractible.

s^* $(-s^*)$ is the equilibrium ask (bid) price quoted by market makers, which is also the half spread. It is determined by zero-profit condition and the fact that in equilibrium a market maker cannot profitably undercut others.

Note that investors' utility is decreasing in s^*

$$E[U_i] = -s^* + 2\tau v - E[W] - C_a(\tau_a)f$$

where $E[W]$ is the expected compensation to managers. Indeed, when s^* becomes smaller, liquidity improves and managers get both a higher return (R_G) when trading in the right direction and a smaller loss (larger R_B) after a wrong trade. As $\Delta R = 2v$ is unaffected by s^*, competitive investor-manager pairs choose their contracts as in our baseline model. Collectively, change in their contract choices triggers change in market liquidity, which in turn affects the total revenue. This highlights an equilibrium effect on investors' utility.

Using a similar argument as in Biais et al. (2015), it is not difficult to show that $\frac{\partial s}{\partial \tau}|_{s=s^*} > 0$. Intuitively, when there is less adverse selection as managers are less informed, market liquidity improves.

Proposition 5 (liquidity). $\frac{\partial s}{\partial \tau}|_{s=s^*} > 0$. *Thus MiFID II increases market liquidity but price is less informative.*

This implies that the unbundling rule decreases s^*, investors' welfare are further increased because of the equilibrium effect. As s^* moves further from the true value of the asset, price is less informative.

A central question about the regulation change is whether it benefits investors as regulators expected. Our extended model provides a clear positive answer. As the investors, uninformed liquidity traders also benefit from this reform. Indeed, their expected utility is

$$\begin{aligned}
U_u = &\int_{s^*}^{\bar{\delta}} [\frac{1}{2}(\delta + v - s^*) + (\frac{1}{2}(\delta - v - s^*)]dG(\delta) \\
&+ \int_{-\bar{\delta}}^{-s^*} [\frac{1}{2}(-\delta - v + s^*) + (\frac{1}{2}(-\delta + v - s^*)]dG(\delta) \\
=&2\int_{s^*}^{\bar{\delta}} (\delta - s^*)dG(\delta)
\end{aligned} \tag{17}$$

which is also decreasing in s^*.

Although the change in utility of investor-manager pair ΔU_c is difficult to pin down, as shown in (15), we can still draw the following conclusion on utilitarian welfare.

Proposition 6. *Under Assumption 1 and 2, MiFID II increases utilitarian welfare.*

This is true simply because trading is a zero-sum game. The managers' raw returns become smaller but this is fully compensated by better trading results of uninformed liquidity traders. In addition, total spending on information acquisition becomes smaller, which improves social welfare.

In our model, we didn't take into account the role of public information dissemination of analysts by, e.g., issuing recommendations or post their reports publicly. The public information they provide may affect the decision of some traders, especially the less informed ones. However, as long as the information that is sold to asset managers has much better quality than the public signal, our model seems to be a good approximation of reality.

8 Empirical implications

Our results so far have a number of empirical implications.

Proposition 3 states that managers are less informed after MiFID II. This implies that the raw performance of the fund should be lower. However, the net return after management fees should be higher as investors benefit from the reform. This implies that investors pay lower total costs as in Corollary 4.

Implication 1. *Asset managers' return before management fees are lower after MiFID II but net returns are higher. Investors pay a lower total cost.*

To make a fair comparison, the econometrician should take into account that investors' costs consist of not only management fees but also trading commissions. Therefore, transaction costs and payment for sell-side research must be added back to get total costs.

As the demand for sell-side research decreases, the supply of sell-side research must also fall when the market clears. We expect that the number of active sell-side analysts is be smaller. Consequently, analyst coverage is also likely to shrink.

Implication 2. *The number of sell-side analysts and analyst coverage falls after MiFID II.*

This implication is in line with Fang et al. (2019) and Guo and Mota (2019). Since we assumed the sell-side research industry to be competitive, we can't directly discuss how the unbundling rule affects different analysts that cover the same stock. However, it is intuitive that when demand falls, analysts with lower quality information are more likely to lose their market share.

Such decrease is smaller if the fundamental value of information is higher as shown in Corollary 3. In general, small stocks are more volatile. Information on their payoff has larger fundamental value. Thus we expect that more analysts drop coverage for large stocks rather than for small stocks.

Implication 3. *Decrease in analyst coverage is larger for large stocks.*

This implication is contrary to the concern of many practitioners and regulators that small stocks may suffer more, but consistent with Guo and Mota (2019). Fang et al. (2019) found a different result. However, their results – based on proportional drop – is not a direct mapping of our results.

Another main result of our model is that the unbundling rule makes it cheaper for investors to incentivize buy-side research. More buy-side research may be interpreted as more buy-side analysts working inside asset management companies or more research activities from them, e.g., attending more earning conferences, as found by Fang et al. (2019).

Implication 4. *The number of buy-side analysts increases and they conduct more research activities after the unbundling rule.*

In our extended set-up, equilibrium bid-and-ask spread decreases as managers are less informed. Moreover, spreads of smaller stocks decrease more than large stocks. This offers us another testable implication.

Implication 5. *Market liquidity measured by bid-and-ask spread improves.*

9 Policy implications and concluding remarks

Our model indicates that the unbundling rule required by MiFID II is beneficial to investors and increases social welfare. This suggests that regulators outside the EU should also consider following suit and adopt a similar regulation. However, several limitations of our model call for more consideration before we can be fully assured.

Our model suggests that sell-side research industry is likely to see a shrink after MiFID II. It may also be important to take into account other effects of equity research in the welfare evaluation, such as impacts on stock prices (see, e.g., Jegadeesh et al. 2004; Loh and Stulz 2010), corporate monitoring (see, e.g., Moyer et al. 1989 and Chung and Jo 1996) and firms' real decisions (e.g., Derrien and Kecskés 2013). But this is beyond the scope of this paper and is left for future research.

Price informativeness may be another important factor in assessing whether a regulation like MiFID II is desirable, as price efficiency affects investment (see, e.g., Dow and Gorton 1997) and firms' cost of capital (Easley and O'hara (2004)). Our model indicates that price efficiency might be lower after the regulation. Therefore the regulator also faces a trade-off. Whether the benefit of investors protection outweighs the negative effect of higher cost of capital requires more research. Nevertheless, we speculate that firms that suffer from the negative effect can respond by disclose more information either directly or through firm-sponsored research.

A natural question about this reform is why such transparency is not voluntarily implemented before MiFID II. Apparently, if such transparency is a Pareto improvement, we expect that it should have been implemented before regulators stepped in. Our model indicates why managers may not benefit from MiFID II. Smaller amount of sell-side research decreases their chance of generating good performance, which lowers their fee income. Investors are willing to pay for more buy-side research but they pay less per precision of information. If buy-side research doesn't increase enough, managers are likely to see their profits drop. Thus our model also gives a rationale why some asset managers pushed against this unbundling rule.

Our model takes the organization of financial markets as given (e.g., payment for trading execution and research was bundled). However, it is interesting and important to understand the forces that shape such organization and how asymmetric information plays a role. This is also left for future research.

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A Proofs

A.1 Proof of Proposition 1

The contract post MiFId II could be given as (τ_m^n, τ_a^n, W), where $W : \{G, B\}^2 \times \left[0, \frac{1}{2}\right] \to \mathbb{R}^+$. Here as the MiFId II requires disclosure of the purchased level of external research and therefore the compensation W depends not only on the realized revenue but also the external research level chosen by the fund manager. To incentivize the fund manager to choose a specific level of external research τ_n^a, the monetary transfer $W(i, j, \tau_a') \equiv 0$ for any $\tau_a' \neq \tau_a^n$ and $(i, j) \in G, B^2$. As a result we abbreviate W_{ij} for $W(i, j, \tau_n^a)$. Moreover the incentive compatibility constraint for the private research level is given as follows

$$\tau_m^n \in \arg\max_{\tau_m} \sum_{i,j \in \{G,B\}} p_i(\tau_m, \tau_a^n) \pi_j(\tau_a^n) W_{ij} - C_m(\tau_m) \tag{18}$$

And therefore the first order constraint is given by

$$\pi_G(\tau_a^n) \left(W_{GG} - W_{BG}\right) + \pi_B(\tau_a^n) \left(W_{GB} - W_{BB}\right) = C_m'(\tau_m) \tag{19}$$

We assume that the second order condition always holds and therefore Equation (19) is equivalent to Equation (18). Moreover due to limited liability and the fund manager could always exert no private effort, therefore Equation (19) also implies participation constraint. Moreover since it is the wedge between W_{GG} and W_{BG}, the wedge between W_{GB} and W_{BB} determines the incentive constraint for exerting private effort and therefore one is supposed to set $W_{BG} = W_{BB} = 0$. As a result the principal's profit then boils down to

$$R_B + p_G \Delta R - \pi_B f - p_G \left(\pi_G W_{GG} + \pi_B W_{GB}\right). \tag{20}$$

Introduce Equation (19) into Equation (20), one then have that the principal set (τ_m^n, τ_a^n) to solve the following optimization equation

$$(\tau_m^n, \tau_a^n) \in argmax_{(\tau_m, \tau_a)} R_B + p_G(\tau_m, \tau_a)\Delta R - \pi_B(\tau_a) f - C_m(\tau_m) - \underbrace{\left(p_G(\tau_m, \tau_a) C_m'(\tau_m) - C_m(\tau_m)\right)}_{\text{Agency Rent due to IC}} {}^{4}.$$

First order conditions are given as follows

$$\begin{cases} \Delta R - C_m'(\tau_m^n) - p_G(\tau_m^n, \tau_a^n) C_m''(\tau_m^n) = 0 \\ \Delta R - C_a'(\tau_a^n) f - C_m'(\tau_m^n) = 0 \end{cases}$$

A.2 Proof of Proposition 2

The contract prior MiFID II is given as (τ_m^o, τ_a^o, W), where $W : \{G, B\}^2 \to \mathbb{R}^+$. The incentive compatibility constraint then requires that

$$(\tau_m, \tau_a) \in \arg\max_{(\tau_m', \tau_a')} \sum_{i,j \in \{G,B\}} p_i(\tau_m', \tau_a') \pi_j(\tau_a') W_{ij} - C_m(\tau_m').$$

Again we assume that the second order condition holds and therefore one could replace the incentive compatibility constraint above by its first order conditions. The first order conditions on private effort τ_m is given by Equation (19) while the first order condition on external research level τ_a is given by

$$\begin{aligned} &\pi_G(\tau_a) W_{GG} + \pi_B(\tau_a) W_{GB} - \pi_G(\tau_a) W_{BG} - \pi_B(\tau_a) W_{BB} \\ &- C_a'(\tau_a) \left(p_G \left(W_{GG} - W_{GB}\right) + p_B \left(W_{GB} - W_{BB}\right)\right) = 0 \end{aligned} \tag{21}$$

Combine Equation (19) and (21), one could then reformulate the set of first order conditions on external research level as

$$p_G(\tau_m, \tau_a)(W_{GG} - W_{GB}) + p_B(\tau_m, \tau_a)(W_{BG} - W_{BB}) = \frac{C_{m'}(\tau_m)}{C_{a'}(\tau_a)}. \tag{22}$$

[4] Since W_{GG} and W_{GB} are perfect substitutes, the limited liability constraint is already contained in Equation (19)

At first we argue that at optimum, the principal is supposed to set $W_{BB} = 0$. Otherwise the principal could decrease W_{BB} and still meet the first order condition by decreasing W_{GG} and W_{BG} or W_{GG} and W_{GB}. Moreover combine Equation (19) and (22), one then have that $W_{GG} = C'_m + \left(W_{BG} - \frac{C'_m}{C'_a}\right)\frac{\pi_G}{p_G}$. Limited liability then requires that

$$W_{BG} \geqslant \max\left\{0, C'_m\left(\frac{1}{C'_a} - \frac{p_G}{\pi_G}\right)\right\}$$

Again introduce Equation (19) into the objective function, the objective function then boils down as

$$R + p_G\Delta R - \pi_B f - p_G\left(C'_m + \pi_G W_{BG}\right) - p_B\pi_G W_{BG}$$

As a result if $\frac{1}{C'_a} - \frac{p_G}{\pi_G} \leqslant 0$, the principal is supposed to set $W_{BG} = 0$ and therefore the optimization problem further boils down as follows

$$(\tau_m^o, \tau_a^o) \in \arg\max_{(\tau_m,\tau_a)} R + p_G\Delta R - \pi_B f - p_G C'_m,$$

which is the same as the case post MiFID II. But if $\frac{1}{C'_a} - \frac{p_G}{\pi_G} > 0$, then at optimum, the principal is supposed to set $W_{BG} = C'_m\left(\frac{1}{C'_a} - \frac{p_G}{\pi_G}\right)$ and therefore the optimization problem boils down as

$$(\tau_m^o, \tau_a^o) \in \arg\max_{(\tau_m,\tau_a)} R + p_G\Delta R - \pi_B f - C_m - \underbrace{(p_G C'_m - C_m)}_{\text{Agency Rent due to IC}} \underbrace{- \pi_G(p_G + p_B)C'_m\left(\frac{1}{C'_a} - \frac{p_G}{\pi_G}\right)}_{\text{Agency Rent due to Limited Liability}}$$

Henceforth the first order conditions are given as

$$\Delta R - C_m^{(1)} - p_G C_m^{(2)} + \left[C_m^{(1)} + p_G C_m^{(2)} - \frac{\pi_G}{C_a^{(1)}} C_m^{(2)}\right] = 0 \tag{23}$$

$$\Delta R - C_a^{(1)} f - C_m^{(1)} + C_m^{(1)}\left[2 + \frac{\pi_G}{(C_a^{(1)})^2} C_a^{(2)}\right] = 0 \tag{24}$$

A.3 Proof of Proposition 3

As we have shown that if $\frac{1}{C_a'} - \frac{p_G}{\pi_G} \leqslant 0$, $(\tau_m^o, \tau_a^o) = (\tau_m^n, \tau_a^n)$. We then focus on the case in which $\frac{1}{C_a'} - \frac{p_G}{\pi_G} > 0$. Denote

$$\begin{cases} g(\tau_m, \tau_a) = C_m^{(1)}(\tau_m) + p_G(\tau_m, \tau_a) C_m^{(2)}(\tau_m) - \dfrac{\pi_G(\tau_a)}{C_a^{(1)}(\tau_a)} C_m^{(2)}(\tau_m) \\ h(\tau_m, \tau_a) = C_m^{(1)}(\tau_m) \left[2 + \dfrac{\pi_G(\tau_a)}{(C_a^{(1)}(\tau_a))^2} C_a^{(2)}(\tau_a) \right] \end{cases}$$

As a result, (τ_m^o, τ_a^o) solve the following equation

$$\Delta R - C_m^{(1)}(\tau_m^o) - p_G(\tau_m^o, \tau_a^o) C_m^{(2)}(\tau_m^o) + g(\tau_m^o, \tau_a^o) = 0 \tag{25}$$

$$\Delta R - C_a^{(1)}(\tau_a^o) f - C_m^{(1)}(\tau_m^o) + h(\tau_m^o, \tau_a^o) = 0 \tag{26}$$

Moreover define $(\tau_m^\alpha, \tau_a^\alpha)$ as the solution to the following equation

$$\begin{cases} \Delta R - C_m^{(1)}(\tau_m) - p_G(\tau_m, \tau_a) C_m^{(2)}(\tau_m) + \alpha g(\tau_m^o, \tau_a^o) = 0 \\ \Delta R - C_a^{(1)}(\tau_a) f - C_m^{(1)}(\tau_m) + \alpha h(\tau_m^o, \tau_a^o) = 0 \end{cases}$$

By the implicit function theorem, one then have that

$$\begin{aligned} \begin{bmatrix} \dfrac{d\tau_m^\alpha}{d\alpha} \\ \dfrac{d\tau_a^\alpha}{d\alpha} \end{bmatrix} &= - \begin{bmatrix} -C_m^{(3)} p_G - 2C_m^{(2)} & -C_m^{(2)} \\ -C_m^{(2)} & -C_a^{(2)} f \end{bmatrix}^{-1} \begin{bmatrix} g(\tau_m^o, \tau_a^o) \\ h(\tau_m^o, \tau_a^o) \end{bmatrix} \\ &= -\frac{1}{\det(\cdot)} \begin{bmatrix} -C_a^{(2)} f & C_m^{(2)} \\ C_m^{(2)} & -C_m^{(3)} p_G - 2C_m^{(2)} \end{bmatrix} \begin{bmatrix} g(\tau_m^o, \tau_a^o) \\ h(\tau_m^o, \tau_a^o) \end{bmatrix} \\ &= \frac{1}{\det(\cdot)} \begin{bmatrix} C_a^{(2)} f g(\tau_m^o, \tau_a^o) - C_m^{(2)} h(\tau_m^o, \tau_a^o) \\ -C_m^{(2)} g(\tau_m^o, \tau_a^o) + C_m^{(3)} p_G h(\tau_m^o, \tau_a^o) + 2C_m^{(2)} h(\tau_m^o, \tau_a^o) \end{bmatrix} \end{aligned}$$

Since we assume that the objective function after MiFID II is concave with respect to (τ_a, τ_m), the determinant of the Hessian matrix is thus negative. We then argue that $h(\tau_m^o, \tau_a^o) > g(\tau_m^o, \tau_a^o)$.

Combining equation (25) and (26), one then have that

$$h - g = C_a^{(1)}(\tau_a^o) f - p_G(\tau_m^o, \tau_a^o) C_m^{(2)}(\tau_m^o) > C_a^{(1)}(\tau_a^o) f - \frac{\pi_G(\tau_a^o)}{C_a^{(1)}(\tau_a^o)} C_m^{(2)}(\tau_m^o)$$
$$= C_a^{(1)}(\tau_a^o) f - \Delta R = C_m^{(1)}(\tau_m^o) + C_m^{(1)}(\tau_m^o) C_a^{(2)}(\tau_a^o) \frac{\pi_G(\tau_a^o)}{(C_a^{(1)}(\tau_a^o))^2} > 0$$

The first inequality follows from the assumption that $\frac{1}{C_a'} - \frac{p_G}{\pi_G} > 0$. The second equality follows from Equation (23). The third equality follows from Equation(24). If $\forall \tau_a, \tau_m, C_a''(\tau_a) f \leq C_m''(\tau_m)$, we then have that

$$\begin{cases} \frac{d\tau_m^\alpha}{d\alpha} > 0 \\ \frac{d\tau_a^\alpha}{d\alpha} < 0 \\ \frac{d\tau_m^\alpha}{d\alpha} + \frac{d\tau_a^\alpha}{d\alpha} = \frac{1}{\det(\cdot)} \left[C_a^{(2)} f g(\tau_m^o, \tau_a^o) + C_m^{(2)} (h(\tau_m^o, \tau_a^o) - g(\tau_m^o, \tau_a^o)) + C_m^{(3)} p_G h(\tau_m^o, \tau_a^o) \right] < 0 \end{cases}$$

A.4 Proof of Corollary 4

$$C_m(\tau_m^n) + C_a(\tau_a^n) f - C_m(\tau_m^o) - C_a(\tau_a^o) f = \int_{\tau_m^o}^{\tau_m^n} C_m'(\tau_m) d\tau_m + \int_{\tau_a^o}^{\tau_a^n} C_a'(\tau_a) f d\tau_a$$
$$< C_m'(\tau_m^n) \Delta\tau_m + C_a'(\tau_a^n) f \Delta\tau_a$$

The inequality follows from the convexity of C_m and C_a and that $\Delta\tau_m > 0, \Delta\tau_a < 0$

From (8) and (9), we have

$$C_a'(\tau_a^n) f = \Delta R - C_m'(\tau_m^n)$$
$$C_m'(\tau_m^n) = \Delta R - (\frac{1}{2} + \tau_m^n + \tau_a^n) C_m^{(2)}(\tau_m^n)$$

Thus,

$$\begin{aligned}
C_a'(\tau_a^n)f - C_m'(\tau_m^n) &= (\frac{1}{2} + \tau_m^n + \tau_a^n)C_m^{(2)}(\tau_m^n) - C_m'(\tau_m^n) \\
&= (\frac{1}{2} + \tau_m^n + \tau_a^n)C_m^{(2)}(\tau_m^n) - \int_0^{\tau_m^n} C_m^{(2)}(\tau_m)d\tau_m \\
&\geq (\frac{1}{2} + \tau_m^n + \tau_a^n)C_m^{(2)}(\tau_m^n) - C_m^{(2)}(\tau_m^n)\tau_m^n \\
&= (\frac{1}{2} + \tau_a^n)C_m^{(2)}(\tau_m^n) \\
&> 0
\end{aligned}$$

The first inequality follows from Assumption 2.

Since $\Delta\tau_a + \Delta\tau_m < 0$, it follows immediately that $C_m'(\tau_m^n)\Delta\tau_m + C_a'(\tau_a^n)f\Delta\tau_a < 0$. Therefore $C_m(\tau_m^n) + C_a(\tau_a^n)f - C_m(\tau_m^o) - C_a(\tau_a^o)f < 0$.

A.5 Proof of Corollary 3

Under the assumption that $C_m(\tau_m) = \frac{1}{2}K_m\tau_m^2$ and $C_a(\tau_a)f = \frac{1}{2}K_a\tau_a^2$, equation (13) becomes

$$\Delta R - K_m(\frac{f}{2K_a\tau_a^o} - \tau_a^o) = 0$$

which implies that $\frac{\partial\tau_a^o}{\partial\Delta R} < 0$.

From the proof of Proposition 3, we know that

$$\frac{d\tau_a^\alpha}{d\alpha} = \frac{1}{det(\cdot)}C_m^{(2)}(2h(\tau_m^o, \tau_a^o) - g(\tau_m^o, \tau_a^o))$$

where $det(\cdot)$ is a constant in this case. Recall from equation (25) and (26) that

$$\begin{aligned}
2h - g &= 2(C_a^{(1)}(\tau_a^o)f + C_m^{(1)}(\tau_m^o) - \Delta R) - (C_m^{(1)}(\tau_m^o) + P_G C_m^{(2)}(\tau_m^o) - \Delta R) \\
&= K_a\tau_a^o - \frac{1}{2}K_m - \Delta R
\end{aligned}$$

Thus $\frac{\partial(2h-g)}{\partial\Delta R} < 0$. Noting that $det(\cdot) < 0$, we have the following result

$$\frac{\partial\Delta\tau^a}{\partial\Delta R} = \int_0^1 \frac{\partial^2\tau_a}{\partial\alpha\partial\Delta R}d\alpha > 0$$

A.6 Proof of Lemma 1

As for the institutional investor, it will choose to purchase a stock upon receiving a positive signal. As a result, the mass of institutional investors bidding for the stock is given as $\frac{1}{2}p_G + \frac{1}{2}p_B$. Suppose that the bid price is given by s. For the liquidity trader, it will bid for the stock if its private value $\tilde{\delta} \geq s$. As a result, the mass of liquidity trader bid for the stock is given by $1 - G(s)$. The market maker sets the bid price such that its expected profit equals to zero. Henceforth we have that

$$\frac{\frac{1}{2}p_G}{\frac{1}{2}p_G + \frac{1}{2}p_B + (1 - G(s))}v + \frac{\frac{1}{2}p_B}{\frac{1}{2}p_G + \frac{1}{2}p_B + 1 - G(s)}(-v) = s$$

This equation have multiple solutions. The minimum, s^*, is selected, as it cannot be undercut.

A.7 Proof of Proposition 5

It follows directly from the Proposition 1 of Biais et al. (2015).

A.8 Proof of Proposition 6

Given a fixed level of aggregate research τ, the aggregate welfare is fixed at zero. However MiFID II decreases the total amount of research and therefore decreases such cost, which makes no contribution to the utilitarian welfare.