Sequential Entry in Illiquid Markets

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Abstract

I study the sequential entry of intermediaries into an illiquid market. As intermediaries trade with rational counterparts, market depth affects and is affected by the possibility of entry. This feedback loop between entry and depth gives incumbent intermediaries more incentives to deter entrants, creating endogenous barriers to entry. Further, whether entry occurs or not in equilibrium has distinct effects ex-ante: entry improves depth, reduces spreads, and speeds up price convergence; the threat of entry disciplines only spreads. In a contestable market, more competition leads to higher spreads ex-ante and intermediaries' counterparties benefit more from deterrence than actual entry.

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1 Introduction

Many financial markets are dominated by imperfectly competitive intermediaries.[1] How competition evolves in these oligopolistic markets has not received much attention in finance. However, this issue is relevant in practice. For instance, in the bond market a number of large dealers cut their market-making after the introduction of new regulations (e.g. Volcker rule).[2] Intermediaries' market power entails welfare losses and leads to delayed price adjustments, making it important to understand entry dynamics.[3]

In this paper, I consider a model of sequential entry in an imperfectly competitive, and thus imperfectly liquid, market. Unlike previous literature, I take into account that incumbent intermediaries may deter entry and study the effects of entry deterrence on market quality, expected returns, and welfare. In my setting, intermediaries trade over time with competitive, rational hedgers, who are aware of potential entry. For this reason, liquidity affects and is affected by potential entry: on the one hand, the cost of deterrence is determined by market depth, as incumbents need to trade more aggressively to reduce intermediation profits and deter entry; on the other hand, depth itself depends on the future degree of competition. For instance, when incumbents sell, hedgers ask for smaller price concessions (i.e. a lower price impact) if they understand that competition will push spreads down in the future.

I obtain three main results. First, I find that entry deterrence leads to an ex-ante improvement in some aspects of market quality (spreads, quantities), but not in depth. Instead, all aspects of market quality improve ex-ante when entry takes place in equilibrium. Second, I show that under entry deterrence the standard relationship between spreads and competition is reversed: spreads *increase* with the number of incumbents. Third, I show that

[1]For evidence of market power in financial markets, see e.g. Kryzanowski, Perrakis and Zhong (2020) for the CDS market, An and Song (2021) for the MBS market, Wallen (2020) for the FX market, Froot (2001) for the catastrophe reinsurance market, Christie and Schultz (1994) and Koijen and Mogo (2019) for the stock market, etc. For more general evidence of concentration in financial markets, see De Loecker et al. (2020).

[2]Academics and practitioners debated whether new players would step in, but did so without a formal model. For instance, Duffie (2012) discusses informally the entry of new players in bond market-making. See also Bao et al. (2018). For practitioners' view, see for instance "Goldman Sachs has a fix for fixed income trading", *Financial Times*, April 11, 2019, which emphasizes strategic aspects: "In the aftermath of the financial crisis, as most trading houses licked their wounds and put safety before sales, Goldman Sachs chose a different path. "You see Morgan Stanley cutting, European banks... who knows what they're doing? And you think: 'Let's go for it!' " recalls one former Goldman partner who worked in its trading division at the time, describing a 'deeply rooted' mission to 'capitalise on others' weakness' ".

[3]Regarding the effects of market power on price adjustment, see, e.g. Pritsker (2009), Rostek and Weretka (2015), Fardeau (2020). Duffie (2010) surveys evidence about slow price adjustments.

incumbents deter less when hedgers are not aware of the entry threats. In such case, depth no longer reflects future competition. Imperfect competition prevents hedgers from achieving perfect risk-sharing in the first place. However, when they are aware of potential entry, hedgers' reactions lead to less entry in equilibrium.

Model and equilibrium. The model has three dates, with two trading rounds ($t = 0, 1$) and final consumption ($t = 2$). The market includes one risk-free and one risky asset. The basic structure of trading is akin to that of models of financially-constrained arbitrage (e.g. Gromb and Vayanos, 2002). In each trading round, intermediaries share risk with two groups of risk-averse, competitive investors (hedgers) trading in segmented markets, A and B. Hedgers trade to hedge endowment shocks correlated with the payoff of the risky asset. For simplicity, I consider opposite hedging needs: hedgers in market A are overexposed to the risky asset, and are thus willing to short, while hedgers in market B are underexposed, and willing to buy in exactly the same magnitude.

The key differences with models of financially constrained arbitrage is that intermediaries are in finite number and face no financial constraints. As a result, intermediaries act strategically, internalizing their price impact in each market. My analysis focuses on sequential entry. A new intermediary can enter the market at time 1 by incurring a fixed entry cost. The fixed cost may include investments in trading infrastructure or in human capital to acquire the appropriate pricing and trading skills.[4]

Suppose first that there is no entry threat. If incumbents were competitive, they would simply buy from one group of hedgers and sell to the other group until the price of the risky asset is the same across markets. This would result in perfect integration of the two markets and perfect risk-sharing. But since intermediaries are imperfectly competitive, they integrate markets only partially and a spread between prices remains in both periods.

Consider now the effects of the entry threat, and suppose that fixed costs are not as prohibitive as to block entry. Entry lowers incumbents' payoffs. At time 0, they face a trade-off between deterring and accommodating entry. To deter, incumbents must trade more aggressively in the first round to decrease the profitability of entry. Indeed, the more risk hedgers have shared in the first round, the less desperate they are to trade in the next round, which reduces intermediation profits, and thus entry gains. Deterrence is costly, however, because intermediaries must depart from their preferred trading strategy. In equilibrium, intermediaries deter entry if the entry cost is large enough relative to hedgers' risk-bearing

[4] In a related context, Herrera and Schroth (2011) showed that expertise allows incumbents to capture larger underwriting fees in the investment banking industry. Alternatively, the fixed cost may represent the certainty equivalent of another trading opportunity.

capacity, and they accommodate entry otherwise.

Results. The first main result concerns the differential effects of actual and deterred entry on ex-ante market quality. Microstructure theories often predict that market quality variables co-move. Here, however, the deterrence and accommodate equilibrium strategies have distinct effects on market quality at time 0. In the accommodate equilibrium, depth improves, the amount of intermediation increases, spreads decrease, and expected returns to intermediaries decrease relative to the benchmark without entry. Instead, in the deterrence equilibrium, there is a reduction in spreads and an increase in intermediated quantities, but market depth and expected returns remain unchanged.

The intuition for these contrasted effects is as follows. Market depth is given by the slope of hedgers' demand: since intermediaries submit quantities (market orders), an extra share traded by an intermediary must be absorbed by the competitive hedgers. Hence, the slope of their demand determines intermediaries' price impact, i.e. market depth. When hedgers conjecture that the new intermediary will enter at time 1, their demand becomes more price-elastic at time 0, as hedgers understand that entry will improve their risk-sharing opportunities. They are thus less reluctant to holding risk today, leading to a deeper market. Since hedgers are rational, they correctly adjust their demand ahead of entry in equilibrium. Hence, depth improves ahead of entry when incumbents accommodate, but not when they deter.

Spreads and the amount of intermediation also improve when entry is accommodated, because of a preemptive behaviour. Since competition is about to increase, incumbents race to trade ahead of the entrant (but not as much as to deter entry), so that spreads decrease relative to the no-entry benchmark. When entry is deterred, providing more risk-sharing at time 0 to reduce time-1 intermediation profits is inherent to the deterrence strategy. As a consequence, spreads also decrease relative to the no-entry benchmark in the deterrence equilibrium.

The accommodate and deterrence equilibria can coexist and can thus be compared directly to each other: spreads are lower and the amount of intermediation higher in the deterrence equilibrium. As a result, hedgers are better off when the new intermediary does *not* enter at time 1, and vice-versa for incumbents. Hedgers are better off because deterrence spreeds up risk-sharing. Sharing risk early is particularly valuable for hedgers, as the asset is conditionally riskier ex-ante.[5] The improvement in hedgers' welfare may dominate, so that total welfare can be larger in the deterrence equilibrium. Overall, the model suggests that

[5]This feature is not *ad-hoc*: it ensures that hedgers' demand remains downward-sloping in the first trading round.

entry is not always a panacea.

The second main result is that strategic deterrence overturns standard comparative statics. In the benchmark without entry, or in the accommodate equilibrium, spreads decrease in competition. It is the opposite when incumbents deter. Intuitively, there is substitution between the initial degree of competition among incumbents and deterrence. If the market is more competitive at time 0, entry is less profitable for the entrant. Thus, incumbents must trade less aggressively to deter entry, and the spread decreases less.

The third main result is that incumbents deter less, leading to more entry, when hedgers are not aware of potential entry. To make the point, I compare my model to one in which hedgers are not aware of the entry threat. In this case, the second part of the feedback loop disappears: depth no longer depends on entry. This helps me stress two effects driven by hedgers' rationality. First, the fact that hedgers are aware of the entry threat reduces incumbents' profits in *both* periods. Intermediaries benefit from market thinness in the first place: it is the origin of their rents. Indeed if hedgers had a perfectly elastic demand, there would be no need for intermediation. Thus, as hedgers anticipate entry and become more price-elastic ex-ante, incumbents' rents decrease. Second, in a deeper market, the cost of deterrence also increases. Indeed, as the market deepens, incumbents willing to accommodate trade smaller quantities to keep spreads high and maintain profits. This increases the potential gains for the entrant, so an incumbent who deviates from the accommodate strategy must trade more aggressively to deter entry, which is costly. I show that the first effect dominates. Hence, incumbents deter more (i.e. on a larger parameter space) when hedgers are aware of the entry threat.

My results lead to new empirical predictions. The first result implies that an increase in depth predicts an increase in the number of intermediaries. It also offers a way to identify deterrence in the data. As emphasized in the empirical IO literature, deterrence is difficult to identify, because entry threats are not observed. Here, given the distinct effects of accommodate and deterrence on different liquidity metrics ex-ante, and the differential effects of deterrence across metrics, depth is the discriminating variable that can help identify entry deterrence. This result may provide an additional test for studies along the lines of Froot (2001), who focuses on the role of deterrence as a determinant of price adjustments in the catastrophe reinsurance market. The second result implies that conditional on deterrence, markets with a smaller number of incumbents have larger spreads. It also suggests that empiricists studying the unconditional relationship between spreads and competition should take into account the contestability of the market.[6] The third result implies that we should

[6]Contestability (Baumol, 1986) means that the threat of entry pushes equilibrium outcomes towards

observe less entry in more sophisticated markets. In the cross-section, hedgers in some markets may be more able to anticipate entry. For instance, institutional investors may be more sophisticated than individual and retail hedgers. All else equal, there should be less entry in markets with a larger fraction of institutional investors. The first two results should also be stronger in these markets.

Related literature. To the best of my knowledge, this is the first analysis of sequential entry and strategic deterrence in a capital market context. The analysis of industry dynamics has been the focus of the IO literature. Holden (1995), Zigrand (2006), Oehmke (2010) and Cimon and Gariott (2019) study the *ex-ante* entry decisions of arbitrageurs or dealers, but do not study *sequential* entry. Banerjee and Breon-Drish (2018) do not consider sequential entry either, but allow a strategic trader to become informed and enter the market after trading has started. Kryzanowski et al. (2020) consider the entry of either an infinitesimal agent or a strategic agent in a static financial oligopoly, but do not allow incumbents to deter entry. Their focus is on transaction costs and information asymmetry as barriers to entry, while I emphasize the role of market depth in entry deterrence and study welfare.[7]

In the IO literature, the closest model is that of Gilbert and Vives (1986), who also consider an established oligopoly facing a potential entrant. In their model, the market structure is determined in a two-stage game between incumbents and the entrant, but the good is produced and consumed only once after the market structure has been determined. Consumers are modeled as exogenously given demand curves. I add two key ingredients: trading dynamics and rational consumers (hedgers). Trading dynamics lead to new comparative statics between spreads and competition when entry is deterred at time 0. Combined with trading dynamics, hedgers' rationality generates a feedback loop between entry and depth. This effect leads to less entry than in models in which hedgers are unaware of potential entry, and

competitive ones in imperfectly competitive markets.

[7]Kyle (1989) studies competition in demand schedules between large informed and uninformed traders and considers the free entry of uninformed strategic traders. His focus is on price informativeness. I am not aware of any previous sequential entry analyses in models where traders compete in demand schedules. Kondor (2009) and Kondor and Zawadowski (2015) model entry as an increase in the mass of competitive arbitrageurs. Duffie and Strulovici (2012) provide a search-based model of the movement of capital across markets.

to differential effects of entry and deterred entry on market depth.[8] [9]

Models based on search frictions predict that more illiquid markets (with infrequent contact between traders) have slower price adjustments (Duffie, Gârleanu and Pedersen, 2005 and 2007, Duffie, 2010, Duffie and Strulovici, 2012). My model makes a similar prediction in the sense that faster price convergence is associated with higher depth. However, in the coexistence region (at least), faster convergence is also associated with larger spreads (in the accommodate equilibrium). Thus, my model delivers a more contrasted set of predictions, depending on the aspect of liquidity one considers, and ties these variables to entry. Further, all the liquidity metrics are endogenous, while search frictions are usually exogenous.

Bond, Goldstein, and Prescott (2010) show that the use of market data to take corrective actions, such as the use of stock prices in corporate governance decisions, is self-defeating in the sense that markets are forward-looking and they reflect the expected action.[10] There is also a self-defeating feedback loop in my model, because hedgers' demand for liquidity reflects the expected entry decision of the imitator. The model structures, however, are very different, since information is complete and cash-flows are exogenous in my setting. The feedback loop arises in my setting because the ex-ante profits of incumbents are endogenous to the possibility of future entry.

The remainder of this paper is organized as follows. In Section 2, I describe the model and the no-entry benchmark. I solve for the sequential entry equilibrium in Section 3. I derive the main implications of strategic deterrence in Section 4. In Section 5 I study the welfare effects of sequential entry. In Section 6, I contrast the results to those of a static model. Section 7 summarizes the empirical implications. Section 8 gives the conclusion. Proofs are provided in the Appendix and Online Appendix.

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[8] With two trading rounds, Coasian dynamics affect liquidity provision by intermediaries. Such dynamics are absent from Gilbert and Vives' model. By Coasian dynamics, I mean that the possibility of retrading erodes intermediaries' market power ex-ante. Another way to express the first result is that entry worsens Coasian dynamics for incumbents. The connection between durable good producers and large investors is also emphasized in Vayanos (1999), Kilhstrom (2000), and DeMarzo and Urosevic (2006), and Marinovic and Varas (2018), among others. In the Appendix, I consider dynamic models without full hedgers rationality, which removes Coasian dynamics.

[9] Spence (1977), Dixit (1980) and Bulow, and Geanakoplos and Klemperer (1985) study strategic deterrence in a model where incumbents can invest ex-ante in production capacity to signal their ability to retaliate to entry. In my setting, there is complete information, and thus no room for signalling. Vives (1988) considers pre-investment in capacity and multiple entrants.

[10] Bond, Edmans, and Goldstein (2012) survey the literature on asset pricing with feedback effects.

2 A model of oligopolistic intermediation

2.1 Set up

The model has three dates, $t = 0, 1, 2$, and two types of investors: hedgers and intermediaries. Investors trade in the first two rounds, and then consume. There is a risky asset and a risk-free asset. The risk-free asset is in perfectly elastic supply and has a return r that is normalized to 0. The risky asset is in zero net supply and pays off a liquidating dividend at time 2, $D_2 = D + \varepsilon_1 + \varepsilon_2$, where ε_t are iid normal variables with mean 0 and variance σ^2. The innovations ε_1 and ε_2 are realized at time 1 and time 2, respectively, and are publicly observed. I denote $D_t = \mathbb{E}_t\left(D_2\right)$ the conditional expected value of the dividend.

The risky asset trades in two segmented markets A and B (e.g. cash and spot markets). There is a continuum mass one of competitive hedgers in each market, which are aggregated into a representative agent. Hedgers have CARA utility over final consumption, i.e. $u(C_2^k) = -\exp(-aC_2^k)$, $k \in \{A, B\}$. They have no intial wealth and no endowment in the risky asset, but receive endowment shocks $s^k\varepsilon_t$ at time $t = 1, 2$. Because the shocks are correlated with the payoff of the risky asset, hedgers seek to share risk. Market segmentation prevents direct risk-sharing between the two groups of hedgers, so that the risky asset can have different prices across markets. One can think of these endowment shocks as a reduced form for capital losses triggered by other, correlated trades, prompting hedgers to rebalance their positions. Segmentation may result from institutional features, e.g. some investors may prefer or be forced to invest in the spot asset instead of the derivative (see Gromb and Vayanos (2010) for various examples). The endowment shocks affect the net supply of the asset in each market, thus I refer to s^k as the supply shock in market k.[11]

Intermediaries (e.g. dealers, hedge funds, reinsurers) are specialized investors with the unique ability to trade across markets. They may thus facilitate risk-sharing between the two groups of hedgers. There are intially $n \geq 1$ intermediaries (incumbents) who can take advantage of the price differences. I take the oligopolistic structure of intermediation among incumbents as given in the model. This structure may result from the previous exit of intermediaries due to losses, or from innovation (e.g. a new product, an arbitrage between newly designed securities, a new quantitative strategy, etc.).[12] A new intermediary may

[11] One may also think of groups A and B as arriving sequentially in each period t, as in Grossman and Miller (1988) or Brunnermeier and Pedersen (2009). In this case market A is the market for the risky asset at time $t_A < t_B$.

[12] For instance, losses caused by natural disasters lead to the exit of reinsurers in the catastrophe reinsurance market. Similarly, shocks to arbitrageurs' capital in convertible bond arbitrage and other fixed income strategies may drive arbitrageurs out of the market (Duffie, 2010, Mitchell et al., 2007). Many markets for

enter at time 1 upon sinking a fixed cost I. I describe the entry game further in Section 3.

Intermediaries have strictly increasing, continuous, and concave utility u^i, with $i = 1, ..., n$. For simplicity, I assume that hedgers have exactly symmetric exposure to the fundamental across markets: $s^A = -s^B = s$. Thus intermediaries can eliminate all aggregate risk by taking offsetting positions. In other words, intermediation is riskless and similar to a textbook arbitrage opportunity.[13]

Because they are finite in number, intermediaries are imperfectly competitive and recognize their price impact. Trading in the risky asset in each market occurs as follows. Hedgers and intermediaries enter period t with positions Y_{t-1}^k, $k \in \{A, B\}$, and $X_{t-1}^{i,k}$, $i = 1, \ldots, n$, respectively. When relevant, all investors learn the realization of the innovation ε_t before trading. Then, given the demand curves of hedgers and the market-clearing conditions, intermediaries compete à la Cournot and choose trades $x_t^{i,k}$. Hedgers' price-dependent demand schedules and intermediaries' trades are then aggregated and a market-clearing price is determined.[14]

2.2 Maximization problems (without entrant)

Hedgers. At time 2, hedgers consume their entire wealth, i.e. $C_2^k = W_2^k = Y_1^k D_2 + B_1^{y,k}$, for $k \in \{A, B\}$, where Y_1^k and $B_1^{y,k}$ denote positions in the risky and risk-free asset after trading at time 1. Let p_t^k denote the price of the risky asset in market k. Hedgers' positions in the risky assets evolve as $Y_t^k = Y_{t-1}^k + y_t^k$, where y_t^k is the trade of time t. The positions in the risk-free asset are given by $B_t^{y,k} = B_{t-1}^{y,k} - y_t^k p_t^k + s^k \varepsilon_t$, i.e. hedgers' risk-free asset holdings change due to trading in the risky asset or the endowment shock.[15] Hedgers thus solve the

derivatives or new financial products are also concentrated, because the banks who innovated have acquired a large market share early on. In the hedge fund industry, Siegmann et al. (2018) show that there exists a first-mover advantage: early entrants in a given strategy earn higher excess returns than followers, which is consistent with an oligopolistic structure.

[13] This assumption helps to isolate the effects of the main economic force of the model – that market depth is endogenous to the possibility of entry. This mechanism would remain even if endowment shocks were imperfectly correlated. In that case, however, intermedation would be risky. Thus, additional effects related to intermediaries' risk-bearing capacity would emerge, with intermediaries facing a trade-off between strategic intermediation and risk-sharing. The results of the paper would continue to hold qualitatively if intermediaires are sufficiently risk-tolerant.

[14] Cournot competition between intermediaries may be rationalized by Kreps-Scheinkman (1983) type of pre-commitment arguments applied to intermediaries, as in Kremer and Polkovnichenko (1999).

[15] Recall that the risk-free rate is nil. Since hedgers have CARA preferences, we can set their initial wealth to zero without loss of generality.

following problem:

$$\text{for } k \in \{A, B\}, \quad \max_{\left(Y_t^k\right)_{t=0,1}} \mathbb{E}\left[u\left(C_2^k\right)\right]$$
$$\text{s.t. } Y_t^k = Y_{t-1}^k + y_t^k$$
$$B_t^{y,k} = B_{t-1}^{y,k} - y_t^k p_t^k + s^k \varepsilon_t$$

This maximisation problem yields the following linear demand:

$$Y_t^k = \frac{\mathbb{E}_t(p_{t+1}^k) - p_t^k}{a\sigma^2} - s^k$$

Hedgers' demand is shifted up or down by the supply shock of market k, s^k.

Intermediaries. Since intermediaries can trade in both markets, their final wealth W_2^i is equal to:

$$W_2^i = B_1^i + \sum_{k \in \{A,B\}} X_1^{i,k} D_2, \; i = 1, \ldots, n \tag{1}$$

where B_1^i and $X_1^{i,k}$ denote final positions in the risk-free asset and the risky asset in market k, respectively. The law of motion for the intermediaries' positions $X_t^{i,k}$ is: $X_t^{i,k} = X_{t-1}^{i,k} + x_t^{i,k}$, where $x_t^{i,k}$ denotes the trade of intermediary i in market k at time t. The position in the risk-free asset evolves as: $B_t^i = B_{t-1}^i - \sum_{k \in \{A,B\}} x_t^{i,k} p_t^k$. Intermediaries have no pre-existing positions in the risky asset.

Since hedging needs are perfectly negatively correlated, it is optimal for intermediaries to take opposite positions across markets in equilibrium. Thus it is convenient to set $x_t^{i,A} = -x_t^{i,B} = x_t^i$ for $t = 0, 1$. Given that assets A and B are both in zero net supply, intermediaries do not bear any aggregate risk.[16]

Intermediaries take into account their price impact, i.e. they choose trades given the price schedule in each market. The price schedules are derived from the inverted demand schedules of hedgers and by imposing market-clearing:

$$Y_t^k + \sum_{i=1}^{n} X_t^{i,k} = 0, \; k \in \{A, B\}, \; t = 0, 1. \tag{2}$$

[16] In the more general case where endowment shocks are not perfectly negatively correlated, intermediaries would not necessarily hold exactly offsetting positions and would bear some of the aggregate risk of the trade with hedgers. The results of the paper would continue to hold qualitatively in this more general setting if intermediaires are sufficiently risk tolerant.

Price schedules map the effect of intermediaries' trades onto the price in each market, i.e., a price schedule is a function $p_t^k\left(\sum_i X_t^i\right)$ giving the price at which the competitive fringe of hedgers in each market is ready to clear the market, given intermediaries positions $\sum_i X_t^i$. Here given the symmetry of market A and B, it is convenient to work directly with the spread schedule, given by $\Delta_t\left(\sum_i X_t^i\right) \equiv p_t^B\left(\sum_i X_t^i\right) - p_t^A\left(\sum_i X_t^i\right)$. Using hedgers' demand and market clearing gives:

$$\Delta_t\left(\sum_i X_t^i\right) = 2a\sigma^2\left(s - \sum_i X_t^i\right) + \mathbb{E}_t(\Delta_{t+1}) \tag{3}$$

This equation illustrates the Coasian dynamics at work in the model. If the spread next period decreases, then the spread today decreases too. Indeed, if hedgers anticipate a smaller spread in the future, their willingness to trade at a high spread today is reduced. Thus, intermediaries compete with their future selves in the same fashion as durable goods producers. Yet, as long as $\sum_i X_t^i \leq s$, spreads are larger at t than at $t+1$. This is because hedgers are risk-averse. Since the asset is conditionally riskier at t than at $t+1$, they are ready to trade at a larger spread at t.[17] The maximisation problem is then given by (assuming no initial wealth)

$$\max_{(x_t^i)_{t=0,1}} u^i\left(\sum_{t=0,1} x_t^i \Delta_t\left(\sum_{j=1}^n X_t^j\right)\right)$$

Because intermediation is risk-free, intermediaries' wealth is deterministic. Thus maximising their utility boils down to maximizing their final wealth.

2.3 Benchmark equilibrium

The equilibrium with a fixed number of incumbent intermediaries, without entry, serves as a benchmark.

Definition 1 *An equilibrium of the benchmark game consists of trades and prices (or equivalently, spreads) such that (i) hedgers' demand is optimal given prices in each market, and (ii) an intermediary's trade maximizes utility given the spread schedule and other intermediaries' trades, $\sum_{-i} x_t^{-i}$, where $\sum_{-i} x_t^{-i} + x_t^i = \sum_{j=1}^n x_t^j$.*

The benchmark equilibrium is standard. However, it is useful for the subsequent analysis to review the main steps leading to the equilibrium and to introduce some notation. In

[17] Thus, risk aversion plays the same role as a discount factor in standard durable goods models in IO.

particular, it will be useful to have a separate notation for the number of intermediaries at time 1.

Definition 2 *Let n_1 denote the number of intermediaries at time 1 and $S = s - \sum_{-i} x_0^{-i}$ the residual supply faced by intermediary i at time 0.*

The number of intermediaries is fixed in this section, thus $n_1 = n$. The payoff in the time-1 subgame is

$$\pi_1(S - x_0^i; n_1) = 2a\sigma^2 \frac{(S - x_0^i)^2}{(n_1 + 1)^2} \tag{4}$$

At time 0, an intermediary chooses a trade, taking into account her price impact given by the spread schedule:

Lemma 1 *The spread schedule at time 0 is*

$$\Delta_0(S - x_0^i; n_1) = 2a\sigma^2 \left(1 + \frac{1}{n_1 + 1}\right)(S - x_0^i) \tag{5}$$

Note that an inermediary's price impact at time 0 is decreasing in n_1. Market depth at time 0 depends on the number of intermediaries in the next period, as a more competitive market at time 1 makes hedgers' demand more price-elastic at time 0. Indeed, hedgers anticipate better risk-sharing opportunities if n_1 is large, which makes them less reluctant to holding risk at time 0, and improves the depth of the market. By contrast, at time 1, I show in the Appendix that price impact is $a\sigma^2$. Thus, it depends only on hedgers' risk-bearing capacity. The reason is that this is the final period, and there are no additional risk-sharing opportunities. Thus, by construction the future degree of competition does not matter.

Let S^{bmk} denote the residual supply faced by intermediary i in the benchmark equilibrium. At time 0, intermediary i's equilbrium trade solves

$$\max_{x_0^i} \; x_0^i \Delta_0(S^{bmk} - x_0^i; n_1) + \pi_1(S^{bmk} - x_0^i; n_1) \tag{6}$$

From the first-order condition, we get

$$\Delta_0(\cdot; n_1) + x_0^i \frac{\partial \Delta_0(\cdot; n_1)}{\partial x_0^i} = \frac{\partial \pi_1(\cdot; n_1)}{\partial x_0^i} \tag{7}$$

Hence, at the margin the intermediary equalizes the marginal cost of buying an extra share on her time-0 profit, taking into account her price impact $\frac{\partial \Delta_0}{\partial x_0^i}$, and the marginal impact on her time-1 payoff. We can now state the equilibrium:

Proposition 1 (Benchmark Equilibrium) *There is a unique (symmetric) equilibrium in which intermediaries' trades in market A are (trades in market B are opposite)* $x_0^i = x_0 = \kappa_{0,n} s$, *and* $x_1^i = x_1 = \kappa_{1,n} s$, *with* $0 < \kappa_{1,n} < \kappa_{0,n} < 1$. *The equilibrium is characterized by*

1. *Order-splitting:* $x_0^i < X_1^i$;
2. *Limited intermediation (risk-sharing):* $\sum_{i=1}^n x_0^i < s$ *and* $\sum_{i=1}^n X_1^i < s$;
3. *A decreasing spread over time:* $\Delta_0 = 2a\sigma^2 \bar{\kappa}_{0,n} s > \Delta_1 = 2a\sigma^2 \bar{\kappa}_{1,n} s > \Delta_2 = 0$.

Due to market power, intermediaries provide limited risk-sharing and intermediate only a fraction of the supply in equilibrium. Given that their price impact is permanent, intermediaries split up orders and increase their positions only gradually. This results in the gradual convergence of prices toward the fundamental. Note that these price dynamics resemble the sluggish adjustments observed in many markets following shocks (Duffie, 2010).[18] Competition among intermediaries determines the speed of the price convergence:

Corollary 1 *In a more competitive market, the spread and expected returns are lower, i.e.* $\frac{\partial \Delta_t}{\partial n} < 0$, *and* $\frac{\partial \left[\frac{\Delta_1 - \Delta_0}{\Delta_0} \right]}{\partial n} < 0$. *In the perfectly competitive limit, the spread vanishes:* $\lim_{n \to \infty} \Delta_t = 0$.

As is standard with Cournot settings, when competition increases, each intermediary buys (sells) a smaller amount in market A (B), but the aggregate quantity traded in equilibrium increases. In the limit, intermediaries fully intermediate trades between the two groups of hedgers, and the equilibrium spread converges to zero.

3 Sequential entry equilibrium

I now turn to the equilibrium with sequential entry. There are n intermediaries in place at time 0 (*incumbents*, $i = 1, \ldots, n$). At time 1, a new trader (the *entrant* or *imitator*, indexed by $n+1$) may become an intermediary after sinking a fixed cost $I > 0$, thus $n_1 \in \{n, n+1\}$.

[18]For instance, the losses caused by natural disasters lead to spikes in catastrophe reinsurance premia, which take months to revert (Froot and O'Connell, 1999). Similarly, arbitrage crashes revert in a matter of weeks or months in many well-known strategies such as risk arbitrage, convertible debt arbitrage, CDS-bond basis, etc. (Mitchell, Pulvino and Pedersen, 2007, Mitchell and Pulvino, 2012). Note that hedgers' endowment shocks are what initially pushes prices apart in the model. They may proxy for losses on other trades or other shocks affecting hedgers. While I call efficiency the speed at which prices converge back to fundamentals after this initial shock, the term resiliency would also be appropriate.

Incumbents are aware of the entry threat. The imitator has no pre-existing positions in the risky assets, so $X_0^{n+1} = 0$.

Timing. At time 1, (i) the imitator decides or not to invest I; (ii) the dividend news ε_1 is realized; (iii) trading takes place. Note that (i) and (ii) could be exchanged without consequences. The imitator may even decide to enter or not and invest at $t = 0$. This is because intermediation is risk-free, so that the imitator's decision rule is deterministic.

If the imitator enters, he maximizes trading profits net of entry costs. If he stays out, he doesn't trade and his wealth is 0. Since the equilibrium in the time-1 subgame is symmetric, the entry condition is

$$\pi_1(S - x_0^i; n+1) \geq I \tag{8}$$

The imitator's decision is thus a pair $(\mathcal{I}, x) \in \{0, I\} \times \mathbb{R}$ such that $(\mathcal{I}, x) = (I, x_1^{n+1})$, where $x_1^{n+1} = \arg\max_{x_1^{n+1}} \; x_1^{n+1}\Delta_1(\sum_{j=1}^{n+1} X_1^j) - I$ if (8) holds, and $(\mathcal{I}, x) = (0, 0)$ otherwise.

Definition 3 *An equilibrium of the sequential entry game consists of incumbents' trades, an entrant's decision (hedgers' trades are given by market clearing), and prices (or equivalently spreads) such that (i) hedgers' demand is optimal given prices in each market, (ii) an incumbent's trade maximizes utility given the spread schedule, other incumbents' trades, and the entrant's decision, and (iii) the entrant's decision to enter or not at time 1 maximizes her utility, given incumbents' equilibrium trades at time 0 and 1.*

Note that in this complete information setting, the anticipation of prices by hedgers is equivalent to the anticipation of the degree of competition among intermediaries. I focus on pure strategy equilibria. Allowing for mixed strategies would eliminate the linearity of hedgers' demands at the expense of tractability. The equilibrium will be expressed as a function of the *normalized entry costs*:

Definition 4 *Let* $\rho \equiv \sqrt{\frac{I}{2a\sigma^2}}$ *denote the entry costs normalized by the hedgers' risk-bearing capacity.*

Hedgers' risk-bearing capacity shows up in the equilibrium variable because it determines hedgers' willingness to hold risk and thus to trade with intermediaries. In particular, it determines the price impact of intermediaries, and, as discussed below, their incentives to deter entry.

3.1 Time 1

Blocked entry. If I is sufficiently large, the entry condition (8) will not be satisfied in equilibrium. Further, if incumbents trade the *benchmark* quantity of Proposition 1 at time 0, then it is too costly for the new intermediary to enter if and only if $\rho > \rho^{bmk}$, where $\rho^{bmk} = f^{bmk}(n)s$, with f^{bmk} positive, decreasing and convex in n. Thus, entry is *blocked* in the region above ρ^{bmk}. I now focus on the more interesting case where $\rho \leq \rho^{bmk}$.

Limit trade. When entry is not blocked, incumbents can choose time-0 positions to ensure that the entry condition (8) is violated. I show in the Appendix that when there is equality, the condition defines a limit trade $x_0^l(S) = S - (n+2)\rho$. If incumbent i trades more than x_0^l, given other incumbents' trades, it is not profitable for the imitator to enter.[19] By deterring entry, incumbents avoid a reduction in their time-1 payoff from $\pi_1(S - x_0^i; n)$ to $\pi_1(S - x_0^i; n+1)$.

3.2 Time 0: dynamic effects of entry and incumbents' trade-offs

Entry also affects incumbents' profits at time 0. Indeed, hedgers are aware of the entry threat, so the spread schedule at time 0 depends on their beliefs about the number of intermediaries at time 1, denoted $\hat{n}_1$.

$$\Delta_0\left(S - x_0^i, \hat{n}_1\right) = 2a\sigma^2\left(1 + \frac{1}{1+\hat{n}_1}\right)\left(S - x_0^i\right) \tag{9}$$

Hedgers are rational, so in equilibrium $\hat{n}_1 = n_1$. For any $0 \leq x_0^i \leq S$, as will be the case in equilibrium, the spread schedule is lower when hedgers anticipate entry (see Figure 2). This is because entry exacerbates the Coasian dynamics. Hence, all else equal, incumbents' time-0 profit $x_0^i\Delta_0$ decreases. Deterring entry, however, is costly. When entry is not blocked, the limit trade does not solve the first-order condition (7). Thus, a deterring incumbent cannot split her trades optimally conditional on no entry. Hence, at time 0, incumbents face a trade-off between lower profits in both periods due to entry and a suboptimal order split.

3.3 Equilibrium

Proposition 2 (Sequential Entry Equilibrium) *Suppose that entry is not blocked, i.e. $\rho \leq \rho^{bmk}$. Then the equilibrium can be of two types:*

[19] Similarly, the incumbent could trade less than $(n+2)\rho - S$ to deter entry, but I show that in the Appendix that it is never in her interest to do so.

1. *If $\rho \in \left(\underline{\rho}, \rho^{bmk}\right]$, then there is a continuum of equilibria where incumbents collectively trade only sufficiently to make entry unprofitable and the imitator does not enter at time 1. The set of incumbents' equilibrium deterrence trades at time 0 is*

$$\left\{ x_0^i \geq 0 \ s.t \ \sum_{j=1}^{n} x_0^j = s - (n+2)\rho + \eta, \ Z_2 < \sum_{j=1, j\neq i}^{n} x_0^j \leq Z_1 \right\},$$

where η is arbitrarily small and positive, and Z_1 and Z_2 are given by equations (23) and (33). The incumbents' time-1 equilibrium deterrence trade is $x_1^{det} = \frac{s - \sum_{i=1}^{n} x_0^i}{n+1}$.

2. *If $0 \leq \rho < \bar{\rho}$, where $\bar{\rho} < \rho^{bmk}$, incumbents accommodate entry and the imitator enters at time 1. Incumbents' equilibrium trades are $x_0^i = \kappa_n^{acc} s \equiv x_0^{acc} > x_0^{bmk}$ and $x_1^i = \frac{s - \sum_i x_0^{acc}}{n+2} \equiv x_1^{acc}$.*

The equilibrium thresholds $\underline{\rho}$, and $\bar{\rho}$ are each increasing in s and decreasing and convex in n.

The equilibrium takes a simple, standard form. When normalized entry costs are sufficiently low ($\rho < \bar{\rho}$), it is too costly to deter the imitator, so incumbents accommodate entry. The accommodate equilibrium resembles the benchmark equilibrium: the accommodate trade at time 0 is determined by the same first-order condition (7), with $n_1 = n + 1$ and the requirement that $x_0^{acc} \leq x_0^l(S^{acc})$, where $S^{acc} = s - (n-1)x_0^{acc}$. Thus, incumbents choose their optimal trade as in the benchmark case, only conditioning on a larger number of competitors at time 1, and provided that the equilibrium trade remains consistent with entry. At time 1, the trade also takes a similar form as in the benchmark, except for the change in competition. If normalized entry costs are intermediate ($\rho \in \left[\underline{\rho}, \rho^{bmk}\right)$), incumbents actively deter the imitator by trading only sufficiently to prevent entry. The entry costs are not sufficient to deter the entrant, so the incumbents must alter their trading strategies in order to avoid entry. In the accommodate equilibrium, incumbents also trade more aggressively at time 0, but not as much as to block entry.

Corollary 2 (Inexistence / Coexistence)

- *With a single incumbent, $\bar{\rho} < \underline{\rho}$, so a pure strategy equilibrium may fail to exist.*
  - *The equilibrium is accommodate if $\rho < \bar{\rho}$, deter if $\rho \in \left(\underline{\rho}, \rho^{bmk}\right]$, and the benchmark equilibrium (blocked entry) if $\rho > \rho^{bmk}$. There is no equilibrium in pure strategies if $\rho \in \left[\bar{\rho}, \underline{\rho}\right]$.*

- *With an oligopoly of incumbents ($n \geq 2$), $\bar{\rho} > \underline{\rho}$, so the accommodate and deter equilibria may coexist.*
  - *The equilibrium is accommodate if $\rho < \bar{\rho}$, deter if $\rho \in \left(\underline{\rho}, \rho^{bmk}\right]$, and the benchmark equilibrium (blocked entry) if $\rho > \rho^{bmk}$. The deterrence and accommodate equilibria coexist when $\rho \in \left[\underline{\rho}, \bar{\rho}\right]$.*

Equilibria can coexist as soon there are at least two incumbents (see Figure 1) due to imperfect coordination among incumbents. Note in particular that the threshold $\underline{\rho}$, above which deterrence is an equilibrium, is the lowest normalized entry cost such that deterrence is an equilibrium. It is determined when incumbents hold symmetric positions.[20] Because incumbents trade just enough to make entry unprofitable, there is some complementarity in incumbents' actions, leading to multiple equilibria.

The inexistence of the equilibrium in the monopolistic case is not a mere technical curiosity. Rather, it results from the dynamic effect of entry on incumbents' time-0 profits. This dynamic effect follows from the feedback loop between depth and entry, given by (9). To make the point formally, it is necessary to compare the model to one without feedback, which is done in the next section.

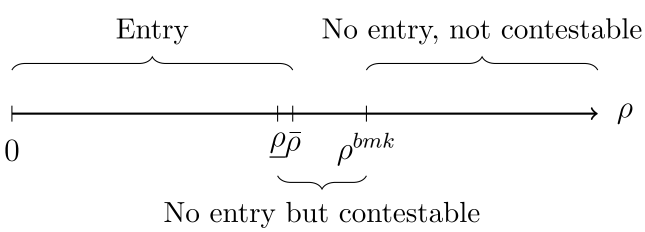

Figure 1: **Equilibrium with sequential entry and strategic deterrence when $n > 1$.** (The parameters are $n = 2, s = 1$)

4 Dynamic effects of strategic deterrence

While the equilibrium takes a standard form, the model delivers novel predictions about the dynamic effects of strategic deterrence. I highlight three main properties: (i) entry deterrence improves some aspects of ex-ante market quality, while actual entry improves all aspects; (ii) entry deterrence overturns the standard relationship between spreads and its determinants (e.g. competition, supply), and (iii) in the presence of the feedback between

[20] I show formally in the proof that the deterrence profit is the lowest in this case.

entry and depth, incumbents have stronger incentives to deter, leading to less entry in equilibrium, than without feedback. In this section, I focus on the mechanisms and elaborate on the empirical implications of these results in Section 7.

4.1 Deterred and actual entry affect differently market quality

To measure market quality, I consider three key variables: spreads Δ_t, the amount of intermediation (per period, x_t, and in total, $\sum_{i=1}^{n} X_t^i$), and time-0 market depth, defined as the inverse of price impact $|\frac{\partial \Delta_0}{\partial x_0^i}|$.

Corollary 3 (Market Quality) *Deterred entry and actual entry affect market quality differently at time 0:*

1. *In both the deterrence and accommodate equilibria:*
   (a) *the quantity intermediated x_t increases at time 0 and decreases at time 1, while the total quantity at time 1 increases relative to the benchmark equilibrium.*
   (b) *The spread is smaller than in the benchmark equilibrium at both time 0 and 1.*
2. *Market depth improves and expected returns decrease at time 0 only in the accommodate equilibrium.*

The fact that depth differs across equilibria follows immediately from equation (9) and the fact that hedgers are rational: they correctly anticipate that in the accommodate equilibrium, competition will increase. Hence, their demand becomes more price-elastic ex-ante, which lowers price impact. In the deterrence equilibrium instead, hedgers understand that the market structure will remain the same, so that depth is unchanged.

The other aspects of market quality (spreads and quantities) are affected in similar ways by the deterrence and accommodate equilibrium strategies. Trading more aggressively at time 0 is a form of preemption for incumbents accommodating entry: incumbents race to trade ahead of the entrant. This more aggressive trading leads to a smaller spread at time 0. The effect is softened by the fact that the market is more liquid.

In the deterrence equilibrium, incumbents also preempt intermediation profits. They do so, however, beyond what would be optimal conditional on no entry, since otherwise the entrant would enter (as $\rho < \rho^{bmk}$). This can be seen from their maximisation problem in the deterrence equilibrium. Assuming that hedgers anticipate no entry and that the residual supply is S, an incumbent solves

$$\max_{x_0^i > x_0^l(S)} \quad x_0^i \Delta_0(S - x_0^i; n) + \pi_1(S - x_0^i; n)$$

Comparing this optimization problem to the benchmark case (6), we see that the only difference is the constraint to trade more than the limit trade. The solution to the unconstrained problem is the best-response $x_0^{bmk}(S)$, as in the benchmark case. However, since entry is not blocked, the constraint $x_0^i > x_0^l(S)$ is binding. Since every incumbent is pivotal, trading $x_0^i > x_0^l(S)$ is required for incumbent i to prevent entry: it ensures that the time-1 payoff is indeed $\pi_1(\cdot; n)$, as anticipated by hedgers.[21] This more aggressive trading leads to tighter spreads than in the benchmark. The mere threat of entry has thus disciplining effects on incumbents, leading to more intermediation and smaller spreads. In Baumol (1986)'s terms, although entry does not occur, the market is *contestable* for intermediate entry costs.

In both cases, the more aggressive trading at time 0 is followed by less aggressive trading at time 1, but the total quantity intermediated increases (even without counting the effect of the entrant in the accommodate case), leading to a smaller spread at time 1 as well. Note that because depth is unchanged in the deterrence equilibrium, the more aggressive trading does not change the expected return. Instead, in the accommodate equilibrium, the time-1 spread decreases proportionately more than the time-0 spread as entry takes place. In other words, spreads converge more quickly towards zero in the accommodate case due to entry.

4.2 Entry deterrence alters ex-ante comparative statics

In the region where the market is contestable, strategic deterrence leads to new comparative statics.

Corollary 4 (Entry Deterrence Overturns Standard Comparative Statics) *In the accommodate and benchmark equilibria, the spread is decreasing in n and increasing in s at time 0 and time 1. Instead, in the deterrence equilibrium, the spread*

1. *is independent of the supply s at time 0 and time 1,*
2. *increases with the number of intermediaries at time 0 and decreases at time 1,*
3. *increases with the entry cost I at all dates.*

[21] Because departing from the optimal strategy is costly, a deterring incumbent trades $x_0^l + \eta$, where η is small and strictly positive.

The predictions of the model stand in sharp contrast to the standard case, but the general intuition is simple: lower supply, stronger competition, and higher entry costs are all substitutes for more deterrence. The first point is that the spread is independent of the supply. Indeed, when they deter incumbents mechanically offset the effect of a larger supply by trading more aggressively. This can be seen by combining equation (9) and the limit trade $x_0^l = S - (n+2)\rho$. When the supply s increases, S goes up, and so does the limit trade. This implies that $S - x_0^l$ remains unchanged, so that the spread is independent of s. The second point is that the spread at time 0 increases with competition. Intuitively, in a more competitive market, the effects of contestability are smaller. Indeed, more competition reduces the rents available for the entrant, and thus makes entry less attractive. Thus, incumbents do not need to deter as intensively at time 0. Hence, the spread decreases less. The third point is that the spread increases with the entry costs. This is because higher entry costs imply less entry, and thus decrease the need to deter, which translates into a larger spread.

4.3 The dynamic feedback loop between depth and entry leads to more deterrence

To show how the feedback loop between entry and depth leads to more deterrence, and thus limits entry, it is necessary to compare the model to one without feedback. I consider two alternatives, in which market depth does not reflect the future level of competition. In the first one, hedgers understand that there are two trading rounds, but are not aware of the possibility of entry. Hence hedgers always believe that $\hat{n}_1 = n$ in equation (9). Thus, the first alternative model has Coasian dynamics, but no feedback from entry to depth. In the second alternative, hedgers are far-sighted: they believe at time 0 that there is a single trading round (i.e. they are focused on time 2, and unaware of time 1). Hence, they believe that $\hat{n}_1 = 0$. At time 1, they realize that there is an extra trading round. Hence the far-sighted model has no Coasian dynamics, and thus no feedback.

I view hedgers as more sophisticated (or markets to be more transparent) in the no-feedback model than in the far-sighted model, since in the former hedgers miss only one piece of information (the possibility of entry), and two pieces in the latter (the possibility to retrade, and thus the possibility of entry).

In the main model, the cost of deterrence is determined by market depth, which itself depends on future competition (equation (9)). Shutting down the feedback from the possibility of entry to depth reveals how this part of the loop affects the cost of deterrence. Consider an incumbent facing a trade-off between accommodating and preventing entry in the accommodate equilibrium, and compare the main model to the no-feedback model.[22] The cost of deterrence is given by the distance between the limit trade and the accommodate trade at time 0. Conditional on entry at time 1, incumbents trade smaller quantities when depth reflects entry than not.[23] Intuitively, as the market becomes more liquid, incumbents buy less to keep spreads high and maintain profits. As other incumbents buy smaller quantities, the residual supply faced by incumbent i increases. However, $x_0^l(S)$ is increasing in S. Hence the distance $|x_0^l - x_0^{acc}|$, which measures the cost of deterrence, is larger when depth depends on entry.

Thus, while the feedback loop between entry and depth reduces incumbents' profits in both periods instead of one (Section 3.2), it also increases the cost of deterrence. The first effect, however, dominates:

Corollary 5 (Comparisons across models) *Entry thresholds are ranked as follows: $\bar{\rho} < \bar{\rho}^{nf} < \bar{\rho}^{fs}$, i.e. the more sophisticated hedgers are, the less likely entry is.*

This result shows that the benefit from accommodating is reduced more than the benefit of deterring by the feedback loop betwen entry and depth. Hence, there is more deterrence, and thus less entry, with the feedback loop than without.

Further, note that in both alternative models, the equilibrium keeps the same form as in the main model, with three thresholds in terms of normalized entry costs, but that in both cases, a unique threshold separates the accommodate and deterrence equilibria in the monopoly case, i.e. $\underline{\rho}^k = \bar{\rho}^k$, $k \in \{nf, fs\}$. This confirms that inexistence stems from the feedback between entry and depth. For an oligopoly, each model has a coexistence region.[24]

These comparisons are useful to clarify the mechanisms at play, but are also economically relevant. Hedgers in different financial markets may differ in sophistication. For instance, retail investors play a larger role in municipal bond markets than in corporate bond markets, and tend to be less sophisticated than institutional investors. Models without feedback effect or without Coasian dynamics may capture markets with less sophisticated investors.

[22]Similar effects arise in the far-sighted model.

[23]Formally, I am comparing two quantities, x_0^{acc} and the counterfactual trade $x_0^{acc,nf}$ of the *no f*eedback model, defined as $x_0^{acc,nf} = \arg\max_{x_0^i} \ x_0^i \Delta_0(\cdot; n) + \pi_1(\cdot; n+1)$. We have: $x_0^{acc} < x_0^{acc,nf}$. See Corollary 9 in the Appendix.

[24]I provide further comparisons between the main model and the alternative models in Corollary 9 and Corollary 13 and Table 1 in the Appendix.

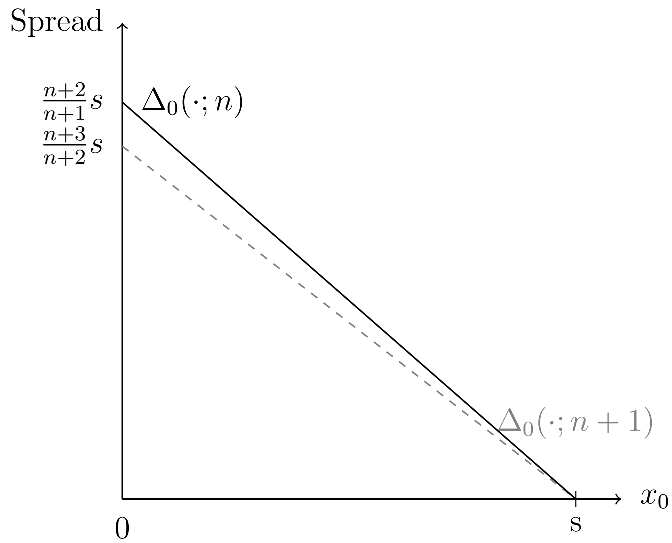

Figure 2: **Spread schedule as a function of time-0 trade x_0 under different expectations.** The dashed gray line represents the spread when hedgers anticipate entry ($\hat{n}_1 = n + 1$). The solid back line represents the spread when hedgers anticipate no entry ($\hat{n}_1 = n$). The parameters are $n = 1$ and $s = 1$.

5 Competition and welfare effects

The model delivers additional predictions about competition and welfare.

5.1 Competition effects

For a given supply s, both thresholds $\bar{\rho}$ and $\underline{\rho}$ decrease with the number of incumbents, (see Figure 3). This implies that, all else equal, there is less entry in more competitive markets. Intuitively, markets dominated by a few incumbents offer larger rents, and thus they are more difficult to ring fence. This result implies that a merger between two incumbents or a group of incumbents can switch the equilibrium from no entry to entry.[25]

5.2 Welfare

When equilibria coexist, we can compare their price and welfare properties.

[25] Given that they receive endowment shocks, hedgers have incentives to enter the market, even if risk-sharing is limited. If their mass is determined by an indifference condition (enter at a cost and trade vs stay out and incur the disutility from the endowment shock), their mass would be positive, unless costs are prohibitive. A lower mass of hedgers makes intermediation less profitable, and thus would be equivalent to an increase in hedgers' risk-tolerance (e.g. a decrease in risk aversion a), shifting normalised entry costs to the right.

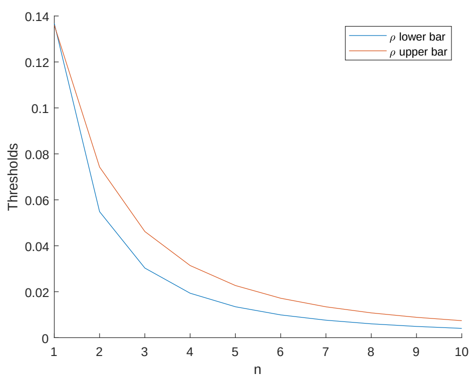

Figure 3: **The thresholds $\underline{\rho}$ and $\bar{\rho}$ as a function of n.** (s=1)

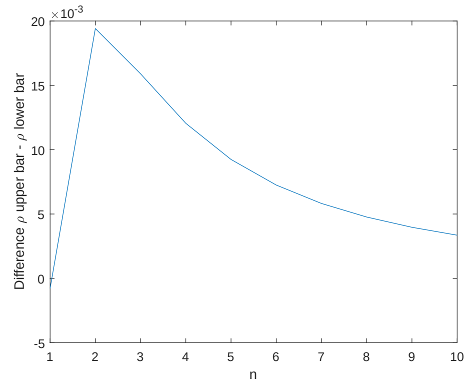

Figure 4: **Difference between $\bar{\rho}$ and $\underline{\rho}$ as a function of n.** (s=1)

Corollary 6 (Price and Welfare Comparison in Multiple Equilibria Region) *In the region where the accommodate and deterrence equilibria coexist, i.e., $\rho \in \left[\underline{\rho}, \bar{\rho}\right]$,*

1. *Incumbents' time-0 aggregate trade is larger in any deterrence equilibrium.*

2. *The spread is always smaller in any deterrence equilibrium: $\Delta_t^{acc} > \Delta_t^{det}$, $t = 0, 1$.*

3. *Incumbents are worse off in the symmetric deterrence equilibrium than in the accommodate equilibrium.*

4. *Hedgers' welfare is higher in any deterrence equilibrium.*

This corollary has the following implications. First, there may be overinvestment in deterrence from the incumbent's point of view. Indeed, with some probability, the equilibrium is deterrence in the coexistence region, and incumbents are worse off in this case. This point agrees with Gilbert and Vives (1986).

Second, there is never overinvestment in deterrence from hedgers' point of view: indeed hedgers are better-off in the deterrence equilibrium, and with some probability the equilibrium is accommodate. The intuition for the higher welfare in the deterrence equilibrium is as follows. When they deter, incumbents provide more intermediation at time 0 than if they accommodate. This increase in risk-sharing at time 0 more than compensates the fact that competition remains unchanged. Indeed, the asset is conditionally riskier at time 0, making early intermediation particularly valuable. Thus, while more competition is desirable from the hedgers' point of view, the mere threat of competition disciplines incumbents in such a way that hedgers are better off.

While no equilibrium makes everyone better off, deterrence may lead to a higher total welfare. Since total welfare is defined as the sum of expected utilities of all agents (including the entrant), it is not possible to compare directly certainty equivalents or profits across equilibria. In the absence of a sharp analytical characterization, I proceed numerically. Intemediaries' utility are arbitrary, only subject to standard monotonicity and concavity requirements. For numerical analysis, I considered two cases: risk-neutral intermediaries, and CARA utility (either with the same level of risk aversion as hedgers or not). In all numerical examples, I found that total welfare is higher in the deterrence equilibrium (see Figures 9-12).[26]

The final remark about the coexistence region concerns spreads: they are smaller at all dates in the deterrence equilibrium. At time 0, there are two conflicting effects: on the one hand, the spread schedule is larger in the deterrence equilibrium, because hedgers anticipate a fixed market structure; on the other hand, incumbents trade larger quantities in both equilibria. However, incumbents trade a larger total quantity in the deterrence equilibrium, and this effect more than offsets the fact that the spread schedule is larger. At time 1, $\Delta_1(\cdot; n_1) = 2a\sigma^2 \frac{s - \sum_i x_0^i}{n_1+1}$. On the one hand, competition is stronger in the accommodate equilibrium, so one would expect a smaller spread (the denominator goes up). On the other hand, incumbents trade more in total at time 0 in the deterrence case, and this effects offsets the first one.

6 Sequential entry in a static model

It is natural to study the sequential entry of intermediaries in a dynamic setting, as trading is likely to be more frequent than entry. However, to show that the model predictions of Section 4 are specific to a dynamic model, I compare them to those of a static model based on Gilbert and Vives (1986).

6.1 Set up

The only difference with Gilbert and Vives (1986) is that hedgers' demand is linear and solves their optimization problem. The latter allows me to compute hedgers' welfare and total welfare.

[26] When intermediaries (including the entrant) have CARA utility, I denote a_i their risk aversion coefficient, which may or may not be equal to hedgers' risk aversion a. Figures 9-12 represent typical situations, which occur also for a larger n or more different levels of risk aversion. The expressions for total welfare underlying the graphs are derived at the end of the proof of Corollary 6.

The timing is as follows. There are two dates: $t = 1, 2$. At time 2, the asset pays off $D_2 = D_1 + \varepsilon_2$, where ε_2 is normally distributed with mean 0 and variance σ^2, and all investors consume. At time 1, incumbents choose trades before entry might take place. Actions occur in the following order: (i) each incumbent chooses a trade x_1^i, $i = 1, \ldots, n$ to maximize expected utility, taking other incumbents' trades x_1^{-i}, the price schedules, and the entrant's decision and (potential) trade as given; (ii) the entrant decides to enter or not. If he does enter, he chooses a trade x_1^{n+1}, given the incumbents' trades and the price schedules. (iii) Hedgers submit their demand, all trades are aggregated and the market clears. For the sake of comparison with the dynamic case, I assume that incumbents have endowments x_0^i in the risky asset. As before, the entrant has no preexisting position, $x_0^{n+1} = 0$, thus his position equals his trade: $X_1^{n+1} = x_1^{n+1}$.

6.2 Predictions of the static model

The equilibrium of the static model is given in Proposition 5 in the Appendix. It has the same form as that of the dynamic model: there exist counterparts $\rho^{bmk,s}$, $\underline{\rho}^s$ and $\bar{\rho}^s$, which determine the type of equilibrium. As in the dynamic case, equilibria coexist on $(\underline{\rho}^s, \bar{\rho}^s)$ when there are at least two incumbents. However, the thresholds coincide ($\underline{\rho}^s = \bar{\rho}^s$) with a monopoly, as there is no feedback effect from entry to depth. I now summarize the main predictions of the static model.[27]

Corollary 7 (Effects on spreads and quantities)

1. *The spread is lower in the accommodate and deterrence equilibria than in the benchmark case without entry.*

2. *Incumbents trade more than the benchmark quantity only in the deterrence equilibrium. In the accommodate equilibrium, incumbents trade the benchmark quantity, but the total amount of intermediation increases due to the quantity traded by the entrant.*

3. *Comparative statics: the spread is increasing with s and decreasing with competition in the benchmark and accommodate equilibria, and is independent of s and of competition in the deterrence equilibrium.*

The result that spreads increase in competition is thus specific to the dynamic model. In the static case, a weaker result is obtained: the spread is independent of competition. This is not driven by the linearity of the demand.

[27] Gilbert and Vives (1986) do not derive these results in their paper as their focus is on entry prevention as a public good.

The reason for the difference is that in the static model, entry condition (the equivalent of (8)) depends only on the fixed cost and the residual supply, but not on the number of incumbents.[28] This is because the entry decision takes place before the market clears. Hence, only the residual supply left after the first stage (incuments' quantity choice) matters. The residual supply is independent of the number of intermediaries: indeed, whether one intermediary acquires 90% of the supply, or ten intermediaries 9% each, the residual supply is 10% in both cases. Instead, in the dynamic model, a deterring incumbent needs to reduce the entrant's payoff in the next trading round (equation (8)), and this payoff depends on both the residual supply and the number of intermediaries, as it depends on the market-clearng price.[29]

Similarly, the preemptive behaviour of incumbents is specific to the dynamic model, at least with linear demand. The total amount of intermediation increases in the accommodate equilibrium only because the entrant acquires some of the residual supply.

Market depth in the static framework depends only on hedgers' risk-bearing capacity, as in time 1 of the dynamic model. Thus it is the same in all equilibria, and there is no feedback loop between market depth and entry.

Welfare results, however, are in line with the dynamic case:[30]

Corollary 8 (Welfare) *When equilibria coexist, hedgers are better off in the deterrence equilibrium, and vice-versa for intermediaries.*

Numerical examples show that total welfare can be higher in the deterrence equilibrium, as in the dynamic model.

7 Empirical predictions

In this section, I summarize the main empirical predictions of the model and review to which extent the existing evidence is consistent with, or can be rationalized through the lens of, the model.

[28]In the Appendix, I show that the limit trade in the static case is $x_1^L = S_1 - 2\rho$, where S_1 is the residual supply faced by incumbent i at time 1. Instead, in the dynamic model, $x_1^l = S - (n+2)\rho$.

[29]Note that in the no-feedback and far-sighted models the spread increases with competition in the deterrence equilibrium. Hence, hedgers do not need to be aware of entry for the result to hold. What is essential is that the market has already cleared once before entry may occur.

[30]These results, except intermediaries' profits, are also not formally derived in Gilbert and Vives (1986), as demand is exogenous. Gilbert and Vives point out that total output and consumer surplus may decrease with an increase in the number of producers. My results show that this property still characterizes hedgers' welfare in a dynamic market, at least in the coexistence region, even when hedgers' demand ex-ante depends on anticipated entry.

7.1 Model predictions

The results of Sections 4 lead to new empirical predictions. These predictions may be tested in the context of an anticipated change in entry costs caused by some exogenous event. The exogenous event (or shock) affecting entry costs could be a change in regulation, the introduction of a new technology, a change in the membership conditions for dealers on CCPs, etc. Empiricists could compare the number of intermediaries (or another proxy for competition) at the announcement and after the implementation of this change. Prediction 1 is based on Corollary 3 about the effects of market quality:

Prediction 1 *An increase in depth before the implementation is associated with a more competitive market afterwards.*

This prediction relies on cross-sectional variation in the change of the number of intermediaries across markets after the implementation of the reform (i.e. comparing the effects of deterrence and accommodate equilibria). However, Corollary 3 shows that within the deterrence equilibrium, market quality metrics react differently, with spreads and quantities improving, and depth remaining unchanged. This differential effects across metrics (and the different effects across equilibria) may be useful for empiricists to identify deterrence in the data, even if the entry threat is not observed.

The model also predicts that spreads decrease because of entry deterrence. However, a similar (albeit smaller in the coexistence region) effect occurs in the accommodate equilibrium. Hence, looking at the change in spreads may not be sufficiently discriminating. However, spreads can be used to test Corollary 4.

Prediction 2 *In markets with ex-post entry, spreads are negatively correlated to the ex-ante number of intermediaries, and vice-versa for markets without ex-post entry.*

Such test thus requires two sources of variation: about entry and about the number of intermediaries before the implementation. Thus, empiricists should collect spreads before the implementation, and then distinguish markets in which entry occurred from those without entry.

The last prediction of the model is that entry is less likely in more sophisticated markets, which also requires variation both in the number of intermediaries after the implementation across markets (or any competition proxy) and in the level of sophistication of market participants (non-dealers) ex-ante.

Prediction 3 *The number of new intermediaries after the implementation is negatively related to the level of sophistication of non-intermediary investors ex-ante.*

Sophistication of the investors trading with intermediaries may be proxied by the share of institutional vs retail investors in the market, or if the market is mostly institutional the share of hedge funds and proprietary trading desks. For instance, in the UK sovereign bond markets, Pinter, Wang and Zou (2021) find that hedge funds are more sophisticated than pension funds, insurance companies, and foreign central banks. Note that in the first two predictions the effect should be stronger when the market is more sophisticated.

7.2 Existing evidence

There is evidence consistent with the predictions of the model, or that can be rationalized through the lens of the model.

Evidence about contestability. There is evidence that contestability plays a role in financial markets. Froot (2001) shows that the decline in reinsurance premia observed at the end of 1990s results from an increase in the contestability of the market through catastrophe bonds: "Probably the best explanation for the magnitude and timing of the recent price decline is a change not in capacity, but in *contestability* [italics in original]. While a large amount of new capacity may be needed to drive down prices in a competitive market, the same is not true when producers are perceived to have market power. In that case, all that is required is to increase the perceived level of competition. This fits with the cat[astrophe] bond experience."[31] Note that Froot focuses on prices. My results shows that this evidence could be strengthened by considering changes in quantities and in depth. Improvement in prices/ spreads should be associated with larger quantities, but not more depth.

Volcker rule. One may wonder how the model can shed light on the changes that followed the implementation of the Volcker rule. Let's first consider how the change in market structure can be related to the model. As mentioned in the introduction, the Volcker rule led to reduced market-making by dealers affected by the new regulation, leaving open the question of whether new players would step in. The evidence in Bao et al. (2018), however, points to only limited substitution from *existing* non-Volcker affected players. There is no evidence of entry of *new* players. More precisely, Bao et al. (2018) show that dealers affected by the Volcker rule decreased their market-making, while non-affected dealers increased it, but were far from offsetting the decreased activity of the affected dealers. Since non-affected dealers represent an almost negligible fraction of the market-making in the data, this phenomenon might be better captured by a change in the mass of hedgers in the model than by entry

[31] Froot (2001) section 4.3.

(note that entry of a new dealer may have been a possibility, but didn't materialize).[32]

In the language of the model, the Volcker rule is akin to a negative shock to n, the number of incumbents. The model may then contribute to explain the changes in market quality induced by the Volcker rule. The evidence is mixed: spreads remained stable in spite of increased Volcker-affected dealer concentration and limited substitution from small, non-affected dealers, while price impact worsened, particularly in times of stress (Dudley, 2016, Bao et al., 2018, Dick-Nielsen and Rossi, 2019).[33] The fact that spreads did not increase in spite of more concentration among large dealers seems consistent with the effects of contestability. Without it, spreads should have increased due to higher dealer concentration. Further, in the model price impact is larger when concentration increases, and is not affected by contestability. Thus, price impact may have worsened due to increased concentration. Moreover, the effect of the market structure on depth is stronger when hedgers' risk-bearing capacity is lower (high risk aversion a and/or high volatility σ); this may explain why the worsening is more pronounced in times of stress.

Other evidence. If we think of the fixed entry costs as a proxy for the "intellectual capital" of the trade, the model predicts more entry, higher depth and faster convergence in simpler trades. Consistent with this prediction, Duarte, Longstaff and Yu (2007) find that only the more intellectually capital-intensive fixed-income arbitrage strategies (yield-curve, mortgage and capital structure arbitrage) generate abnormal returns. Instead, simpler strategies such as the swap spread and volatility arbitrage do not produce significant risk-adjusted returns.

Siegmann et al. (2018) note that traditional barriers to entry studied in Industrial Organization may not be relevant in the context of capital markets. My result about how hedgers' sophistication may lead to less entry (Prediction 3) highlights other impediments to entry in capital markets.

8 Conclusion

In this paper, I study the sequential entry of intermediaries into an imperfectly liquid market. Imperfect liquidity stems from imperfect competition among intermediaries, which characterizes many modern financial markets.

[32]The concomitant development of electronic platform may also have contributed to make the market contestable.

[33]See "William C. Dudley: Market and funding liquidity - an overview", Remarks by Mr William C. Dudley, President and Chief Executive Officer of the Federal Reserve Bank of New York, at the Federal Reserve Bank of Atlanta 2016 Financial Markets Conference, Fernandina Beach, Florida, 1 May 2016, at https://www.bis.org/review/r160502a.htm

The main contribution of the paper is to analyze sequential entry and deterrence in a dynamic framework of strategic trading. Doing so leads to new predictions about the ex-ante effects of deterrence on market quality. By contrast, standard IO analyses of sequential entry are done without trading dynamics.

While entry deterrence leads to more intermediation and smaller spreads ex-ante, it does not improve market depth. Instead, all these variables, including depth, improve ex-ante when entry occurs in equilibrium. These distinct effects provide a way to identify entry deterrence, circumvening the standard issue that entry threats are difficult to observe.

Deterrence also overturns the standard relationshp between spreads and competition: spreads are *larger* in a more competitive market. This novel prediction suggests that empiricists should control for the contestability of the market when testing the relationship between spreads and competition.

The key dynamic effects on market depth arise because all market participants in the model are rational and aware of the entry threat. Hence, while depth determines the cost of deterrence for incumbents, it also reflects the anticipated degree of competition, creating a feedback loop. I show that if intermediaries' counterparties are not aware of entry, depth does not reflect the future degree of competition. In this case, incumbent intermediaries have lower incentives to engage in deterrence. Hence, the model predicts more entry in less sophisticated markets and shows how the reactions of incumbents' counterparties may exacerbate barriers to entry.

The empirical predictions of the model find support in the evolution of the catastrophe bond markets and other bond markets. The analysis also shows that contestability may reduce intermediaries' welfare more than actual entry, and vice-versa for their trading counterparties.

An interesting extension of the model would be to relax the assumption that competition can only occur by directly entering the asset market. In standard IO models, competition can occur in homogeneous good or in a differentiated good. In my model, intermediaries help other investors share risk by trading in the market for the asset that they want to hedge. An alternative would be that new intermediaries offer these investors "structured products" or "derivatives"-like insurance contracts to provide them with risk-sharing.

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Appendix

A Graphs

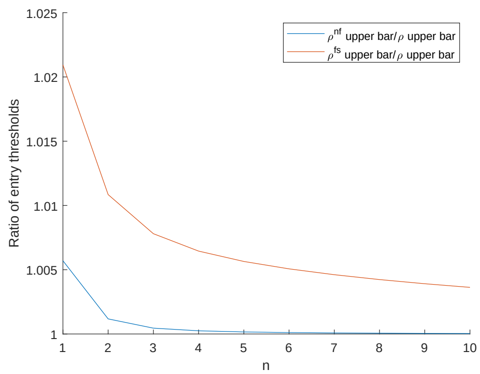

Figure 5: **The ratio $\frac{\bar{\rho}^l}{\bar{\rho}}$ $(l \in \{nf, fs\})$ as a function of n in the no feedback and far-sighted models.** $(s = 1)$

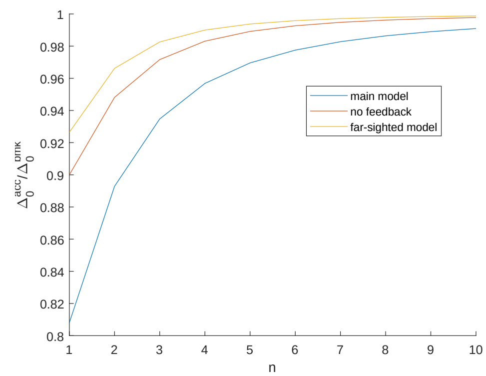

Figure 6: $\frac{\Delta^{acc}}{\Delta^{bmk}}$ **as a function of n in the different models.**

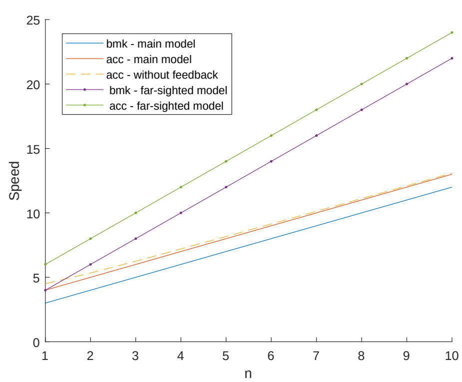

Figure 7: **Benchmark and accommodate equilibrium speeds $\mathcal{S}_0$ across models**

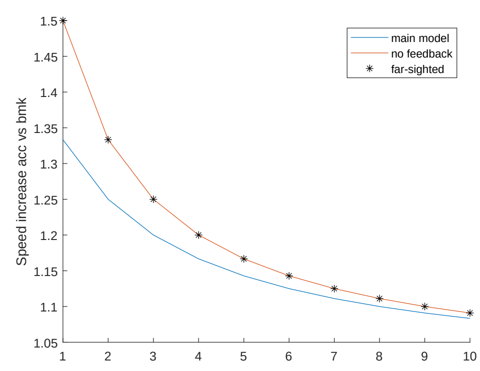

Figure 8: **Speed improvement $\frac{\mathcal{S}_0^{acc}}{\mathcal{S}_0^{bmk}}$ due to entry across models.**

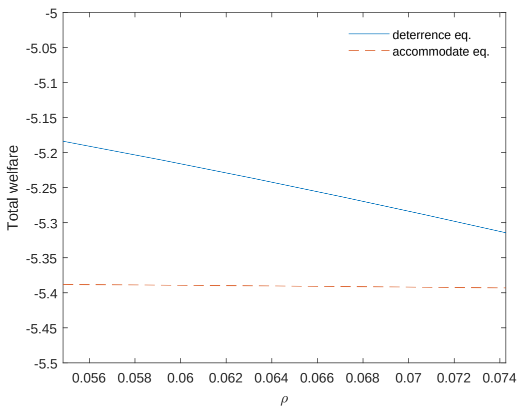

Figure 9: **Total welfare for equal risk aversion** The parameters are $s = 1$, $n = 2$, $\sigma^2 = a = 1 = a_i$.

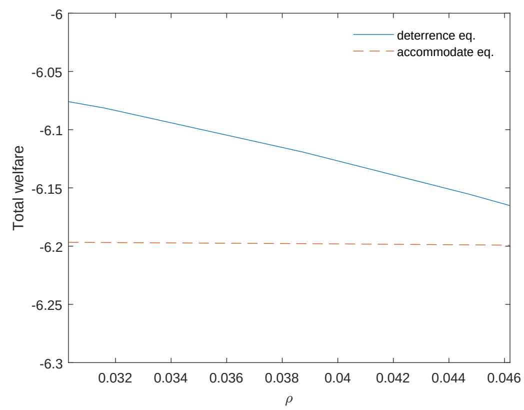

Figure 10: **Total welfare for equal risk aversion** The parameters are $s = 1$, $n = 3$, $\sigma^2 = a = 1 = a_i$.

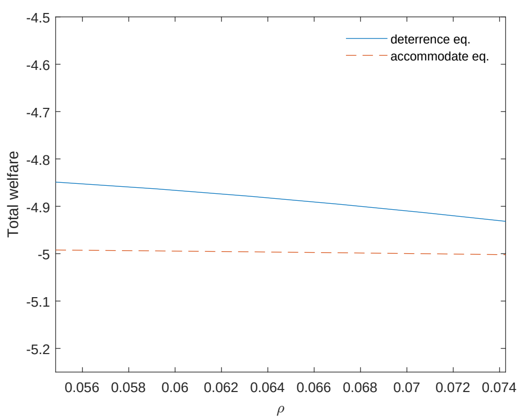

Figure 11: **Total welfare for different risk aversion** The parameters are $s = 1$, $n = 2$, $\sigma^2 = a = 1$, $a_i = 2$.

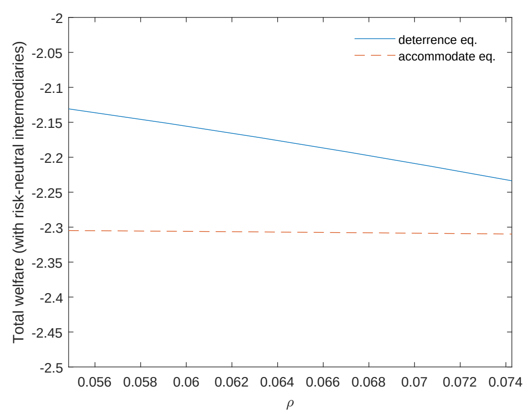

Figure 12: **Total welfare for different risk aversion** The parameters are $s = 1$, $n = 2$, $\sigma^2 = a = 1$, risk-neutral intermediaries.

B Fixed market structure

Lemma 2 (Hedgers' demand) *At time t, hedgers' demand in market k is $Y_t^k = \frac{\mathbb{E}(p_{t+1})-p_t}{a\sigma^2} - s^k$, $k \in \{A, B\}$.*

Proof. Since markets A and B are symmetric, it is sufficient to solve for the demand of hedgers in market A, and thus I drop the superscript A. By applying the projection theorem for normals and using the notation $D_t = \mathbb{E}_t(D_2)$, we can write the maximization problem of the hedgers as follows:

$$\max_{Y_1} \mathbb{E}\left[u\left(W_2\right)\right] = \max_{Y_1} - \exp\left(-a\ CE_1\right),$$

where $CE_1 = W_1 + Y_1(D_1 - p_1) - \frac{a\sigma^2}{2}\left(Y_1 + s\right)^2$. From the first-order condition (FOC), we obtain $Y_1 + s = \frac{D_1 - p_1}{a\sigma^2}$. Substituting back optimal holdings into the maximand gives the certainty equivalent at time 1:

$$CE_1 = W_1 + \frac{\left(D_1 - p_1\right)^2}{2a\sigma^2} - s\left(D_1 - p_1\right) \tag{10}$$

Going backward, hedgers solve:

$$\max_{y_0} -\mathbb{E}_0\left[\exp\left(-a\left(-y_0 p_0 + Y_0 p_1 + \frac{\left(D_1 - p_1\right)^2}{2a\sigma^2} - s\left(D_1 - p_1\right) + s\epsilon_1\right)\right)\right]$$

The only random components in the expection are $s\epsilon_1$ and p_1, to the extent that it also depends on $s\epsilon_1$, which is not known at time 0. However, the risk premium $D_1 - p_1$ is deterministic. Thus, computing the expectation, we get:

$$\max_{y_0} - \exp\left\{-a\left(-y_0 p_0 + Y_0 \mathbb{E}_0(p_1) - \frac{a\sigma^2}{2}\left(Y_0 + s\right)^2 + \frac{\left(D_1 - p_1\right)^2}{2a\sigma^2} - s\left(D_1 - p_1\right)\right)\right\}$$

From the first-order condition, we get

$$a\sigma^2\left(Y_0 + s\right) = \mathbb{E}_0(p_1) - p_0 \tag{11}$$

■

B.1 Proposition 1

Proof. We proceed by backward induction.

Time 1. From Lemma 2 and market-clearing, the spread schedule at time 1 is:

$$\Delta_1\left(\sum_{j=1}^{n_1} X_1^j\right) = 2a\sigma^2\left(s - \sum_{j=1}^{n_1} X_1^j\right) \tag{12}$$

Thus using (1) for intermediaries' wealth at time 2 and the assumption of opposite positions, we have:

$$W_2^i = B_0^i + x_1^i\Delta_1(\cdot) = B_0^i + 2a\sigma^2 x_1^i\left(s - \sum_{j=1}^{n_1} X_1^j\right),$$

Since intermediaries can eliminate all risk, we only to maximize their final wealth. Using $\sum_{j=1}^{n_1} X_1^j = \sum_{j=1}^{n} X_0^j + \sum_{-i} x_1^{-i} + x_1^i = \sum_{j=1}^{n} x_0^j + \sum_{-i} x_1^{-i} + x_1^i$, where $-i$ denote all intermediaries but intermediary i, an intermediary solves $\max_{x_1^i}\ x_1^i\left(s - \sum_{j=1}^{n_1} X_1^j\right)$. The first-order condition gives the best-response of intermediary i:

$$x_1^i = \frac{s - \sum_{j=1}^{n} x_0^j - \sum_{-i} x_1^{-i}}{2}, \quad i = 1, \dots, n_1$$

The equilibrium trade in the time 1 subgame is

$$x_1^i = \frac{s - \sum_{j=1}^{n} x_0^j}{n_1 + 1}, \quad i = 1, \dots, n_1 \tag{13}$$

Substituting (13) into the spread schedule and the objective functions, we get the equilibriul spread in the subgame

$$\Delta_1 = 2a\sigma^2\frac{s - \sum_{j=1}^{n} x_0^j}{n_1 + 1} \tag{14}$$

and the payoff of the subgame: $B_0^i + \pi_1(\cdot; n_1)$, where π_1 is given by (4) in the text.

Time 0. We obtain the price schedule (5) given in the text by substituting the equilibrium spread (14) in the general expression for spread schedules given in the text. Using $B_0^i = B_{-1}^i + x_0^i\Delta_0$, and normalizing that $B_{-1} = 0$, we obtain the intermediary's problem (6) given in the text. The first-order condition (7) gives:

$$\frac{n_1+2}{n_1+1}\left(S-2x_0^i\right)=\frac{2}{\left(n_1+1\right)^2}\left(S-x_0^i\right),\ i=1,\ldots,n$$

Using $n_1 = n$, and solving for the Nash equilibrium, we obtain intermediaries' trades:

$$x_0^i = x_0 = \frac{n(n+3)}{n^3+4n^2+3n+2}s \equiv \kappa_{0,n}s \tag{15}$$

Substituting into (15) into (13) gives the time 1 equilibrium trade:

$$x_1^i = x_1 = \frac{n+2}{n^3+4n^2+3n+2} \equiv \kappa_{1,n}s \tag{16}$$

It is clear that for all $n \geq 1$, $n\kappa_{0,n} < 1$ and $n(\kappa_{0,n}+\kappa_{1,n}) < 1$, so that $\sum_{i=1}^n x_0^i < s$ and $\sum_{i=1}^n X_1^i < s$. Then, by substituting (15) into the spread schedules, we obtain the equilibrium spreads:

$$\Delta_0 = 2a\sigma^2 \underbrace{\frac{(n+2)^2}{n^3+4n^2+3n+2}}_{\bar{\kappa}_{0,n}} s \tag{17}$$

$$\Delta_1 = 2a\sigma^2 \underbrace{\frac{n+2}{n^3+4n^2+3n+2}}_{\bar{\kappa}_{1,n}} s \tag{18}$$

■

B.2 Corollary 1

Proof. Using (17)-(18), for any $n \geq 1$, $\Delta_0 > \Delta_1 > 0 = \Delta_2$, and $\frac{\partial \Delta_t}{\partial n} < 0$ (t=0,1). Further, $\frac{\Delta_1}{\Delta_0} = \frac{1}{n+2}$ is decreasing in n and $lim_{n\to\infty}\Delta_t = 0(t=0,1)$. ■

C Sequential entry

C.1 Proposition 2 and Corollary 2

Proof. For given hedgers' beliefs about entry (and thus given price schedules), I derive the incumbents' reaction functions and pin down the equilibrium.

If hedgers anticipate no entry at time 1 ($\hat{n}_1 = n$). Suppose first that hedgers anticipate no entry. Then the price schedule is given by $\Delta_0(S - x_0^i; n)$. Using (6), and replacing the spread and time-1 payoff by their expressions, incumbents' value function is

$$\Pi_0^{ne}\left(x_0^i; S\right) = \max_{x_0^i} 2a\sigma^2 \frac{n+2}{n+1} x_0^i \left(S - x_0^i\right) + 2a\sigma^2 \frac{\left(S - x_0^i\right)^2}{(n+1)^2} \tag{19}$$

Since the entrant has no initial position nor cash, her gross payoff is $\pi_1(S - x_0^i; n+1)$. Thus, using (4) the entry condition at time 1 is:

$$2a\sigma^2 \frac{(s - \sum_{i=1}^n x_0^i)^2}{(n+2)^2} \geq I \tag{20}$$

This condition is equivalent to $|S - x_0^i| \geq (n+2)\rho$, where $\rho \equiv \sqrt{\frac{I}{2a\sigma^2}}$ stand for normalized entry costs. Upon inspection of equation (19), we can see that Π^{ne} is negative if $x_0^i > S$, thus it is sufficient to consider $x_0^i \in [0, S]$. In this case, condition (20) is equivalent to $S - x_0^i \geq (n+2)\rho$ and we can define

$$x_0^l(S) = S - (n+2)\rho \tag{21}$$

as the limit trade allowing entry. From the first-order condition, the maximum of Π^{ne} is attained at

$$x_0^i = x_0^{bmk}(S) = \frac{n(n+3)}{2(n^2+3n+1)} S \tag{22}$$

This trade is consistent with no entry if $x_0^{bmk}(S) > x_0^l(S)$, which, using (21), is equivalent to $\sum_{-i} x_0^{-i} > Z_1$, where

$$Z_1 = s - \frac{2(n^2+3n+1)}{n+1} \rho \tag{23}$$

Thus if $\sum_{-i} x_0^{-i} > Z_1$, incumbent i's best-response is $x_0^{bmk}(S)$. If $\sum_{-i} x_0^{-i} \leq Z_1$, the incumbent's optimal trade is noy large enough to deter the imitator from entering, and thus the incumbent must trade-off deterring and accommodating the entrant. Deterring requires to trade a quantity above x_0^l. Since in this case, $x_0^l \geq x_0^{bmk}(S)$, and since Π^{ne} is decreasing for $x_0 \leq x_0^{bmk}(S)$, the incumbent chooses $x_0^{det} = x_0^l + \eta$, where η is arbitrarily small and positive. Letting $\eta \to 0$, the payoff of deterring converges towards

$\Pi^{ne}(x_0^l) = 2a\sigma^2 \frac{n+2}{n+1}(S-(n+2)\rho)(n+2)\rho + 2a\sigma^2 \frac{(n+2)^2}{(n+1)^2}\rho^2$. This can be simplified to:

$$\Pi^{ne}(x_0^l) = 2a\sigma^2 \frac{(n+2)^2}{n+1}\left[S\rho - \frac{n^2+3n+1}{n+1}\rho^2\right] \tag{24}$$

The alternative for the incumbent is to accommodate. In this case, the incumbent's problem is

$$\begin{aligned}\max_{x_0^i} \Pi^e\left(x_0^i; S\right) &= x_0^i \Delta_0(S - x_0^i; n) + \pi_1(S - x_0^i; n+1) \\ &= 2a\sigma^2 \frac{n+2}{n+1} x_0^i (S - x_0^i) + 2a\sigma^2 \frac{(S-x_0^i)^2}{(n+2)^2} \end{aligned} \tag{25}$$

Since each incumbent is pivotal, the continuation payoff changes to $\frac{(S-x_0^i)^2}{(n+2)^2}$, i.e. the accommodating incumbent internalizes the fact that his trade will increase competition in the next period. From the first-order condition, Π^e is maximum at:

$$x_0^i = x_0^{acc}(S) = \frac{n^3+6n^2+10n+6}{2(n^3+6n^2+11n+7)} S \tag{26}$$

This trade does lead to entry if $x_0^{acc}(S) \leq x_0^l(S)$, which is equivalent to $\sum_{-i} x_0^{-i} \leq \tilde{Z}$, where

$$\tilde{Z} = s - \frac{2(n^3+6n^2+11n+7)}{(n+2)^2}\rho \tag{27}$$

I study the position of $\tilde{Z}$ relative to Z_1:

$$Z_1 > \tilde{Z} \Leftrightarrow \; 2n+3 > 0$$

Thus for any $n \geq 1$, $Z_1 > \tilde{Z}$. Hence if $\sum_{-i} x_0^{-i} \in \left(\tilde{Z}, Z_1\right]$, the incumbent will always prefer to deter. Indeed, in this case, accommodating requires to trade at most x_0^l and $\Pi^{ne}(x_0^l) > \Pi^e(x_0^l)$. Thus, it is sufficient to analyze the trade-off between deterring and accommodating for $\sum_{-i} x_0^{-i} \leq \tilde{Z}$. To do so, one needs to calculate the payoff of each action. The deterrence payoff is given by (24). Substituting (26) into Π^e yields the accommodating payoff:

$$\Pi^e\left(x_0^{acc}(S)\right) = 2a\sigma^2 \frac{(n+2)^4}{4(n+1)(n^3+6n^2+11n+7)} S^2 \tag{28}$$

Thus, the incumbent prefers to deter iff

$$\Pi^{ne}(x_0^l) \geq \Pi^e(x_0^{acc}(S)) \Leftrightarrow \frac{(n+2)^2}{n+1}\left[S\rho - \frac{n^2+3n+1}{n+1}\rho^2 - \frac{(n+2)^2}{4(n^3+6n^2+11n+7)}S^2\right] \geq 0 \tag{29}$$

The term in bracket can be viewed as a second-order polynomial in S. Its discriminant is:

$$\mathbf{\Delta} = \frac{2n+3}{(n+1)(n^3+6n^2+11n+7)}\rho^2 \tag{30}$$

Inspecting (29), one can see that there are two positive roots,

$$S_1 = \frac{2(n^3+6n^2+11n+7)}{(n+2)^2}\left[1 - \sqrt{\frac{2n+3}{(n+1)(n^3+6n^2+11n+7)}}\right]\rho \equiv \underline{\lambda}_n\rho \tag{31}$$

$$S_2 = \frac{2(n^3+6n^2+11n+7)}{(n+2)^2}\left[1 + \sqrt{\frac{2n+3}{(n+1)(n^3+6n^2+11n+7)}}\right]\rho \equiv \bar{\lambda}_n\rho \tag{32}$$

Hence deterring is the incumbent's best-response when $S \in [S_1, S_2]$.

$$S \geq S_1 \Leftrightarrow \; s - \underline{\lambda}_n\rho \geq \sum_{-i} x_0^{-i}$$

However, from the definitions of $\tilde{Z}$ and $\underline{\lambda}_n$ in (27) and (31),

$$\underline{\lambda}_n < \frac{2(n^3+6n^2+11n+7)}{(n+2)^2},$$

which implies that $s - \underline{\lambda}_n\rho > \tilde{Z}$. Thus the first root is not relevant. Since $\bar{\lambda}_n > \frac{2(n^3+6n^2+11n+7)}{(n+2)^2}$, we have $s - \bar{\lambda}_n\rho < \tilde{Z}$. It will be convenient to use the following notation:

$$Z_2 \equiv s - \bar{\lambda}_n\rho \tag{33}$$

In summary, if hedgers anticipate no entry, we can write the best-response of incumbent i as follows.

$$x_0^{b.r.}(S) = \begin{cases} x_0^{bmk}(S) \text{ if } \sum_{-i} x_0^{-i} > Z_1 \\ x_0^{det} = x_0^l(S) + \eta \text{ if } Z_2 < \sum_{-i} x_0^{-i} \leq Z_1 \\ x_0^{acc}(S) \text{ if } \sum_{-i} x_0^{-i} \leq Z_2 \end{cases}$$

We can now determine the equilibrium and the equilibrium thresholds by intersecting the best-response functions. There are three type of equilibria depending on where best-responses intersect. In the first region, there is a unique equilibrium since the best-response function has slope between -1 and 0. The equilibrium is the benchmark trade

$$x_0^{bmk} = \frac{n(n+3)}{n^3+4n^2+3n+2}s$$

(This quantity is the equilibrium trade, and is thus different from $x_0^{bmk}(S)$, which is the best-response to S when $\sum_{-i} x_0^{-i} > Z_1$) This equilibrium trade implies that the condition $\sum_{-i} x_0^{-i} > Z_1$ is equivalent to the following equilibrium threshold:

$$\rho > \rho^{bmk} \equiv \frac{n+1}{n^3+4n^2+3n+2}s \tag{34}$$

In the second region, with $Z_2 < \sum_{-i} x_0^{-i} \leq Z_1$, the best-response function has slope -1, thus there is a continuum of equilibria that are such that $\sum_{i=1}^{n} x_0^i = s-(n+2)\rho+\eta$, with η arbitarily small and positive, where $\forall\ i = 1,\ldots,n, x_0^i \geq 0$ and $\sum_{j=1,j\neq i}^{n} x_0^j \in\ ]Z_2, Z_1]$. The equilibrium is not necessarily symmetric, but one can show that the lowest ρ such that deterrence is an equilibrium is obtained when the equilibrium is symmetric. This is intuitive since the condition $Z_2 < \sum_{-i} x_0^{-i} \leq Z_1$ must hold for any $i = 1,\ldots,n$, and thus the equilibrium condition results from the intersection of the conditions on ρ for all i, i.e. the equilibrium condition is the highest threshold. In the symmetric equilibrium, $x_0 = \frac{1}{n}\left[s-(n+2)\rho+\eta\right]$. This implies that ρ must be lower than ρ^{bmk} and strictly larger than

$$\underline{\rho} = \frac{s}{n\bar{\lambda}_n-(n-1)(n+2)} \tag{35}$$

(note that $\bar{\lambda}_n > (n+2)$, which guarantees that $\underline{\rho} > 0$). We can show that this is the lowest possible equilibrium threshold. First, note that $\rho > Z_2$ is equivalent to

$$\rho > \frac{s-\sum_{-i}^{n} x_0^{-i}}{\bar{\lambda}_n}$$

This condition is valid for all i. Now consider an asymmetric equilibrium. There exists at least an incumbent j with $x_0^j = x_0^{det}+\mu > x_0^{det}$, and an incumbent k, with $x_0^k = x_0^{det}-\mu < x_0^{det}$. Thus, there exists quantities $X^u = (n-1)x_0^{det}+\mu$ (incumbent j plus $n-2$ others, but not k) and $X^d = (n-1)x_0^{det}-\mu$ (incumbent k plus n-2 others, but not j). X^u is the largest of $\sum_{-i} x_0^{-i}$ and X^d the smallest. Thus the binding constraint is $\rho > \frac{s-(n-1)x_0^{det}+\mu}{\bar{\lambda}_n}$ which is strictly greater $\underline{\rho} = \frac{s-(n-1)x_0^{det}}{\bar{\lambda}_n}$ in the symmetric case. Thus $\underline{\rho}$ is the lowest deterrence equilibrium threshold.

In the third region, the slope of the best-response function is negative but strictly greater than -1, so that the intersection of the best-response functions is unique. At the intersection, the total quantity traded by incumbents will be such that the imitator enters at time 1, contradicting the anticipation of hedgers. Since hedgers have rational expectations, this is not possible. Thus we need to study the case where hedgers anticipate entry.

If hedgers anticipate entry at time 1 ($\hat{n}_1 = n+1$). Suppose now that hedgers believe that the imitator enters the market at time 1. The spread schedule is given by $\Delta_0(S - x_0^i; n+1)$. Therefore, incumbent i's value function under the expectation of entry is

$$\max_{x_0^i} \bar{\Pi}^e\left(x_0^i; S\right) = x_0^i \Delta_0(S - x_0^i; n+1) + \pi_1(S - x_0^i; n+1)$$
$$= 2a\sigma^2 \frac{n+3}{n+2} x_0^i (S - x_0^i) + 2a\sigma^2 \frac{(S - x_0^i)^2}{(n+2)^2} \tag{36}$$

Note that to distinguish notations from the case where hedgers anticipate no entry, all relevant quantities have a "−". Writing the first-order condition, we find that $\bar{\Pi}^e$ is maximum at

$$x_0^i = \frac{(n+1)(n+4)}{2(n^2+5n+5)} S = \bar{x}_0^{acc}(S) \tag{37}$$

This trade does lead to entry at time 1 if $\bar{x}_0^{acc}(S) \leq x_0^l(S) \Leftrightarrow \sum_{-i} x_0^{-i} \leq \bar{Z}_1$, where

$$\bar{Z}_1 \equiv s - \frac{2(n^2+5n+5)}{n+3} \rho \tag{38}$$

Even when $\bar{x}_0^{acc}(S)$ leads to entry, one must check for deviations leading to no entry, as each incumbent understands that he is pivotal for the outcome of the game and can thus raise his time-1 payoff. When $\sum_{-i} x_0^{-i} > \bar{Z}_1$, it is clear that incumbent i will always deviate and prevent entry. In this case, $\bar{x}_0^{acc}(S) > x_0^l(S)$, so that letting the imitator enter imposes to trade $x_0^l(S)$. But then increasing the trade by a small amount will deter the imitator and raise the time-1 continuation profit. Indeed $\bar{\Pi}^{ne}(x_0^l(S)) > \bar{\Pi}^e(x_0^l(S))$, where

$$\bar{\Pi}^{ne}(x_0^i) = 2a\sigma^2 \frac{n+3}{n+2} x_0^i (S - x_0^i) + 2a\sigma^2 \frac{(S - x_0^i)^2}{(n+1)^2} \tag{39}$$

Thus by continuity there exists a small $\eta > 0$ such that $\bar{\Pi}^{ne}(x_0^l(S) + \eta) > \bar{\Pi}^e(x_0^l(S))$.

When $\sum_{-i} x_0^{-i} \leq \bar{Z}_1$, it is no longer obvious that preventing entry dominates. Answering this question requires to study $\bar{\Pi}^{ne}$. $\bar{\Pi}^{ne}$ is maximum at

$$x_0^i = \frac{n^3 + 5n^2 + 5n - 1}{2(n^3 + 5n^2 + 6n + 1)} S \equiv \bar{x}_0^{det}(S) \tag{40}$$

This trade deters the imitator if $\bar{x}_0^{det}(S) > x_0^e(S)$, that is if $\sum_{-i} x_0^{-i} > \hat{Z}$, with

$$\hat{Z} = s - \frac{2(n+2)(n^3 + 5n^2 + 6n + 1)}{n^3 + 5n^2 + 7n + 3} \rho \tag{41}$$

The threshold $\hat{Z}$ is strictly greater than $\bar{Z}_1$, as $\hat{Z} > \bar{Z}_1$ is equivalent to $9(n+1) > 0$, which holds true. Thus, in the interval of interest, $\left[0, \bar{Z}_1\right]$, deterring entry requires to trade $x_0^e + \eta$. To determine incumbent i's best-response, one must thus compare $\bar{\Pi}^e(\bar{x}_0^{acc}(S))$ and $\bar{\Pi}^{ne}(x_0^l + \eta)$. Substituting (21) into (39) gives the deterrence payoff (with $\eta \to 0$)

$$\bar{\Pi}^{ne}(x_0^l) = 2a\sigma^2(n+3)S\rho - 2a\sigma^2 \frac{(n+2)(n^3 + 5n^2 + 6n + 1)}{(n+1)^2} \rho^2 \tag{42}$$

Similarly, substituting (37) into $\bar{\Pi}^e$ yields the accommodation payoff:

$$\bar{\Pi}^e(\bar{x}_0^{acc}(S)) = 2a\sigma^2 \frac{(n+3)^2}{4(n^2 + 5n + 5)} S^2 \tag{43}$$

Then given the aggregate trade by other incumbents, $\sum_{-i} x_0^{-i}$, incumbent i's best-response is to accommodate if $\bar{\Pi}^e(\bar{x}_0^{acc}(S)) \geq \bar{\Pi}^{ne}(x_0^l)$, which is equivalent to

$$\frac{(n+3)^2}{4(n^2 + 5n + 5)} S^2 - (n+3)S\rho + \frac{(n+2)(n^3 + 5n^2 + 6n + 1)}{(n+1)^2} \rho^2 \geq 0 \tag{44}$$

The discriminant of this polynomial in S is

$$\bar{\boldsymbol{\Delta}} = \frac{(n+3)^2(2n+3)\rho^2}{(n+1)^2(n^2 + 5n + 5)} > 0$$

Following standard arguments, one can see that there are two positive roots:

$$\bar{S}_1 = \frac{2(n^2+5n+5)}{n+3}\left[1 - \frac{1}{n+1}\sqrt{\frac{2n+3}{n^2+5n+5}}\right] = \underline{\alpha}_n\rho \tag{45}$$

$$\bar{S}_2 = \frac{2(n^2+5n+5)}{n+3}\left[1 + \frac{1}{n+1}\sqrt{\frac{2n+3}{n^2+5n+5}}\right] = \bar{\alpha}_n\rho \tag{46}$$

The incumbent chooses to accommodate when $S \leq \bar{S}_1$ or when $S \geq \bar{S}_2$. $S \leq \bar{S}_1$ is equivalent to $\sum_{-i} x_0^{-i} \geq s - \underline{\alpha}_n\rho$. However, since $\forall n \geq 1$, $\underline{\alpha}_n < \frac{2(n^2+5n+5)}{n+3} < \frac{2(n^2+3n+1)}{n+1}$, $s - \underline{\alpha}_n\rho > \bar{Z}_1$, and thus the first condition is irrelevant. The second condition, $S \geq \bar{S}_2$, is equivalent to $\sum_{-i} x_0^{-i} \leq s - \bar{\alpha}_n\rho$. Since $\forall n \geq 1$, $\bar{\alpha}_n > \frac{2(n^2+3n+1)}{n+1}$, $s - \bar{\alpha}_n\rho < \bar{Z}_1$. Hence, if hedgers anticipate entry, incumbent i's best-response is

$$x_0^i = \begin{cases} \bar{x}_0^{acc}(S) \text{ if } \sum_{-i} x_0^{-i} \leq s - \bar{\alpha}_n\rho \\ x_0^l + \eta,\ \eta \text{ positive and arbitrarily small, if } \sum_{-i} x_0^{-i} > s - \bar{\alpha}_n\rho \end{cases}$$

Since hedgers anticipate entry, only the accommodate best-response is consistent with equilibrium. When $\sum_{-i} x_0^{-i} \leq s - \bar{\alpha}_n\rho$, best-responses have a negative slope which is strictly larger than one, and thus have a unique intersection. The equilibrium is

$$x_0^{acc} = \frac{(n+1)(n+4)}{n^3+6n^2+9n+6}s \tag{47}$$

This implies that the equilibrium threshold is

$$\begin{aligned} &(n-1)x_0^{acc} > s - \bar{\alpha}_n\rho \Leftrightarrow\ \rho < \bar{\rho} \\ &\text{with } \bar{\rho} \equiv \frac{2(n^2+5n+5)}{(n^3+6n^2+9n+6)\bar{\alpha}_n}s \end{aligned} \tag{48}$$

Ranking thresholds. We can now compare the thresholds ρ^{bmk}, $\underline{\rho}$ and $\bar{\rho}$. First, let's show that $\bar{\rho} < \rho^{bmk}$. Since $s > 0$, using (34) and (48)

$$\rho^{bmk} > \bar{\rho} \Leftrightarrow\ \frac{n+1}{n^3+4n^2+3n+2} > \frac{n+3}{(n^3+6n^2+9n+6)\left[1+\frac{1}{n+1}\sqrt{\frac{2n+3}{n^2+5n+5}}\right]}$$

$$4n + (n^3+6n^2+9n+6)\sqrt{\frac{2n+3}{n^2+5n+5}} > 0$$

which holds for any $n \geq 1$. Second, let's compare $\underline{\rho}$ and $\bar{\rho}$. When $n = 1$, $\bar{\rho} \approx 0.13598s$

and $\underline{\rho} \approx 0.13675s$. Thus, $\bar{\rho} < \underline{\rho}$ in this case, implying that there is no equilibrium in pure strategies when $\rho \in [\bar{\rho}, \underline{\rho}]$. I turn to the case where $n \geq 2$. Using (35) and (48), and substituting for $\bar{\lambda}_n$ and $\bar{\alpha}_n$ (equations (32) and (46)) gives:

$$\bar{\rho} = \frac{(n+3)s}{(n^3+6n^2+9n+6)\left[1+\frac{1}{n+1}\sqrt{\frac{2n+3}{n^2+5n+5}}\right]} \tag{49}$$

$$\underline{\rho} = \frac{(n+2)^2 s}{2n(n^3+6n^2+11n+7)\left[1+\sqrt{\frac{2n+3}{(n+1)(n^3+6n^2+11n+7)}}\right]} \tag{50}$$

Thus, after developing and rearranging terms, we find that $\bar{\rho} > \underline{\rho}$ is equivalent to:

$$2n(n+3)\theta_n\left(1+\sqrt{\frac{2n+3}{\theta_n}}\right) > (n+2)^2\phi_n\left(1+\frac{1}{n+1}\sqrt{\frac{2n+3}{n^2+5n+5}}\right)$$

where I denoted $\theta_n = n^3+6n^2+11n+7$ and $\phi_n = n^3+6n^2+9n+6$. Denote $T_n = 2n(n+3)\theta_n - (n+2)^2\phi_n$. After developing terms, we get:

$$(n+1)\left[T_n + 2n(n+3)\sqrt{\theta_n(2n+3)}\right] > (n+2)^2\phi_n\sqrt{\frac{2n+3}{n^2+5n+5}}$$

This condition can be rewritten as:

$$I_n + (n^2+5n+5)(n+1)^2 4n(n+3)T_n\sqrt{\theta_n(2n+3)} > 0$$

where $I_n = (n^2+5n+5)(n+1)^2(T_n^2+4n^2(n+3)^2\theta_n(2n+3)) - (n+2)^2\phi_n^2(2n+3)$. Since $I_n > 0$ for all $n \geq 1$, the previous condition holds, and thus $\bar{\rho} > \underline{\rho}$, implying that the deterrence and accommodate equilibria coexist when $\rho \in [\underline{\rho}, \bar{\rho}]$.

Equilibrium spreads. I compute the equilibrium spreads by substituting equilibrium trades into the relevant spread schedules. In the benchmark case, the spread is given in

Proposition 1. In the other cases, this gives:

$$\Delta_0^{acc} = 2a\sigma^2 \frac{(n+3)^2}{n^3+6n^2+9n+6} s \tag{51}$$
$$\Delta_1^{acc} = 2a\sigma^2 \frac{n+3}{n^3+6n^2+9n+6} s \tag{52}$$
$$\Delta_0^{det} = 2a\sigma^2 \frac{n+2}{n+1} \left((n+2)\rho - \eta\right) \tag{53}$$
$$\Delta_1^{det} = 2a\sigma^2 \frac{(n+2)\rho - \eta}{n+1} \tag{54}$$

■

C.2 Corollary 6

Proof. Aggregate trade. Since entry occurs in the accommodate equilibrium, $s - \sum_{i=1}^n x_0^{acc} \geq (n+2)\rho > s - \sum_{i=1}^n x_0^{det}$, thus $\sum_{i=1}^n x_0^{det} > \sum_{i=1}^n x_0^{acc}$. *Spreads.* At time 0, equilibrium spreads are given by (51) and (53). From these expressions, $\Delta_0^{acc} < \Delta_0^{det}$ is equivalent to $\rho > \tilde{\rho}$, with

$$\tilde{\rho} = \frac{(n+1)(n+3)^2}{(n+2)^2(n^3+6n^2+9n+6)} s$$

I now show that $\rho \in \left[\underline{\rho}, \bar{\rho}\right]$ implies that $\rho > \tilde{\rho}$, so that the condition is satisfied on the interval of interest. From equation (35), $\tilde{\rho} < \bar{\rho}$ is equivalent to

$$(n+1)(n+3)\left[1 + \frac{1}{n+1}\sqrt{\frac{2n+3}{n^2+5n+5}}\right] > (n+2)^2$$

After some simple algebra, the condition becomes $(n^2+6n+9)(2n+3) > n^2+5n+5$, which holds true for any $n \geq 1$. Thus, $\tilde{\rho} > \underline{\rho}$, and thus $\Delta_0^{acc} > \Delta_0^{det}$ when equilibria coexist.

At time 1, $\Delta_1^{acc} > \Delta_1^{det}$ is equivalent to $\rho < \frac{(n+3)(n+1)}{(n+2)(n^3+6n^2+9n+6)} s \equiv \tilde{\rho}_1$. But $\tilde{\rho}_1 > \bar{\rho}$ is equivalent to (skipping some simple algebra)

$$(n+3)(n+1)(n^3+6n^2+11n+7)\left(1 + \sqrt{\frac{2n+3}{(n+1)(n^3+6n^2+11n+7)}}\right)$$
$$> (n+2)^3(n^3+6n^2+9n+6) - 2n(n+3)(n+1)(n^3+6n^2+11n+7)$$

The right-hand side boils down to $-(n^8+8n^5+19n^4-2n^3-70n^2-102n-48)$, which is negative for any $n \geq 2$. Note that for $n = 1$, direct calculation of $\bar{\rho}$ and $\tilde{\rho}_1$ shows that $\bar{\rho} < \tilde{\rho}_1$. Thus, for $t = 0, 1$, for any $n \geq 1$, $\Delta_t^{acc} > \Delta_t^{det}$ when equilibria coexist.

Intermediaries' welfare. Substituting equilibrium trades into Π^{ne} and $\bar{\Pi}^{e}$ gives the equilibrium payoffs from deterrence and accommodate (assuming that incumbents hold symmetric positions in the deterrence equilibrium):

$$\Pi^{acc} = 2a\sigma^2 \frac{(n+3)^2(n^2+5n+5)}{(n^3+6n^2+9n+6)^2} s^2 \tag{55}$$

$$\Pi^{det} = 2a\sigma^2 \frac{(n+2)^2}{n(n+1)} \left[s\rho - \frac{n^2+2n+2}{n+1} \rho^2 \right] \tag{56}$$

Thus the difference is

$$\Pi^{det} - \Pi^{acc} = -\frac{(n+2)^2}{n(n+1)} \frac{n^2+2n+2}{n(n+1)^2} \rho^2 + \frac{(n+2)^2}{n(n+1)} s\rho - \frac{(n+3)^2(n^2+5n+5)}{(n^3+6n^2+9n+6)^2} s^2$$

The discriminant of this second-order polynomial in ρ is (skipping some algebra)

$$\Lambda = \frac{(n+2)^2 A_n}{n^2(n+1)^2(n^3+6n^2+9n+6)^2} s^2$$

where $A_n = n^8 + 12n^7 + 54n^6 + 112n^5 + 109n^4 + 68n^3 + 120n^2 + 216n + 144 > 0$. There are two positive roots r_1, and r_2, given by

$$r_1 = \frac{n+1}{2(n^2+2n+2)} \left[1 - \frac{\sqrt{A_n}}{(n+2)(n^3+6n^2+9n+6)} \right] s = \underline{\lambda}_n s \tag{57}$$

$$r_2 = \frac{n+1}{2(n^2+2n+2)} \left[1 + \frac{\sqrt{A_n}}{(n+2)(n^3+6n^2+9n+6)} \right] s = \bar{\lambda}_n s, \tag{58}$$

and $\Pi^{det} \geq \Pi^{acc} \Leftrightarrow \rho \in [r_1, r_2]$. I now show that this condition is never satisfied in the interval of interest, $[\underline{\rho}, \bar{\rho}]$, because for all $n \geq 2$, $r_1 > \bar{\rho}$. Indeed, some simple algebra shows that $r_1 > \bar{\rho}$ requires

$$\begin{aligned} 2(n+2)(n+3)(n^2+2n+2) &< (n+1)(n+2)(n^3+6n^2+9n+6) \\ &- \left(n+1+\sqrt{\frac{2n+3}{n^2+5n+5}} \right) \sqrt{A_n} + (n+2)(n^3+6n^2+9n+6)\sqrt{\frac{2n+3}{n^2+5n+5}} \end{aligned}$$

We can rewrite this inequality as

$$\sqrt{A_n}\left(n+1+\sqrt{\frac{2n+3}{n^2+5n+5}}\right) < v_n\sqrt{\frac{2n+3}{n^2+5n+5}}+u_n$$

where $v_n = (n+2)(n^3+6n^2+9n+6)$, and $u_n = n^5+7n^4+15n^3+9n^2-8n-12$. Thus, raising both sides to the square and rearranging terms gives:

$$A_n g_n - h_n < 2k_n\sqrt{j_n}$$

where $g_n = (n+1)^2(n^2+5n+5)+2n+3$, $h_n = (2n+3)v_n^2+(n^2+5n+5)u_n^2$, $k_n = u_n v_n-(n+1)A_n$ and $j_n = (2n+3)(n^2+5n+5)$. Both $A_n g_n - h_n$ and k_n are positive for all $n \geq 2$, thus raising again both sides to the square gives

$$4k_n^2 j_n - A_n^2 g_n^2 - h_n^2 + 2A_n g_n h_n > 0$$

The left-hand side takes the form of a polynom in n, $\sum_{i=0}^{19} a_i n^i$. The coefficients, calculated using Mathematica, are $a_0 = 4976640$, $a_1 = 34007040$, $a_2 = 103373568$, $a_3 = 176828160$, $a_4 = 165480128$, $a_5 = 27690368$, $a_6 = -153420416$, $a_7 = -244934720$, $a_8 = -202669456$, $a_9 = -95356096$, $a_{10} = -10534000$, $a_{11} = 21485328$, $a_{12} = 19664048$, $a_{13} = 9779632$, $a_{14} = 3299888$, $a_{15} = 789136$, $a_{16} = 132704$, $a_{17} = 14992$, $a_{18} = 1024$, $a_{19} = 32$. It is easy to check that this polynom is positive for any $n \geq 2$.

Hedgers' welfare. Next, I calculate hedgers' welfare in both equilibria. First, susbstituting hedgers' optimal demand functions into their maximisation problems yields their equilibrium certainty equivalent as a function of the spreads Δ_0 and Δ_1. Starting from in the proof of Proposition , and using the assumptions that $W_0^k = Y_{-1}^k = 0$, we get, for hedgers in market A (market B is symmetric):

$$\begin{aligned}
CE_0 &= y_0\left(\mathbb{E}_0(p_1)-p_0\right) - \frac{a\sigma^2}{2}\frac{\left(\mathbb{E}_0(p_1)-p_0\right)^2}{a^2\sigma^4} + \frac{\mathbb{E}_0\left[(D_1-p_1)^2\right]}{2a\sigma^2} - \mathbb{E}_0(s_1(D_1-p_1)) \\
&= y_0\left(\mathbb{E}_0(p_1)-p_0\right) - \frac{\left(\mathbb{E}_0(p_1)-p_0\right)^2}{2a\sigma^2} + \mathbb{E}_0\left[\frac{(D_1-p_1)^2}{2\sigma^2} - s_1(D_1-p_1)\right] \\
&= \frac{\mathbb{E}_0\left[(p_1-p_0)^2\right]+\mathbb{E}_0\left[(D_1-p_1)^2\right]}{2a\sigma^2} - s_0\left[\mathbb{E}_0(p_1)-p_0\right] - s_1\mathbb{E}_0(D_1-p_1) \\
&= \frac{\mathbb{E}_0\left[(p_1-p_0)^2\right]+\mathbb{E}_0\left[(D_1-p_1)^2\right]}{2a\sigma^2} - s\left[\mathbb{E}_0(p_1)-p_0+\mathbb{E}_0(D_1-p_1)\right]
\end{aligned}$$

where the third equation follows from substituting hedgers' demand and the fourth by using the assumption that $s_0 = s_1 = s$. Since in market A, $D - p_0 = \frac{\Delta_0}{2}$ and $D_1 - p_1 = \frac{\Delta_1}{2}$, and $\mathbb{E}_0(p_1) - p_0 = \mathbb{E}(p_1 - D_1) + D - p_0 = \frac{\Delta_0 - \Delta_1}{2}$, we can write hedgers' equilibrium certainty equivalent as follows:

$$CE_0 = \frac{(\Delta_0 - \Delta_1)^2 + \Delta_1^2}{8a\sigma^2} - \frac{s\Delta_0}{2} \tag{59}$$

Taking the first derivative, we get:

$$\frac{\partial CE_0}{\partial \Delta_0} \leq 0 \Leftrightarrow \ \Delta_0 - \Delta_1 \leq 2a\sigma^2 s$$

This inequality is always satisfied in equilibrium since $\Delta_0 = \Delta_1 + 2a\sigma^2 \left(s - \sum_{i=1}^n x_0^i\right)$ and $x_0^i \geq 0$ in equilibrium.

$$\frac{\partial CE_0}{\partial \Delta_1} \leq 0 \Leftrightarrow \ \Delta_1 \leq \frac{\Delta_0}{2}$$

This equality is satisfied for any $n \geq 1$ whether entry is anticipated by hedgers or not, since by dividing the time-1 spread in the subgame equilibrium and the time 0 spread schedule, one gets that (assuming $\sum_j x_0^j < s$, which holds true in equilibrium):

$$\frac{\Delta_1^{ne}\left(\sum_{i=1}^n x_0^i\right)}{\Delta_0^{ne}\left(\sum_{i=1}^n x_0^i\right)} = \frac{1}{n+2}, \text{ and } \frac{\Delta_1^{e}\left(\sum_{i=1}^n x_0^i\right)}{\Delta_0^{e}\left(\sum_{i=1}^n x_0^i\right)} = \frac{1}{n+3}$$

Substituting deterrence equilibrium spreads (53) and (54) into (59) yields hedgers' equilibrium certainty equivalent when incumbents deter:

$$CE^{det} = \frac{a\sigma^2}{2}\frac{(n+2)^2(n^2+2n+2)}{(n+1)^2}\rho^2 - a\sigma^2\frac{(n+2)^2}{n+1}s\rho \tag{60}$$

Similarly, substituting deterrence equilibrium spreads (51) and (52) into (59) yields hedgers' equilibrium certainty equivalent in the accommodate case:

$$CE^{acc} = -\frac{(n+3)^2(2n^3+11n^2+14n+7)}{2(n^3+6n^2+9n+6)^2}a\sigma^2 s^2 \tag{61}$$

(60) and (61) imply that $CE^{det} \geq CE^{acc}$ is equivalent to

$$\frac{a\sigma^2}{2}\frac{(n+2)^2(n^2+2n+2)}{(n+1)^2}\rho^2 - a\sigma^2\frac{(n+2)^2}{n+1}s\rho + \frac{(n+3)^2(2n^3+11n^2+14n+7)}{2(n^3+6n^2+9n+6)^2}a\sigma^2 s^2 \geq 0$$

The discriminant of the left-hand side (as a polynomial in ρ) is

$$\Delta^h = \frac{(n+2)^2}{(n+1)^2} \frac{n^8 + 14n^7 + 79n^6 + 236n^5 + 417n^4 + 456n^3 + 301n^2 + 114n + 18}{(n^3 + 6n^2 + 9n + 6)^2} \equiv \frac{(n+2)^2}{(n+1)^2} \tilde{\Delta}^h$$

There are two positive roots, with the smallest one given by

$$r_1^h = \frac{(n+1)(n+2-\sqrt{\tilde{\Delta}^h})}{(n+2)(n^2+2n+2)}$$

Then it is possible to show that $r_1^h > \bar{\rho}$. This inequality is equivalent to

$$(n+1)(n+2-\sqrt{\tilde{\Delta}^h})\phi_n \left(1 + \frac{1}{n+1}\sqrt{\frac{2n+3}{n^2+5n+5}}\right) > l_n$$

where $\phi_n = n^3+6n^2+9n+6$ and $l_n = (n+2)(n+3)(n^2+2n+2)$. Developing and rearranging terms, we get:

$$(n+1)(n+2)\phi_n - l_n + (n+2)\phi_n \sqrt{\frac{2n+3}{n^2+5n+5}} > \phi_n \sqrt{\tilde{\Delta}^h} \left(n+1+\sqrt{\frac{2n+3}{n^2+5n+5}}\right)$$

Let $L_n = (n+1)(n+2)\phi_n - l_n = n^5 + 8n^4 + 22n^3 + 27n^2 + 14$, and raise both side to the square to get

$$(n^2+5n+5)L_n^2+(n+2)^2\phi_n^2(2n+3) > \phi_n^2 \tilde{\Delta}^h \left((n+1)^2(n^2+5n+5) + 2n + 3 + 2(n+1)\sqrt{(2n+3)(n^2+5n$$

Raising both sides to the square and rearranging terms, we can simplify the expression as for intermediaries' welfare. We obtain a positive polynomial. Thus, when equilibria coexist, hedgers are better off in any deterrence equilibrum.

Total welfare. Total welfare is defined as the sum of intermediaries' and hedgers' expected utilities. In the accommodate equilbrium, the entrant's utility is as of time 1. However, since the equilibrium is deterministic and the risk-free rate equal to zero, it coincides with the expected utility at time 0. The entrant's profit is $\Pi^{n+1} = 2a\sigma^2 \frac{(n+3)^2}{(n^3+6n^2+9n+6)^2} s^2 - I$ if he enter and 0 otherwise. Given that there are two mass-one fringes of hedgers, we have: $TW^{det} = \sum_{j=1}^{n} u^j(\Pi^{det}) + u^{n+1}(0) + 2(-\exp(-aCE^{det}))$ and $TW^{acc} = \sum_{j=1}^{n} u^j(\Pi^{acc}) + u^{n+1}(\Pi^{n+1}) + 2(-\exp(-aCE^{acc}))$.

■

C.3 Corollary 3

Proof. Accommodate vs benchmark. The effect on market depth follows from (9). Comparing (47) and (15) shows that $\forall n \geq 1$, $x_0^{acc} > x_0^{bmk}$. This implies that

$$x_1^{acc} = \frac{s - \sum_j x_0^{acc}}{n+2} < \frac{s - \sum_j x_0^{acc}}{n+1} < \frac{s - \sum_j x_0^{bmk}}{n+1} = x_1^{bmk}$$

This implies that $\Delta_1^{acc} < \Delta_1^{bmk}$. At time 0, it is straightforward to show that $\Delta_0^{acc} < \Delta_0^{bmk}$ using (51) and (17).

Deterrence vs benchmark. By construction, $\forall n \geq 1$, $x_0^{det} > x_0^{bmk} \Leftrightarrow \rho < \rho^{bmk}$. This implies that $\Delta_0^{det} < \Delta_0^{bmk}$ and that

$$x_1^{det} = \frac{s - \sum_j x_0^{det}}{n+1} < \frac{s - \sum_j x_0^{bmk}}{n+1} = x_1^{bmk}$$

This inequality further implies that $\Delta_1^{det} < \Delta_1^{bmk}$. ■

C.4 Corollary 4

Proof. The comparative statics are immediate from the definition of Δ_t^{det} in equations (53)-(54), Δ_t^{acc} in equations (51)-(52), and Δ_t^{bmk} in (17)-(18). ■

D Model without feedback effect

I solve for the accommodate equilibrium, assuming that hedgers understand that there are two trading rounds, but are not aware that entry may occur. Therefore the price schedule is unchanged relative to the deterrence equilibrium. Note that the deterrence equilibrium is unchanged. I keep the same notation as in the main model, unless I make comparisons between models. In that case, a superscript "nf" denotes the 'no feedback' model.

D.1 Equilibrium

Proposition 3 (Equilibrium without feedback effects) *The equilibrium is the same as in the main model, except that in the accommodate equilibrium the treshold is $\bar{\rho}^{nf}$, and the equilibrium trade is $x_0^{acc,m} = \frac{n^3+6n^2+10n+6}{n^4+7n^3+16n^2+18n+8}s$. Further, when $n = 1$, there is a single threshold between the deterrence and accommodate equilibria, i.e. $\underline{\rho}^{nf} = \bar{\rho}^{nf}$.*

Proof. Incumbents' value function when they expect entry but hedgers do not is

$$\max_{x_0^i} \bar{\Pi}^e\left(x_0^i, S\right) = x_0^i \Delta_0(S - x_0^i; n) + \pi_1(S - x_0^i, n+1)$$
$$= 2a\sigma^2 \frac{n+2}{n+1} x_0^i (S - x_0^i) + 2a\sigma^2 \frac{(S - x_0^i)^2}{(n+2)^2} \tag{62}$$

From the first-order condition, we find that $\bar{\Pi}^e$ is maximum at

$$x_0^i = \frac{n^3 + 6n^2 + 10n + 6}{2(n^3 + 6n^2 + 11n + 7)} S = \bar{x}_0^{acc}(S) \tag{63}$$

Note that this is the same quantity as the deviation from deterrence in the model with rational hedgers, which is logical. This trade does lead to entry at time 1 if $\bar{x}_0^{acc}(S) \leq x_0^l(S) \Leftrightarrow \sum_{-i} x_0^{-i} \leq \bar{Z}_1$, where

$$\bar{Z}_1 \equiv s - \frac{2(n^3 + 6n^2 + 11n + 7)}{(n+2)^2} \rho \tag{64}$$

Even when $\bar{x}_0^{acc}(S)$ leads to entry, one must check for deviations leading to no entry, as each incumbent understands that he is pivotal for the outcome of the game and can thus raise his time-1 payoff. When $\sum_{-i} x_0^{-i} > \bar{Z}_1$, following the same argument as in the main model, it is clear that incumbent i will always deviate and prevent entry.

When $\sum_{-i} x_0^{-i} \leq \bar{Z}_1$, as before, it is necessary to study the trade-off between accommodating and deterring. Since hedgers do not anticipate entry, the deterrence deviation is similar to the deterrence equilibrium strategy. We get:

$$\bar{x}_0^{det}(S) = \frac{n(n+3)}{2(n^2 + 3n + 1)} S \tag{65}$$

when $\bar{x}_0^{det}(S) > x_0^l(S)$. This condition requires $\sum_{-i} x_0^{-i} > \hat{Z}$, with

$$\hat{Z} = s - \frac{2(n^2 + 3n + 1)}{n+1} \rho \tag{66}$$

The threshold $\hat{Z}$ is strictly greater than $\bar{Z}_1$, as $\hat{Z} > \bar{Z}_1$ is equivalent to $2n+3 > 0$, which holds true, so $\hat{Z} > \bar{Z}_1$. Thus, in the interval of interest, $\left[0, \bar{Z}_1\right]$, deterring entry requires to trade $x_0^e + \eta$. To determine incumbent i's best-response, one must thus compare $\bar{\Pi}^e(\bar{x}_0^{acc}(S))$ and $\bar{\Pi}^{ne}(x_0^l + \eta)$. The deterrence deviation payoff (with $\eta \to 0$) is the same as in the deterrence equilibrium:

$$\bar{\Pi}^{ne}(x_0^l) = 2a\sigma^2 \frac{(n+2)^2}{n+1} S\rho - \frac{(n+2)^2(n^2+3n+1)}{(n+1)^2}\rho^2 \tag{67}$$

Similarly, substituting (63) into $\bar{\Pi}^e$ yields the accommodate payoff:

$$\bar{\Pi}^e(\bar{x}_0^{acc}(S)) = \frac{(n+2)^4}{4(n+1)(n^3+6n^2+11n+7)} S^2 \tag{68}$$

Then given the aggregate trade by other incumbents, $\sum_{-i} x_0^{-i}$, incumbent i's best-response is to accommodate if $\bar{\Pi}^e(\bar{x}_0^{acc}(S)) \geq \bar{\Pi}^{ne}(x_0^l)$, which is equivalent to

$$\frac{(n+2)^4}{4(n+1)(n^3+6n^2+11n+7)} S^2 - \frac{(n+2)^2}{n+1} S\rho + \frac{(n+2)^2(n^2+3n+1)}{(n+1)^2}\rho^2 \geq 0 \tag{69}$$

This is exactly the opposite trade-off as between the deterrence equililbrium and accommodate deviation in the main model. The roots remain the same, but the equilibrium conditions are different, since we are studying situations where accommodate dominates. The discriminant of this polynomial in S is

$$\bar{\boldsymbol{\Delta}} = \frac{(n+2)^4(2n+3)\rho^2}{(n+1)^3(n^3+6n^2+11n+7)} > 0$$

and the two positive roots are

$$\bar{S}_1 = \frac{2(n^3+6n^2+11n+7)}{(n+2)^2}\left[1 - \sqrt{\frac{2n+3}{(n+1)(n^3+6n^2+11n+7)}}\right] = \underline{\alpha}_n \rho \tag{70}$$

$$\bar{S}_2 = \frac{2(n^3+6n^2+11n+7)}{(n+2)^2}\left[1 + \sqrt{\frac{2n+3}{(n+1)(n^3+6n^2+11n+7)}}\right] = \bar{\alpha}_n \rho \tag{71}$$

The incumbent chooses to accommodate when $S \leq \bar{S}_1$ or when $S \geq \bar{S}_2$. $S \leq \bar{S}_1$ is equivalent to $\sum_{-i} x_0^{-i} \geq s - \underline{\alpha}_n\rho$. However, since $\forall n \geq 1$, $\underline{\alpha}_n < \frac{2(n^3+6n^2+11n+7)}{(n+2)^2} < \bar{\alpha}_n$, $s - \underline{\alpha}_n\rho > \bar{Z}_1$, and thus the first condition is irrelevant. The second condition, $S \geq \bar{S}_2$, is equivalent to $\sum_{-i} x_0^{-i} \leq s - \bar{\alpha}_n\rho$, so $s - \bar{\alpha}_n\rho < \bar{Z}_1$. Hence, incumbent i's best-response is

$$x_0^i = \begin{cases} \bar{x}_0^{acc}(S) \text{ if } \sum_{-i} x_0^{-i} \leq s - \bar{\alpha}_n\rho \\ x_0^l + \eta,\ \eta \text{ positive and arbitrarily small, if } Z_1 \geq \sum_{-i} x_0^{-i} > s - \bar{\alpha}_n\rho \end{cases}$$

The only response that is consistent with the equilibrium construction is $\bar{x}_0^{acc}(S)$, since it leads to entry in equilibrium, which is what incumbents anticipate when solving their maximization problem. In this case, best-responses have a negative slope which is strictly larger than one, and thus have a unique intersection. The equilibrium is

$$x_0^{acc} = \frac{n^3 + 6n^2 + 10n + 6}{n^4 + 7n^3 + 16n^2 + 18n + 8} s \tag{72}$$

This implies that the equilibrium threshold is

$$\begin{aligned} & (n-1)x_0^{acc} > s - \bar{\alpha}_n \rho \Leftrightarrow \;\; \rho < \bar{\rho} \\ \text{with } \bar{\rho} \equiv \; & \frac{2(n^3 + 6n^2 + 11n + 7)}{(n^4 + 7n^3 + 16n^2 + 18n + 8)\bar{\alpha}_n} s \end{aligned} \tag{73}$$

Therefore, when hedgers are not aware of the possibility of entry, the accommodate equilibrium occurs for $\rho \leq \bar{\rho}$. ■

D.2 Model comparisons

Corollary 9 *Knowledge of the possibility of entry by hedgers*

1. *Limits entry:* $\bar{\rho}^{nf} > \bar{\rho}$*;*
2. *Reduces time-0 trading and increases time-1 trading:* $x_0^{acc,nf} > x_0^{acc}$*, and* $x_1^{acc,nf} < x_1^{acc}$*;*
3. *Decreases the spread at time 0 and increases it at time 1:* $\Delta_0^{acc,nf} > \Delta_0^{acc}$*, and* $\Delta_1^{acc,nf} < \Delta_1^{acc}$*, and slows down price convergence at time 0;*
4. *Decreases intermediaries' utility,* $\bar{\Pi}_0^{e,nf} > \bar{\Pi}_0^{e}$*;*
5. *Decreases an intermediary's utility from deviating:* $\bar{\Pi}_0^{ne,nf} > \bar{\Pi}_0^{ne}$

Proof. Anticipation of entry limits entry. We can now compare the thresholds and show that $\bar{\rho}^{nf} > \bar{\rho}$. This condition is equivalent to

$$\frac{(n+2)^2}{(n^4 + 7n^3 + 16n^2 + 18n + 8)\left[1 + \sqrt{\frac{2n+3}{(n+1)(n^3+6n^2+11n+7)}}\right]} >$$
$$\frac{n+3}{(n^3 + 6n^2 + 9n + 6)\left[1 + \frac{1}{n+1}\sqrt{\frac{2n+3}{n^2+5n+5}}\right]}$$

After some simple algebra, the condition becomes

$$B_n\sqrt{\frac{2n+3}{(n+1)(n^3+6n^2+11n+7)}}+2n<C_n\frac{1}{n+1}\sqrt{\frac{2n+3}{n^2+5n+5}}$$

where $B_n = n^5 + 10n^4 + 37n^3 + 66n^2 + 62n + 24$ and $C_n = B_n - 2n =$. We can develop further into

$$4nB_n\sqrt{\frac{2n+3}{(n+1)(n^3+6n^2+11n+7)}}<\frac{G_n}{F_n}$$

where $G_n = (2n+3)D_n - 4n^2F_n$, and $F_n = (n^2+5n+5)(n+1)^2(n^3+6n^2+11n+7)$, $D_n = (n^3+6n^2+11n+7)C_n^2-(n+1)(n^2+5n+5)B_n^2$. This is equivalent to $16n^2B_n^2F_n^2(2n+3) < (n+1)(n^3+6n^2+11n+7)G_n^2$, which holds for any $n \geq 1$.

Anticipation of entry decreases time-0 trading. Starting from equation (72) and comparing it to its counterpart in the rational model, we get $\bar{x}_0^{acc,nf} > \bar{x}_0^{acc}$ iff $\frac{(n+1)(n+4)}{n^3+6n^2+9n+6} < \frac{n^3+6n^2+10n+6}{n^4+7n^3+16n^2+18n+8}$, which is equivalent to $2(n+2) > 0$.

Anticipation of entry decreases intermediaries' payoff. In equilibrium, the residual supply is $S^{nf} = s - (n-1)x_0^{acc,nf} = \frac{2(n^3+6n^2+11n+7)}{n^4+7n^3+16n^2+18n+8}s$. Substituting the residual supply in the intermediary's objective function gives the equilibrium payoff

$$\bar{\Pi}_0^e(\bar{x}_0^{acc,nf}) = 2a\sigma^2\frac{(n+2)^4(n^3+6n^2+11n+7)}{(n+1)(n^4+7n^3+16n^2+18n+8)^2}s^2 \tag{74}$$

Comparing this payoff to (55), we get: for all $n \geq 1$, $\bar{\Pi}^e < \bar{\Pi}^{e,nf}$.

Anticipation of entry decreases the spread at time 0 and increases it at time 1. From the equilibrium trade, we get

$$\Delta_0^{acc,nf} = 2a\sigma^2\frac{(n+2)^4}{(n+1)(n^4+7n^3+16n^2+18n+8)}s \tag{75}$$

$$\Delta_1^{acc,nf} = 2a\sigma^2\frac{(n+2)^2}{n^4+7n^3+16n^2+18n+8}s \tag{76}$$

Using spreads of the rational model we get $\Delta_0^{acc,nf} > \Delta_0^{acc}$ iff $n^5 + 10n^4 + 25n^3 + 58n^2 + 54n + 26 > 0$, which holds true. Similarly, $\Delta_1^{acc,nf} < \Delta_1^{acc}$ iff $2n > 0$. Further, since

$(n+1)(n+3) > (n+2)^2$,

$$\frac{\Delta_1^{acc}}{\Delta_0^{acc}} > \frac{\Delta_1^{acc,nf}}{\Delta_0^{acc,nf}},$$

i.e. the anticipation of entry slows down price convergence ahead of entry.

Anticipation of entry decreases the profit from deviating. At time 1, an incumbent deviating from the accommodate strategy always receives a benefit $\frac{(n+2)^2\rho^2}{(n+1)^2}$, whether hedgers anticipate entry or not. At time 0, however, the payoff is $x_0^l \frac{n+2}{n+1}(n+2)\rho$ when hedgers do not anticipate entry and $x_0^l \frac{n+3}{n+2}(n+2)\rho$ when they do. The limit trade depends on the residual supply, which differs depending on whether hedgers anticipate entry or not. Indeed, $x_0^{acc} < x_0^{acc,nf} \Rightarrow S > S^{nf}$, and since $x_0^l = S - (n-2)\rho$, $x_0^e > x_0^{e,nf}$. We can then compute $x_0^{e,nf}\frac{n+2}{n+1} = \frac{2(n+2)(n^3+6n^2+11n+7)}{(n+1)(n^4+7n^3+16n^2+18n+8)}s$, while $x_0^e\frac{n+3}{n+2} = \frac{2(n+3)(n^2+5n+5)}{(n+2)(n^3+6n^2+9n+6)}s$. For all $n \geq 1$, $x_0^e\frac{n+3}{n+2} < x_0^{e,nf}\frac{n+2}{n+1}$, thus $\bar{\Pi}_0^{ne,m} > \bar{\Pi}_0^{ne,m}$, i.e. deviation yields a higher payoff when hedgers do not anticipate entry. ■

E Model with far-sighted hedgers

In this section, I consider an alternative model in which hedgers are "far-sighted". This means that (i) At time 0, hedgers do not realize that the asset can be retraded at time 1. (ii) At time 1, hedgers "forget" that they planned to trade only at time 0, and reoptimize at time 1, with an endowment Y_0^k in the risky asset. Thus the model with far-sighted hedgers is exactly the same as the model with rational hedgers at time 1. Under these assumptions, hedgers behave as "long-term value traders", a common assumption in the literature, and ignore short-term price movements and the possibility of entry.

As discussed in the text, with far-sighted hedgers the spread schedule at time 0 is given by (9) with $\hat{n}_1 = 0$, so that:

$$\Delta_0^{fs}(\cdot) = 4a\sigma^2\left(s - \sum_{i=1}^{n} x_0^i\right) \tag{77}$$

Formally, the reduced form of the far-sighted model at time 0 is similar to Gilbert and Vives (1986)'s model (denoted as GV86) in the context of a homogeneous goods market, with the difference that the far-sighted model has trading dynamics. The equilibrium of the far-sighted model is as follows (proofs are relegated to the Internet Appendix).

Proposition 4 (Equilibrium in the far-sighted model)

1. *There are three types of equilibria:*

   - *If* $\rho > \rho^{bmk,fs}$*, incumbents trade the benchmark quantity* $(x_0^{bmk,fs}, x_1^{bmk,fs})$ *and the imitator does not enter. Entry is blocked. Equilibrium trades are:*

   $$x_0^{bmk,fs} = \frac{n(n+2)}{n^3+3n^3+2n+1}s,\ \ x_1^{bmk,fs} = \frac{s - nx_0^{bmk,fs}}{n+1}$$

   - *If* $0 \leq \rho \leq \bar{\rho}^{fs}$*, with* $0 < \bar{\rho}^{fs} < \rho^{bmk,fs}$*, incumbents strategically accommodate by trading quantities* $(x_0^{acc,fs}, x_1^{acc,fs})$ *and the imitator enters at time 1 (and also trades* $x_1^{acc,fs}$*).*

   $$x_0^{acc,fs} = \frac{(n+1)(n+3)}{n^3+5n^2+7n+4}s > x_0^{bmk,fs},\ \ x_1^{acc,fs} = \frac{s - nx_0^{acc,fs}}{n+2} < x_1^{bmk,fs}$$

   - *If* $\rho \in \left]\underline{\rho}^{fs}, \rho^{bmk,fs}\right]$*, there is a continuum of equilibria in which incumbents deter the entrant by trading (in aggregate) just enough to make entry unprofitable. The set of equilibrium time-0 trades is given by*

   $$\left\{x_0^i \geq 0\ s.t \sum_{j=1}^{n} x_0^j = s - (n+2)\rho + \eta,\ Z_2^{fs} < \sum_{j=1, j\neq i}^{n} x_0^j \leq Z_1^{fs}\right\},$$

   where η *is arbitrarily small and positive, and the thresholds* Z_1^{fs} *and* Z_2^{fs} *are given by (23) and (33). The incumbents' time-1 equilibrium trade is* $x_1^{det,fs} = \frac{s-\sum_{i=1}^{n} x_0^i}{n+1}$*,* $i = 1, \ldots, n$*.*

2. *Coexistence:*

   - *If* $n = 1$*,* $\bar{\rho}^{fs} = \underline{\rho}^{fs}$*, so that there is a unique threshold separating the accommodate and deterrence equilibria.*
   - *If* $n \geq 2$*,* $\bar{\rho}^{fs} > \underline{\rho}^{fs}$*, so that the accommodation and deterrence equilibria coexist when* $\rho \in \left[\underline{\rho}^{fs}, \bar{\rho}^{fs}\right]$*.*

The thresholds $\rho^{bmk,fs}$, $\underline{\rho}^{fs}$ and $\bar{\rho}^{fs}$ are the counterparts of ρ^{bmk}, $\underline{\rho}$, and $\bar{\rho}$ given in Proposition 2. As with the no-feedback model, there is a single cutoff between accommodate and deterrence when there is a monopolistic incumbent. When there is an oligopoly, accommodate and deterrence equilibria coexist instead when $\rho \in \left[\underline{\rho}^{fs}, \bar{\rho}^{fs}\right]$.

Figures in the Online Appendix show that $\bar{\rho}^{fs} > \bar{\rho}$ and $\underline{\rho}^{fs} > \underline{\rho}$. This means that in the main model, incumbents deter more (on a larger parameter space) and accommodate less (smaller parameter space). [34]

E.1 Corollaries

Corollary 10 (Spreads in the far-sighted model) *The equilibrium spreads are*

$$\Delta_0^{bmk,fs} = 4a\sigma^2 \frac{(n+1)^2}{n^3+3n^2+2n+1} s, \quad \Delta_1^{bmk,fs} = 2a\sigma^2 \frac{n+1}{n^3+3n^2+2n+1} s \tag{78}$$

$$\Delta_0^{acc,fs} = 4a\sigma^2 \frac{(n+2)^2}{n^3+5n^2+7n+4} s, \quad \Delta_1^{bmk,fs} = 2a\sigma^2 \frac{n+2}{n^3+5n^2+7n+4} s \tag{79}$$

$$\Delta_0^{det,fs} = 4a\sigma^2 (n+2)\rho, \quad \Delta_1^{bmk,fs} = 2a\sigma^2 \frac{n+2}{n+1} \rho \tag{80}$$

Corollary 11 *(Comparison of equilibrium spreads in far-sighted model]*

- *When the deterrence and accommodate equilibria coexist, i.e. when* $\rho \in \left[\underline{\rho}^{fs}, \bar{\rho}^{fs}\right]$ *($n \geq 2$), the spread is smaller in the deterrence equilibrium only at time 0:*

$$\Delta_0^{acc,fs} > \Delta_0^{det,fs}, \ \Delta_1^{acc,fs} < \Delta_1^{det,fs}$$

- *The spread is larger in the benchmark case than in the accommodate equilibrium at all dates:* $\Delta_t^{bmk,fs} > \Delta_t^{acc,fs}$, $t = 0, 1$.

- *When* $\rho \in \left[\underline{\rho}^{fs}, \rho^{bmk,fs}\right]$*, the spread is smaller in the deterrence equilibrium than in the benchmark case:* $\Delta_t^{det,fs} < \Delta_t^{bmk,fs}$, $t = 0, 1$.

Corollary 12 *When the symmetric deterrence and accommodate equilibria coexist, each incumbent's profit is higher in the accommodate equilibrium.*

Corollary 13 Proof. By definition, $\mathcal{S}_0^{acc} = \frac{2a\sigma^2 \frac{n+3}{n+2}(s - \sum_i x_0^{acc})}{2a\sigma^2 \frac{1}{n+2}(s - \sum_i x_0^{acc})} = n+3$. Similarly, $\mathcal{S}_0^{acc,nf} = \frac{2a\sigma^2 \frac{n+2}{n+1}(s - \sum_i x_0^{acc,nf})}{2a\sigma^2 \frac{1}{n+2}(s - \sum_i x_0^{acc,nf})} = \frac{(n+2)^2}{n+1}$ and $\mathcal{S}_0^{acc,fs} = \frac{4a\sigma^2 (s - \sum_i x_0^{acc,fs})}{2a\sigma^2 \frac{1}{n+2}(s - \sum_i x_0^{acc,fs})} = 2(n+2)$. By the same token, $S_0^{bmk} = n+2 = S_0^{bmk,nf} < S_0^{bmk,fs} = 2(n+1)$, and $S_0^{det} = S_0^{det,nf} = n+2$, $S_0^{det,fs} = S_0^{bmk,fs}$. The results about convergence speeds follow.

[34] Note that in this three-period setting, hedgers' beliefs about entry affect the incentives of incumbents to deter or accommodate the entrant, but *not* the entrant's incentives to enter. This is because in the last period, market depth is fixed by construction. Suppose that entry can occur only at time 1 and that there are extra trading rounds between time 1 and the time at which the risky asset pays off. Then entry would be reflected in the market depth of these additional trading rounds and would reduce the entrant's profit.

■

Definition 5 (Convergence speed) *At time 0, the speed is* $\mathcal{S}_0 = \frac{\Delta_0}{\Delta_1}$. *At time 1, the speed is given by* $\mathcal{S}_1 = \Delta_2 - \Delta_1$. *The speed improvement* $\delta\mathcal{S}_t^{l,k}$ *between two equilibria* l, k *is defined as* $\delta\mathcal{S}_t^{l,k} = \frac{\mathcal{S}_t^l}{\mathcal{S}_t^k}$.

Note that the definitions of speed differ slightly across dates, because $\Delta_2 = 0$. Further, a market converges quickly when spread *decrease* significantly from one period to the next, i.e. when the return is particularly negative. For simplicity, I thus adjust the definitions to make sure that speed is always a positive number and that a larger number means a higher speed.

Corollary 13 (Comparisons across models)

1. *Entry tresholds are ranked as follows:* $\bar{\rho} < \bar{\rho}^{nf} < \bar{\rho}^{fs}$, *i.e. the more sophisticated hedgers are, the less likely entry is.*

2. *Depth predicts entry only in the main model, where hedgers are fully rational.*

3. *The spread improvement at time 0 due to entry is stronger when hedgers are more sophisticated:* $\frac{\Delta_0^{acc}}{\Delta_0^{bmk}} < \frac{\Delta_0^{acc,nf}}{\Delta_0^{bmk,nf}} < \frac{\Delta_0^{acc,fs}}{\Delta_0^{bmk,fs}}$.

4. *In all models, the threat of entry increases the convergence speed at time 0 relative to the benchmark, even more so if entry actually occurs, i.e. in all cases,* $\mathcal{S}_0^{acc} > \mathcal{S}_0^{det} > \mathcal{S}_0^{bmk}$, *but the effects of entry on convergence speed are stronger when hedgers are less sophisticated:* $\mathcal{S}_0^{acc,fs} > \mathcal{S}_0^{acc,nf} > \mathcal{S}_0^{acc}$.

5. *The speed improvement due to entry relative to the benchmark case is also stronger when hedgers are less sophisticated:* $\delta\mathcal{S}_0^{acc,bmk,fs} = \delta\mathcal{S}_0^{acc,bmk,nf} > \delta\mathcal{S}_0^{acc,bmk}$.

Since spreads adjust immediately in anticipation of entry in the main model (due both to intermediaries' preemptive trading and hedgers' shift in demand), most of the adjustment takes place instantaneously, so that the subsequent adjustment is slower (see Figure 7). Importantly, speed represents here the observed speed in equilibrium, not the expected speed, since the expectation would be based on the incorrect anticipation of no entry in both the no-feedback and far-sighted models.

Spreads in the benchmark case are not the same across models, because liquidity is different across models. Liquidity is lowest at time 0 in the far-sighted model, because hedgers expect that they will trade only once, making them reluctant to holding risk and increasing price impact. In fact, the ranking of the effects of entry on speed is similar to the ranking of changes in liquidity across equilibria. Because benchmark spreads differ across models, it is useful to look at the relative speed increase induced by entry, $\delta\mathcal{S}_0^{acc,bmk}$. Again, the speed increase is lowest in markets where hedgers are more sophisticated (Figure 8): this is because spreads compress immediately, leaving little room for further adjustment between time 0 and time 1. In other cases, entry comes as a surprise, decreasing time 1 spreads, and increasing the observed speed of convergence.

Feature/Model	Gilbert-Vives (1986)	Far-sighted	No feedback	Main
Trading dynamics	✗	✓	✓	✓
Coasian dynamics	✗	✗	✓	✓
Feedback loop Entry-Depth	✗	✗	✗	✓
Inexistence for $n = 1$	✗	✗	✗	✓
Entry threshold	n/a	+++	++	+
Spread improvement (acc vs bmk)	n/a	+	++	+++
Convergence speed at time 0	n/a	+++	++	+
Speed improvement (acc vs bmk)	n/a	++	++	+

Table 1: Model Comparisons

F Static model

Proposition 5 (Equilibrium - Gilbert & Vives (1986)) *In the static model, the equilibrium takes the same form as in the dynamic model:*

1. *If $\rho > \rho^{bmk,s}$, entry is blocked. The equilibrium trade and spread are $x_1^{bmk} = \frac{s-\sum_{j=1}^n x_0^j}{n+1}$ and $\Delta_1^{bmk} = 2a\sigma^2 \frac{s-\sum_{j=1}^n x_0^j}{n+1}$.*

2. *If $\underline{\rho}^s \leq \rho \leq \rho^{bmk,s}$, then there is a continuum of equilibria in which incumbents collectively trade just enough to deter entry. The spread is $\Delta_1^{det,s} = 4a\sigma^2\rho$.*

3. *If $\rho \leq \bar{\rho}^s$, incumbents accommodate entry, by trading $x_1^{acc,s} = \frac{s-\sum_{j=1}^n x_0^j}{n+1} = x_1^{bmk,s}$. The entrant enters and trades $x_1^{n+1} = \frac{s-\sum_{j=1}^n x_0^j}{2(n+1)}$. The spread decreases by half relative to the benchmark case, $\Delta_1^{acc,s} = a\sigma^2 \frac{s-\sum_{j=1}^n x_0^j}{n+1} = \frac{\Delta_1^{bmk,s}}{2}$.*

When $n \geq 2$, $\underline{\rho}^s < \bar{\rho}^s$, so that the accommodate and deterrence equilibria coexist for $\rho \in \left(\underline{\rho}^s, \bar{\rho}^s\right)$. When $n = 1$, $\underline{\rho}^s = \bar{\rho}^s$, thus equilibria do not coexist.

Corollary 14 (Effects on spreads and quantities)

1. *The spread is lower in the accommodate and deterrence equilibria than in the benchmark case without entry.*

2. *Incumbents trade more than the benchmark quantity only in the deterrence equilibrium. In the accommodate equilibrium, incumbents trade the benchmark quantity, but the total amount of intermediation increases due to the entrant.*

3. *Comparative statics: the spread is decreasing with competition in the benchmark and accommodate equilibria, and is independent of competition in the deterrence equilibrium.*

Corollary 15 (Welfare) *When equilibria coexist, hedgers are better off in the deterrence equilibrium, and vice-versa for intermediaries.*

Proof. As in the subgame of time 1 in the dynamic model, hedgers' demand in market A is $Y_1^A = \frac{D_1 - p_1^A}{a\sigma^2} - s$, so that by market clearing in each segmented market, the spread schedule remains $\Delta_1(\cdot) = 2a\sigma^2(s - \sum_{j=1}^n X_1^j - X_1^{n+1})$. I first derive the benchmark without possibility of entry.

Notation 6 *Let $S_1 = s - \sum_{j=1}^n X_0^j - \sum_{j \neq i} x_1^{-i}$ denote the residual supply faced by intermediary i at time 1.*

Benchmark without entry

This step is the same as in the time 1 subgame of the dynamic model, so denoting , the best response and equilibrium trade are:

$$x_1^{i,bmk}(S_1) = \frac{S_1}{2} \tag{81}$$

$$x_1^{bmk} = \frac{s - \sum_{j=1}^n X_0^j}{n+1} \tag{82}$$

The profit as a function of the best-response and the equilibrium profits are:

$$\Pi^{bmk}(S_1) = a\sigma^2 \frac{S_1^2}{2} \tag{83}$$

$$\Pi^{bmk} = 2a\sigma^2 \frac{(s - \sum_{j=1}^n X_0^j)^2}{(n+1)^2} \tag{84}$$

Sequential entry

Entrant's decision. Let's consider first the entrant's decision and trade. Given incumbents' already chosen positions $\sum_{j=1}^{n} X_1^j$, the entrant solves:

$$\max_{x_1^{n+1}} \; 2a\sigma^2 x_1^{n+1}(s - \sum_{j=1}^{n} X_1^j - X_1^{n+1}) - I$$

From the first-order condition, we get the best-response function:

$$x_1^{n+1}(S_1 - x_1^i) = \frac{s - \sum_{j=1}^{n} X_1^j}{2} = \frac{S_1 - x_1^i}{2} \tag{85}$$

Then substituting back into the maximand, we get the entrant's payoff as a function of incumbents' positions

$$\Pi^{n+1}(S_1 - x_1^i) = \frac{1}{2}a\sigma^2 \left(s - \sum_{j=1}^{n} X_1^j \right)^2 - I = \frac{1}{2}a\sigma^2 \left(S_1 - x_1^i \right)^2 - I \tag{86}$$

The entrant enters the market iff $\Pi^{n+1} \geq 0$, and otherwise stays out and does not trade.

Incumbents' best-response given entry. Suppose that entry takes place and that $x_1^{n+1} \neq .0$. Then, given a residual supply from other incumbents, incumbent i solves:

$$\max_{x_1^i} \; 2a\sigma^2 x_1^i \left(s - \sum_{j=1}^{n} X_1^j - x_1^{n+1}(S_1 - x_1^i) \right)$$

Substituting for $x_1^{n+1}(S_1 - x_1^i)$, the problem simplifies to

$$\max_{x_1^i} \; a\sigma^2 x_1^i \left(s - \sum_{j=1}^{n} X_1^j \right)$$

From the first-order condition, we get the best-response of incumbent i

$$x_1^{i,acc}(S_1) = \frac{S_1}{2} \tag{87}$$

The best-response is the same as in the benchmark case (this is a peculiarity due to the linear demand), however, profits are halved:

$$\Pi^{acc}(S_1) = \frac{1}{4}a\sigma^2 S_1^2 \tag{88}$$

Blocked entry. Entry is blocked when the incumbents' benchmark trades leads to a negative net payoff for the entrant, i.e. when $\Pi^{n+1}(S_1 - x_1^{bmk}(S_1)) < 0$. Substituting $x_1^{bmk}(S_1)$ into (86) gives $\Pi^{n+1}(S_1 - x_1^{bmk}(S_1)) = a\sigma^2 \frac{S_1^2}{8} - I$, so entry is blocked iff $|S_1| < 4\rho$, where ρ is defined as before, $\rho = \sqrt{\frac{I}{2a\sigma^2}}$.

Limit trade. Given the entrant's best-response, incumbent i can make the entrant's net profit negative by buying a large portion of the residual net supply, since $\Pi^{n+1}(S_1 - x_1^i) < 0$ is equivalent to $|S_1 - x_1^i| < 2\rho$. The incumbent's payoff function when entry does not take place is $2a\sigma^2 x_1^i \left(s - \sum_{j=1}^n X_1^j\right) = 2a\sigma^2 x_1^i(S_1 - x_1^i)$. Thus choosing $x_1^i > S_1$ leads to a negative payoff, while accommodating leads to (88), which is always positive. Thus, $S_1 - x_1^i$ will remain positive. This implies that the limit trade is

$$x_1^{i,L} = S_1 - 2\rho \tag{89}$$

Trade-off deterrence/accommodate. Suppose that entry is not blocked, i.e. $|S_1| \geq 4\rho$. Then, given the residual supply, the incumbent either deters by trading the limit trade or accommodate. To determine the incumbent's best-response, one must compare the two deterrence and accommodate payoff. The latter is given by equation (88), the former is obtained by substituting the limit trade into the objective function:

$$\Pi^{det}(S_1, \rho) = 4a\sigma^2(S_1 - 2\rho)\rho \tag{90}$$

Then, the incumbent best-responds by deterring iff $4a\sigma^2(S_1 - 2\rho) \geq \frac{1}{4}a\sigma^2 S_1^2$, which can be written as

$$-S_1^2 + 16\rho S_1 - 32\rho^2 \geq 0 \tag{91}$$

There are two roots $z_{1/2} = (8 \pm 4\sqrt{2})\rho$. So deterrence is the best response for $S_1 \in (z_1, z_2)$. However, $|S_1| < 4\rho$, so we can summarize as follows:

$$x_1^{i,br}(S_1) = \begin{cases} x_1^{bmk}(S_1) \quad \text{if } |S_1| < 4\rho \\ x_1^{det}(S_1) = x_1^L(S_1, \rho) \quad \text{if } 4\rho \geq S_1 < z_2 \\ x_1^{acc}(S_1) \quad \text{if } S_1 \geq z_2 \end{cases} \tag{92}$$

Equilibrium and comparisons across equilibria. We can pin down the equilibrium by intersecting best-response functions. This step is identical to the dynamic case, so I skip the details. The thresholds are:

$$\rho^{bmk,s} = \frac{\hat{S}_0}{2(n+1)} \tag{93}$$

$$\bar{\rho}^s = \frac{\hat{S}_0}{2(2+\sqrt{2})(n+1)} \tag{94}$$

$$\underline{\rho}^s = \frac{\hat{S}_0}{2((3+2\sqrt{2})n+1)} \tag{95}$$

where I use notation $\hat{S}_0 = s - \sum_{j=1}^n x_0^j$.

It is straightforward to check that for $n = 1$, $\bar{\rho}^s = \underline{\rho}^s$, and for $n \geq 2$, $\underline{\rho}^s < \bar{\rho}^s$, so equilibria coexist on $(\underline{\rho}^s, \bar{\rho}^s)$.

Equilibrium quantities are

$$x_1^{bmk,s} = \frac{\hat{S}_0}{(n+1)} \tag{96}$$

$$x_1^{acc,s} = \frac{\hat{S}_0}{(n+1)}, \quad x_1^{n+1} = \frac{\hat{S}_0}{2(n+1)} \tag{97}$$

$$x_1^{det,s} = S_1 - 2\rho \tag{98}$$

By construction, for $\rho \in (\underline{\rho}^s, \rho^{bmk,s})$, $x_1^{det,s} > x_1^{bmk,s}$. Similarly, in the coexistence region, $x_1^{det,s} > x_1^{acc,s}$. Substituting quantities into the spread schedule, we obtain the equilibrium spreads:

$$\Delta_1^{bmk,s} = 2a\sigma^2 \frac{\hat{S}_0}{n+1} \tag{99}$$

$$\Delta_1^{acc,s} = a\sigma^2 \frac{\hat{S}_0}{n+1} \tag{100}$$

$$\Delta_1^{det,s} = 4a\sigma^2 \rho \tag{101}$$

Proceeding as in the dynamic case, we obtain the certainty equivalents $CE = \frac{\Delta_1^2}{8a\sigma^2} - \frac{s}{2}\Delta_1$.

Substituting equilibrium spreads, we get

$$CE_1^{bmk,s} = \frac{1}{2}a\sigma^2\frac{\hat{S}_0^2}{(n+1)^2} - a\sigma^2 s\frac{\hat{S}_0}{n+1} \tag{102}$$

$$CE_1^{acc,s} = \frac{1}{8}a\sigma^2\frac{\hat{S}_0^2}{(n+1)^2} - \frac{a\sigma^2}{2}s\frac{\hat{S}_0}{n+1} \tag{103}$$

$$CE_1^{det,s} = 2a\sigma^2\rho^2 - 2a\sigma^2 s\rho \tag{104}$$

Note that CE_1 decreases with Δ_1 iff $\Delta_1 \leq 2a\sigma^2$, which is always true. Thus, since they feature lower spreads, hegders are better off in the accommodate and deterrence equilibria than in the benchmark equilibrium. Further, since in the coexistence region, the spread is smaller in the deterrence equilibrium, hedgers are better off in the deterrence than accommodate equilibrium.

Substituting the equilibrium quantities into the intermediaries' objective functions, we get:

$$\Pi_1^{bmk,s} = 2a\sigma^2\frac{\hat{S}_0^2}{(n+1)^2} \tag{105}$$

$$\Pi_1^{acc,s} = a\sigma^2\frac{\hat{S}_0^2}{(n+1)^2}, \quad \Pi_1^{n+1} = \frac{1}{2}a\sigma^2\frac{\hat{S}_0^2}{(n+1)^2} - I \tag{106}$$

$$\Pi_1^{det,s} = 4a\sigma^2\rho\left(\frac{2\hat{S}_0}{n+1} - 2\rho\right) \tag{107}$$

Note that $\Pi_1^{det,s}(S_1) = 4a\sigma^2\rho(S_1 - 2\rho)$ is increasing in S_1. The deterrence equilibrium yielding the highest profits to intermediaries is thus the one where $\sum_{-i} x_1^{-i}$ is lowest and deterrence is an equilibrium. This case arises when $x_1^{-i} = x_1^{acc}$, which is the quantity other intermediaries trade when $\rho = \bar{\rho}$. In this case, $S_1^{acc} = \frac{2}{n+1}\hat{S}_0$. Substituting this quantity into $\Pi_1^{det,s}(S_1)$ gives (107).

Let's rank equilibrium profits in the coexistence region: $\Pi_1^{acc,s} > \Pi_1^{det,s}$ is equivalent to

$$\mathcal{S}_0^2 - 8(n+1)\rho\hat{S}_0 + 8(n+1)^2\rho^2 > 0$$

The discriminant of this polynomial is $32(n+1)^2\hat{S}_0^2$, and there are two positive roots, $\frac{1}{2}\frac{\hat{S}_0}{n+1}(1 \pm \frac{\sqrt{2}}{2})$. However, simple algebra shows that $\frac{1}{2}\frac{\hat{S}_0}{n+1}(1 - \frac{\sqrt{2}}{2}) \geq \bar{\rho}$. Since $\Pi_1^{acc,s} > \Pi_1^{det,s}$ when $\rho \leq \frac{1}{2}\frac{\hat{S}_0}{n+1}(1 - \frac{\sqrt{2}}{2})$, we conclude that intermediaries' profits are higher in the accommodate equilibrium when it coexists with the deterrence one. ■