Regulation and Security Design in Concentrated Markets*

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Abstract

The vast majority of regulatory debates about the benefits of centralized trading assume that the set of securities designed by financial intermediaries is immune to the market structure in which trade occurs. In this paper, we consider a regulator who redesigns the market structure for certain financial contracts by introducing an exchange to increase liquidity, understanding that security design is endogenous. For a given market structure, investors would like to trade a less risky security and, for a given security, they would like to trade in a larger market. We show that the security that intermediaries design after the introduction of the exchange is of lower quality, in the sense of a lower expected payoff per unit of standard deviation. This reflects the relative dilution of investor market power, as investors have zero price impact on the exchange and hence less influence on intermediary security design. The issuance of lower quality securities to investors arises even when the introduction of the exchange leads intermediaries to originate better underlying assets. With a large enough exchange, the decline in the quality of the security is so severe that investors can be worse off as a result of the introduction of the exchange. We then consider how origination subsidies could be used by the regulator to counter the negative effects of introducing the exchange on security design.

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1 Introduction

The 2007-09 financial crisis spurred regulatory efforts to move the trading of many financial instruments from decentralized over-the-counter markets to centralized platforms. The argued benefits of trading in centralized markets include liquidity and transparency. These arguments are almost always made on the premise that the set of securities designed by financial intermediaries is immune to the market structure in which trading occurs. Do all securities trading in decentralized markets migrate to the centralized platform rather than ceasing to be issued? How can a regulator ensure that they do migrate? We present a framework to study these questions here.

We consider a regulator who redesigns the market structure for certain financial contracts to increase liquidity. In particular, the regulator introduces an exchange in which financial securities that have traditionally traded in fragmented markets can also trade. We consider that financial intermediaries design asset-backed securities taking into account investor demand in the markets in which the securities will be traded. Our prior work (Babus and Hachem (2020)) shows that intermediaries will create increasingly riskier securities when facing deeper, more concentrated markets. It is in these markets that investors have less market power relative to intermediaries. The regulator understands that simply shifting trade from a decentralized market to a centralized one will result in financial intermediaries having more market power relative to investors, and this will lead to the design of riskier securities.

In our baseline model, the market structure is given and consists of a set of fragmented (local) markets in addition to an exchange in which securities can be traded. In each local market, investors trade strategically whereas the exchange is perfectly competitive and thus highly liquid. Each intermediary designs an asset-backed security for his local market. This security can also be traded on the exchange. The payoff of the security is backed by an underlying asset, with the intermediary choosing how much of the underlying asset to acquire (or originate) at a cost.

We characterize the effect of introducing the exchange on security design and the welfare of investors. For a given market structure, investors would like to trade a less risky security and, for a given security, they would like to trade in a larger market. The introduction of the exchange therefore makes investors better off holding constant the payoffs of the security. However, we show that the security that intermediaries design after the introduction of the exchange is of lower quality, in the sense of a lower expected payoff per unit of standard deviation. This reflects the relative dilution of investor market power, which is a powerful tool in disciplining the incentives of intermediaries in security design (Babus and Hachem (2020)). The decline in the quality of the security issued to investors then makes them worse off, all else constant. For a sufficiently small exchange, that is, an exchange where the intermediary does not have very high market power, the decline in the quality of the security is not large enough to offset the benefits to investors of trading in a larger, more liquid market. The investor is then unambiguously better off. However, for a larger exchange, the decline in the quality of the security is severe enough that the investor can be worse off as a result of the introduction of the exchange.

In the next part of the paper, we consider how the introduction of the exchange affects an intermediary's incentive to originate higher quality assets. We find that introducing an exchange leads the intermediary to originate better underlying assets, as indicated by a higher expected payoff per unit of standard deviation, in order to relax the feasibility constraint on the payoffs in his security design problem. However, the quality of the asset-backed securities sold by intermediaries to investors still declines as a result of the introduction of the exchange, reflecting once again the loss of market power by investors in the local market. The local market power of investors is thus a powerful disciplining device on intermediary security design, so much so that even with better quality underlying assets, the asset-backed security can still be worse.

These results motivate the need to coordinate regulations aimed at enhancing market liquidity with those that control security design. A policy tool that the regulator could use to counter the negative effects of the exchange on security design is a subsidy that lowers the cost to intermediaries of originating more and/or better underlying assets. For the same quality underlying asset, higher origination means that the intermediary has more returns, in any given state, from which to design the payoff of the asset-backed security. This allows him to create a security with higher average payoff, without increasing the variability of those payoffs across states. The same is true if the intermediary is incentivized to originate better quality underlying assets, holding constant their quantity. Alternatively, the regulator could impose explicit floors on origination (or asset purchases) and supervise to ensure compliance. This would be more budget neutral than origination subsidies provided supervision costs are not too high.

Our paper is motivated by post-crisis regulation of over-the-counter (OTC) derivatives. Lack of transparency in OTC markets is widely cited as an amplifier of the 2007-09 financial crisis, resulting in a regulatory push to have all "standardized" OTC derivatives cleared through central counterparties (Geithner (2009)). An important attribute of a standardized contract is high transaction volume. Illiquid contracts, i.e., those with low transaction volume, are not amenable to central clearing (Spatt (2017)). Thus, G-20 leaders agreed in September 2009 that all standardized OTC derivatives should be traded on exchanges or electronic trading platforms, in addition to being centrally cleared. Exchanges improve market access, enhancing the liquidity of contracts and facilitating migration into central clearing.

While derivatives, and in particular swaps, have been the prime target of these efforts because of their role in the crisis, the objective of market access transcends any one financial product. It is then important to understand more broadly the implications of trade centralization. In the case of swaps, the distinction between primary and secondary markets is blurred, hence the debates about centralization have not focused on one market as opposed to the other. For products where this distinction is sharper, liquidity in the secondary market is generally believed to positively affect liquidity in the primary market, making it natural to consider what happens if both markets are effectively centralized.

Our results suggest that caution is warranted when trying to improve market access: exchange trading also alters security design, to the detriment of investors. In practice, the move to a more centralized market structure has faced pushback from some market participants. As discussed in Spatt (2017), end-users hedge risk in a variety of ways, including the use of customized derivative contracts. Highly customized contracts will never achieve the transaction volume necessary for centralized clearing, and end-users have complained about the imposition of seemingly punitive rules on non-centrally-cleared contracts as regulators try to disincentivize them. Our results support some of the concerns voiced by end-users.

Holding constant the products being traded, investors are better off in more liquid markets. This serves as a motivation for centralization in our model. However, once security design is endogenized, the optimal amount of centralization is lower because investors need market power to elicit their preferred securities.[1]

Related Literature There is a large literature on financial innovation, with many studies concentrating on whether market competition affects the introduction of new securities (e.g., Allen and Gale (1991), Axelson (2007), Carvajal, Rostek, and Weretka (2012)). In recent work, Rostek and Yoon (2020a,b) show that under imperfect competition even derivatives need not be a redundant financial innovation. We contribute to this literature by exploring how the introduction of a centralized market affects the incentives of financial intermediaries that design securities for fragmented markets. In Babus and Hachem (2020), we considered the joint determination of market structure and security design and showed that investors choose to trade in thinner, more fragmented markets to obtain safer securities. Here, we take market structure as given and focus on how adding access to an exchange affects security design and investor welfare.

The role of market structure for welfare has received renewed attention, spurred by the regulations introduced in the aftermath of the 2007-09 financial crisis. Traders in fragmented, decentralized markets exercise market power, often resulting in inefficiencies that do not exist in centralized markets. For instance, market power leads to distortions in risk-sharing and investment decisions (Neuhann and Sockin (2020)). Moreover, even when externalities arise under perfect competition, such as in models of fire sales, market power can exacerbate the associated inefficiency (Eisenbach and Phelan (2020)). At the same time, several studies have shown that centralized trading does not unambiguously increase welfare. In Dugast, Üslü, and Weill (2019), increasing the participation of banks that can take large positions to a centralized market can improve welfare, but conditions have to be met. In Chen and Duffie (2020), fragmentation allows market participants to split their trades, generating welfare gains, while in Malamud and Rostek (2017), a decentralized market can

[1] The securities in our model are designed before individual preference shocks are realized so they are not customized to these realizations. However, the more market power investors have, the more they can customize the security to align with their expected preferences. In this regard, centralization leads to a loss of customization, which negatively impacts the welfare of end-users.

increase welfare by reallocating systematic risk toward less risk-averse agents. Competition between various platforms (Lee and Wang (2018)) or between multiple exchanges (Cespa and Vives (2018)) can also increase welfare.

We also show that centralized trading need not increase investor welfare. However, the mechanism in our analysis is through the security that is issued. Access to a centralized market increases the relative market power of financial intermediaries, enabling them to issue riskier securities than they otherwise would. This mechanism is in sharp contrast to previous work where the security traded is taken as given.

The rest of the paper proceeds as follows. Section 2 extends the set-up in Babus and Hachem (2020) to include an exchange, with the equilibrium defined and characterized in Section 3. Sections 4 and 5 then present the policy implications, namely the effect of introducing an exchange to improve market access on the overall welfare of investors and the need for coordinated policies to mitigate welfare losses stemming from endogenous changes in security design. The quality of underlying assets is held fixed in the analysis of Section 4, with changes in origination quality explored in Section 5. Section 6 concludes. All proofs are collected in Appendix A.

2 The Model Set-Up

We consider an economy with three dates, $t = 0, 1, 2$, populated by financial intermediaries and investors. There is a mass M of financial intermediaries indexed by $m \in \mathcal{M}$, where $\mathcal{M} = [0, M]$ is the set of intermediaries. Each intermediary m has access to a risky asset Z_m. Each unit of Z_m yields a payoff $z_m(s) \geq 0$ if the idiosyncratic state $s \in [0, S]$ is realized at date $t = 2$. We assume $z'_m(\cdot) > 0$. The cumulative distribution function for states is $F_m(s)$, with $F_m(\cdot)$ continuous and differentiable. The probability density function is $f_m(s)$. The realization of the assets Z_m is assumed to be independent across intermediaries.

A local market m is associated with each intermediary m. In each market m, the intermediary can issue a security W_m that pays $w_m(s)$ if state s is realized at $t = 2$. We fix the quantity A_m of the security issued by intermediary m and allow him to choose how many units K_m of the asset Z_m to acquire subject to a cost $u(K_m) = \frac{\delta K_m^2}{2}$, where $\delta > 0$. In this sense, W_m is an asset-backed security with an underlying asset Z_m that can be a loan originated by the intermediary or purchased from another originator. As in the literature on the spanning role of securities (Duffie and Rahi (1995)), the security payoff is subject to the feasibility constraint

$$A_m w_m(s) \leq K_m z_m(s), \forall s \in [0, S]. \tag{1}$$

There is a finite number of investors $n_m > 2$ in each market m. The set of investors in market m is $\mathcal{N}_m$. Overall, there is a mass N of investors in the economy. Investors are indexed by $i \in \mathcal{N}$, where $\mathcal{N} = [0, N]$ is the set of investors. As in Babus and Hachem (2020), investor i is subject to a preference shock θ^i that shifts her marginal utility of consumption. The shock θ^i is independently distributed across investors according to a distribution $G(\cdot)$ with mean μ_θ and standard deviation σ_θ. The realization of the shock θ^i is also independent of the realization of the state s.

Investors do not have access to the assets Z_m. However, an investor in market m can obtain an exposure to Z_m by trading the security W_m that intermediary m designs. Intermediaries design securities before preference shocks are realized, so whether or not a security in our model is standardized is squarely a question about whether or not it is sufficiently liquid.

We add to this environment a centralized market (or exchange) e where all securities W_m are traded. The introduction of an exchange will allow us to study the effect of regulations that push towards trade centralization in Sections 4 and 5. Let $\mathcal{E}^i$ denote the set of securities traded by investor i in the centralized market, with $e^i = \left|\mathcal{E}^i\right|$ denoting the number of these securities. We assume $W_m \notin \mathcal{E}^i$ for any $i \in \mathcal{N}_m$. That is, investor i in market m only trades the security W_m in her local market, using the centralized market to acquire exposure to other underlying assets $Z_{\ell \neq m}$.[2]

Each security W_m that is traded in the centralized market also attracts a competitive

[2] Suppose instead $W_m \in \mathcal{E}^i$. Then, since the centralized market is perfectly competitive, investors can arbitrage away any price differences between the local market and the exchange, driving the price in the local market to the competitive price in the centralized market. We thus consider $W_m \notin \mathcal{E}^i$ to allow for strategic trading in local markets and develop a richer understanding of how the exchange affects security design and investor welfare.

fringe with mass η_m. We refer to the agents in the competitive fringe as traders to distinguish them from the investors that participate in local markets. For simplicity, each fringe trader k only trades one security on the exchange. The competitive fringe across all securities has mass $\int \eta_m dm = H$. The overall mass that trades the security W_m in the centralized market is η_m, including (a finite set of) investors.

To summarize, the timing of events is as follows. At date $t = 0$, the intermediary in market m designs the security W_m. We assume that the intermediary supplies a quantity a_m of the security W_m in his local market m and a quantity a_m^e in the centralized market e, where $a_m + a_m^e \equiv A_m$. At date $t = 1$, each investor i and trader k learns their preference shock, θ^i and θ^k, respectively. After this, all markets open and trade occurs. At date $t = 2$, the states s are realized. Investors and the competitive fringe receive payoffs according their final holdings of the security. Each intermediary m pays $A_m w_m(s)$ and receives $K_m z_m(s)$. Consumption takes place.

We model investors' trading strategies as quantity-price schedules, as in Kyle (1989) and Vives (2011). In particular, the strategy of an investor i in market m with preference shock θ^i is a map from her information set to the space of demand functions, as follows. When trading in the local market, the demand function of investor i is a continuous function $Q_m^i : \mathbb{R}^{e^i+1} \to \mathbb{R}$ which maps the price p_m at which the security W_m trades in her local market m, as well as the vector of prices $\mathbf{p}_{\mathcal{E}^i} = \left(p_{\ell_j}^e\right)_{j=\overline{1,\ldots,e^i}}$ at which securities $W_{\ell_j} \in \mathcal{E}^i$ trade in the centralized market e, into a quantity q_m^i she wishes to trade

$$Q_m^i\left(p_m, \mathbf{p}_{\mathcal{E}^i}; \theta^i\right) = q_m^i.$$

To avoid confusion, we use p_m to denote the price of the security W_m in the local market m and p_m^e to denote the price of the same security in the centralized market e.

Similarly, when trading security $W_{\ell_j} \in \mathcal{E}^i$ in the centralized market, the demand function of investor i is a continuous function $X_{\ell_j}^i : \mathbb{R}^{e^i+1} \to \mathbb{R}$ which maps the vector of prices $\mathbf{p}_{\mathcal{E}^i} = \left(p_{\ell_j}^e\right)_{j=\overline{1,\ldots,e^i}}$ at which securities $W_{\ell_j} \in \mathcal{E}^i$ trade in the centralized market e, as well as the price p_m at which the security W_m trades in her local market m, into a quantity $x_{\ell_j}^i$

she wishes to trade

$$X^i_{\ell_j}\left(p_m, \mathbf{p}_{\mathcal{E}^i}; \theta^i\right) = x^i_{\ell_j}.$$

An investor i who trades q^i_m units of security W_m in market m and $x^i_{\ell_j}$ units of security W_{ℓ_j} in the centralized market e at date $t = 1$ consumes C^i_m at date $t = 2$, with

$$C^i_m = q^i_m W_m + \left[\mathbf{W}_{\mathcal{E}^i}\right]^T \mathbf{x}_{\mathcal{E}^i}, \tag{2}$$

where $\mathbf{W}_{\mathcal{E}^i} = \left(W_{\ell_j}\right)_{j=\overline{1,\ldots,e^i}}$ is the vector of securities $W_{\ell_j} \in \mathcal{E}^i$ and $\mathbf{x}_{\mathcal{E}^i} = \left(x^i_{\ell_j}\right)_{j=\overline{1,\ldots,e^i}}$ is the vector of quantities of securities traded in the centralized market.

We model investors as having mean-variance preferences. Therefore, the expected payoff of an investor i with preference shock θ^i who trades security W_m in her local market m and a set of securities $\mathcal{E}^i$ in the centralized market e is

$$V^i_m = \theta^i E_1\left(C^i_m\right) - \frac{\gamma}{2}\mathcal{V}_1\left(C^i_m\right) - \begin{bmatrix} p_m \\ \mathbf{p}_{\mathcal{E}^i} \end{bmatrix}^T \begin{bmatrix} q^i_m \\ \mathbf{x}_{\mathcal{E}^i} \end{bmatrix}, \tag{3}$$

where $\mathcal{V}(\cdot)$ is the variance operator. We use $E_1(\cdot)$ and $\mathcal{V}_1(\cdot)$ to indicate that expectations are being taken after the realization of preference shocks but before the realization of states.

Traders in the competitive fringe have the same preferences as investors. That is, the demand for security W_ℓ by a fringe trader $k \in \eta_\ell$ with preference shock θ^k is given by a function $X^k_\ell\left(p^e_\ell; \theta^k\right)$ and the trader's expected payoff takes the form of Eq. (3) with the difference that he trades only the security W_ℓ in the centralized market.

The price p_m in Eq. (3) is the price at which local market m clears, given that intermediary m supplies a_m units of the security W_m. That is, p_m is such that

$$\sum_{i \in m} Q^i_m\left(p_m, \mathbf{p}_{\mathcal{E}^i}; \theta^i\right) = a_m. \tag{4}$$

When a security W_ℓ is traded in the centralized market by investors and the competitive fringe η_ℓ, the price p^e_ℓ at which all trades clear given that intermediary ℓ supplies a^e_ℓ units of W_ℓ in market e is

$$\int_{k\in\eta_\ell} X_\ell^k \left(p_\ell^e;\theta^k\right) dk = a_\ell^e. \tag{5}$$

Note that there are finite investors that trade W_ℓ in the centralized market, so it is the competitive fringe that ultimately determines the market clearing price p_ℓ^e.

Substituting Eq. (2) into Eq. (3), we obtain the objective function at date $t=1$ for an investor i with trading strategy represented by the demand functions $\left\{Q_m^i, \mathbf{X}_{\mathcal{E}^i}\right\}$:

$$V_m^i = \left\{\theta^i E_1\left(\left[\begin{array}{c} W_m \\ \mathbf{W}_{\mathcal{E}^i}\end{array}\right]\right) - \left[\begin{array}{c} p_m \\ \mathbf{p}_{\mathcal{E}^i}\end{array}\right]\right\}^T \left[\begin{array}{c} Q_m^i \\ \mathbf{X}_{\mathcal{E}^i}\end{array}\right] - \frac{\gamma}{2}\left[\begin{array}{c} Q_m^i \\ \mathbf{X}_{\mathcal{E}^i}\end{array}\right]^T \Sigma^i \left[\begin{array}{c} Q_m^i \\ \mathbf{X}_{\mathcal{E}^i}\end{array}\right], \tag{6}$$

where $\mathbf{X}_{\mathcal{E}^i} = \left(X_{\ell_j}^i\right)_{j=\overline{1,\ldots,e^i}}$ is the vector of demands for securities W_{ℓ_j} and Σ^i is the variance-covariance matrix of all securities that are traded by investor i. For any security m, $E_1\left(W_m\right) \equiv \int_0^S w_m(s)\, dF_m(s)$ and $\mathcal{V}_1\left(W_m\right) \equiv \int_0^S \left[w_m(s) - E_1\left(W_m\right)\right]^2 dF_m(s)$. Since the assets Z_m are independent across financial intermediaries, the payoff realizations of two securities W_m and W_ℓ are also independent. This implies that the matrix Σ^i is diagonal.

An intermediary m that designs security W_m receives the price p_m per unit of the security issued in the local market m and the price p_m^e per unit of the security issued in the centralized market e. This is consistent with the interpretation that each intermediary m places the security W_m with investors in the local market m as well as with investors and fringe traders in the centralized market e by running a share auction as described by Wilson (1979). Thus, even though the intermediary is not directly involved in the trade between investors at date $t=1$, an intermediary m's expected payoff at date $t=1$ is

$$V_m = p_m a_m + p_m^e a_m^e + \beta E_1\left[K_m Z_m - \left(a_m + a_m^e\right) W_m\right] - u\left(K_m\right),$$

for any amount a_m issued in the local market and a_m^e issued in the centralized market, where $\beta \in [0,1]$ is a discount factor that captures the impatience of intermediaries relative to investors.

3 Equilibrium

In this section, we define and characterize the equilibrium. We start by solving for the trading equilibrium in each local market m and in the centralized market e at date $t = 1$, given the securities W_m that intermediaries design at date $t = 0$. We then characterize the security that each intermediary designs in equilibrium at date $t = 0$.

Definition 1 *A subgame perfect equilibrium is a set of securities* $\{W_m\}_{m \in \mathcal{M}}$*, an amount* K_m *of the asset* Z_m *that each financial intermediary* m *acquires, a set of demand functions* $\left\{Q^i_m, \mathbf{X}_{\mathcal{E}^i}\right\}_{i \in \mathcal{N}}$ *for each investor* i *that trades security* W_m *in the local market* m *and the set of securities* $\mathcal{E}^i$ *in the centralized market* e*, and a demand function* X^k_ℓ *for each trader* k *in the competitive fringe* η_ℓ *that trades security* W_ℓ *in the centralized market* e*, such that:*

1. $\left\{Q^i_m, \mathbf{X}_{\mathcal{E}^i}\right\}$ *solve each investor* i*'s problem at date* $t = 1$

$$\max_{\left\{Q^i_m, \mathbf{X}_{\mathcal{E}^i}\right\}} \left\{ \left\{ \theta^i E_1 \left(\begin{bmatrix} W_m \\ \mathbf{W}_{\mathcal{E}^i} \end{bmatrix} \right) - \begin{bmatrix} p_m \\ \mathbf{p}_{\mathcal{E}^i} \end{bmatrix} \right\}^T \begin{bmatrix} Q^i_m \\ \mathbf{X}_{\mathcal{E}^i} \end{bmatrix} - \frac{\gamma}{2} \begin{bmatrix} Q^i_m \\ \mathbf{X}_{\mathcal{E}^i} \end{bmatrix}^T \Sigma^i \begin{bmatrix} Q^i_m \\ \mathbf{X}_{\mathcal{E}^i} \end{bmatrix} \right\}; \tag{7}$$

2. X^k_ℓ *solves each trader* k*'s problem at date* $t = 1$

$$\max_{X^k_\ell} \left\{ \left\{ \theta^k E_1 \left(W_\ell \right) - p^e_\ell \right\} X^k_\ell - \frac{\gamma}{2} \mathcal{V}_1 \left(W_\ell \right) \left(X^k_\ell \right)^2 \right\}$$

3. W_m *and* K_m *solve each intermediary* m*'s problem at date* $t = 0$

$$\max_{W_m, K_m} \left\{ p_m a_m + p^e_m a^e_m + \beta E_1 \left[K_m Z_m - \left(a_m + a^e_m \right) W_m \right] \right\} - u \left(K_m \right), \tag{8}$$

subject to the feasibility constraint

$$A_m w_m \left(s \right) \leq K_m z_m \left(s \right), \forall s \in [0, S].$$

3.1 The Trading Equilibrium

At date $t = 1$, after each investor i learns her preference shock θ^i, markets open and trade takes place. Each investor chooses her trading strategy in order to maximize her expected payoff, understanding that she may have an impact on security price, depending on which security she is trading. The optimization problem (7), which is defined over a function space, is simplified to finding the functions $Q_m^i\left(p_m, \mathbf{p}_{\mathcal{E}^i}; \theta^i\right)$ for security W_m and $X_{\ell_j}^i\left(p_m, \mathbf{p}_{\mathcal{E}^i}; \theta^i\right)$ for each security $W_{\ell_j} \in \mathcal{E}^i$ pointwise**.**

The first order condition from investor i's optimization problem is

$$\left\{\theta^i E_1\left(\begin{bmatrix} W_m \\ \mathbf{W}_{\mathcal{E}^i} \end{bmatrix}\right) - \begin{bmatrix} p_m \\ \mathbf{p}_{\mathcal{E}^i} \end{bmatrix}\right\} - \left(\Lambda^i + \gamma\Sigma^i\right)\begin{bmatrix} q_m^i \\ \mathbf{x}_{\mathcal{E}^i} \end{bmatrix} = \begin{bmatrix} 0 \\ \mathbf{0} \end{bmatrix}, \tag{9}$$

where Λ^i represents the price impact matrix of investor i for the securities she trades. Specifically, Λ^i is an $e^i \times e^i$ matrix of the inverse residual demand of investor i, as implied by the the market clearing conditions (4) and (5) given the schedules submitted by other investors and traders in the competitive fringe. Entry (k, ℓ) in the matrix represents the price change of security ℓ that results from a marginal increase in the demanded quantity of security k.

The following proposition characterizes the trading equilibrium.

Proposition 1 *Given a set of securities $\{W_\ell\}_{\ell\in\mathcal{M}}$, there exists a unique symmetric linear equilibrium that characterizes trading strategies for each security, as follows.*

1. *(**Centralized market**) The equilibrium demand function of an investor i for security $W_\ell \in \mathcal{E}^i$ is*

$$X_\ell^i\left(p_\ell; \theta^i\right) = \frac{1}{\gamma\mathcal{V}_1\left(W_\ell\right)}\left(\theta^i E\left(W_\ell\right) - p_\ell^e\right), \tag{10}$$

which is also the demand of a trader in the competitive fringe η_ℓ. The equilibrium price at which security W_ℓ trades in the centralized market is

$$p_\ell^e = \mu_\theta E\left(W_\ell\right) - \gamma\mathcal{V}_1\left(W_\ell\right)\frac{a_\ell^e}{\eta_\ell}. \tag{11}$$

2. ***(Local market)*** *The equilibrium demand function of an investor i for security W_m is*

$$Q_m^i\left(p_m;\theta^i\right)=\frac{1}{\left(1+\lambda_m\right)\gamma\mathcal{V}_1\left(W_m\right)}\left[\theta^i E_1\left(W_m\right)-p_m\right], \tag{12}$$

where $\lambda_m^{-1}\equiv\left(n_m-2\right)$ is an index of the depth of the local market m. The equilibrium price in market m is

$$p_m=\left(\frac{1}{n_m}\sum_{i\in m}\theta^i\right)E_1\left(W_m\right)-\gamma\mathcal{V}_1\left(W_m\right)\left(1+\lambda_m\right)\frac{a_m}{n_m}. \tag{13}$$

Proposition 1 shows that in equilibrium the demand function of an investor for a security depends only on the price of that security either in the local market or in the centralized market. In other words, the investor's equilibrium demand for one security is not contingent on the prices of the other securities. When trading in the centralized market, the investor faces a competitive fringe, hence her price impact is 0 for any security $W_\ell\in\mathcal{E}^i$. For the same reason, the price of a security W_ℓ in the centralized market is not affected as an investor $i\in\mathcal{N}_m$ changes her trade in either her local market security W_m or in another security $W_{\ell'}$ traded in the centralized market. When trading in the local market, an investor $i\in\mathcal{N}_m$ has a price impact, $\partial p_{m,-i}/\partial q_m^i=\lambda_m\gamma\mathcal{V}_1\left(W_m\right)$, that decreases with the depth of the local market, λ_m^{-1}. Trading other securities in the centralized market does not affect the price p_m of the security W_m, despite the fact that the investor has a price impact in the local market, because the securities have independent payoffs.

We also see from Proposition 1 that investor $i\in\mathcal{N}_m$ buys (sells) security W_m in the local market if her valuation $\theta^i E_1\left(W_m\right)$ of the security's expected payoff is above (below) the price p_m at which she can trade. Similarly, she buys (sells) security $W_\ell\in\mathcal{E}^i$ in the centralized market if her valuation $\theta^i E_1\left(W_\ell\right)$ is above (below) the price p_ℓ^e. In the centralized market, the price of a security W_ℓ is simply the expected value of the security, adjusted by the mean valuation of the competitive fringe trading the security, minus a risk premium. The risk premium exists because traders are risk averse and, in expectation, have to hold a_m^e/η_m units of a risky security. Similarly, in the local market, the price of the security W_m is the expected value of the security, adjusted by the mean valuation of the investors trading the security, minus a risk premium. However, the risk premium in the local market depends not only on the amount of the security issued per capita, a_m/n_m, but also on the depth of the local market, λ_m^{-1}.

Given a realization of preference shocks, the price at which the security W_m trades either in the local market or the centralized market in Proposition 1 decreases with the variance of the security. However, the price in the local market decreases less with the variance of the security as the market becomes deeper. Moreover, the variance of the security is endogenous since the security is a choice of the intermediary, as we describe next.

3.2 The Equilibrium Security

At the end of date $t = 0$, each intermediary m designs a security W_m taking into account both investors' demand in the local market and the demands in the centralized market. In particular, an intermediary m chooses the payoff $w_m(s)$ of the security for each state s to maximize his expected profit in (8), subject to the feasibility constraint (1). At the same time, the intermediary also chooses the amount K_m of the underlying asset Z_m to acquire at the cost $u(K_m) = \frac{\delta K_m^2}{2}$. The amount K_m determines how many units of the underlying asset are used to back the issuance of A_m units of the security W_m. Essentially, the intermediary uses the amount K_m as another margin when deciding how much of the payoff of the underlying asset Z_m he transfers to the investors and how much he keeps for himself.

In solving for the equilibrium security, many of the forces identified in Babus and Hachem (2020) are at work. Substituting into (8) the expected price $E_0(p_m)$ at which investors trade the security W_m in the local market m (see Eq. (13)) and the price p_m^e at which the same security is traded in the centralized market (see Eq. (11)), we obtain that intermediary m designs the security W_m to maximize the following objective function:

$$V_m = (\mu_\theta - \beta) E_1(W_m) A_m - \gamma \mathcal{V}_1(W_m) \left((1+\lambda_m) \frac{a_m}{n_m} a_m + \frac{a_m^e}{\eta_m} a_m^e \right) + \beta K_m E_1(Z) - u(K_m), \tag{14}$$

where $A_m = a_m + a_m^e$.

The intermediary faces a trade-off between the mean and the variance of the security he designs. The intermediary benefits from offering a security that pays well in expectation, as the expected price at which trade occurs in either market (local or centralized) is increasing in $E_1(W_m)$. However, the feasibility constraint (1) implies that the intermediary cannot increase the mean of the security without increasing its variance $\mathcal{V}_1(W_m)$. A security W_m has a higher variance when it has more variable payoffs. Alternatively, the variance of the security increases when a greater amount K_m of the asset Z_m backs the security, as the feasibility constraint (1) becomes laxer holding fixed the amount A_m of the security issued. However, a security with a higher variance decreases the expected payoff of the intermediary in a way that depends both on the market power of the investors in the local market as well as on the market power of the intermediary, as defined next.

In the local market, investors' market power is captured through their price impact. We recall that a higher price impact $\partial p_{m,-i}/\partial q_m^i$ is associated with a higher value of λ_m for a given security W_m. All else constant, the intermediary's expected payoff in Eq. (14) decreases more with the variance of W_m when λ_m is high, therefore the security design of the intermediary will be more responsive to investors' demand in a thinner local market. Hence, we interpret λ_m as a measure of investor market power in the local market.

We also see from Eq. (14) the effect of the exchange on the security design problem. Holding fixed the total supply A_m of the security designed by intermediary m, an increase in the quantity a_m^e supplied to the exchange dilutes (or down-weights) the negative effect of the variance on the intermediary's expected payoff. This is because the intermediary is shifting the sale of his security away from the local market, where investors have market power via their price impact, towards the centralized market where there is no price impact. As trade shifts to the centralized market, investors cede market power to the intermediary. Therefore, we define

$$\chi_m \equiv \frac{\frac{a_m^e}{\eta_m} a_m^e}{\frac{a_m}{n_m} a_m}$$

to capture the market power of the intermediary relative to investors in the local market, for given market sizes n_m and η_m. Intuitively, an increase in χ_m implies an increase in a_m^e relative to $a_m \equiv A_m - a_m^e$ and thus higher expected profit for the intermediary on any given security W_m.

The following proposition characterizes the optimal security in this environment.

Proposition 2 *Suppose $\mu_\theta > \beta$ so that intermediaries find it profitable to design securities for investors. An intermediary m designs a security W_m with payoffs*

$$w_m(s) = \begin{cases} \frac{K_m}{A_m} z_m(s) & \text{if} \quad s < \overline{s}_m \\ \frac{K_m}{A_m} z_m(\overline{s}_m) & \text{if} \quad s \geq \overline{s}_m \end{cases} \tag{15}$$

where the threshold state $\overline{s}_m \in [0, S]$ is defined by

$$\overline{s}_m = \begin{cases} z_m^{-1}\left[\frac{A_m}{K_m} E_1(W_m) + \frac{1}{K_m}\frac{\mu_\theta - \beta}{2\gamma}\frac{\left(\sqrt{\eta_m \chi_m} + \sqrt{n_m}\right)^2}{1 + \lambda_m + \chi_m}\right], & \forall n_m < \overline{n}_m \\ S, & \forall n_m \geq \overline{n}_m \end{cases} \tag{16}$$

with $\overline{n}_m$ finite if and only if the equation

$$\frac{\delta}{2\gamma}\frac{\left(\sqrt{\eta_m \chi_m} + \sqrt{\overline{n}_m}\right)^2}{\frac{\overline{n}_m - 1}{\overline{n}_m - 2} + \chi_m} = \frac{\mu_\theta}{\mu_\theta - \beta} E_1(Z_m)\left[z_m(S) - E_1(Z_m)\right] - \mathcal{V}_1(Z_m) \tag{17}$$

has a solution $\overline{n}_m \geq 3$.

To rule out corner solutions in security design, we assume for the remainder of the paper that condition (17) has a solution $\overline{n}_m \geq 3$, and we focus on $n_m \in [3, \overline{n}_m]$.

Proposition 2 shows that intermediary m finds it optimal to design an asset-backed security that pays the lesser of a flat payoff $z_m(\overline{s}_m)$ and the full value of the underlying asset $z_m(s)$, scaled by the ratio K_m/A_m of the quantity of the underlying asset originated to the quantity of the asset-backed security issued, in every state s. Debt securities have the least variance among all limited-liability securities with the same expected value, so, for the preferences we consider, the optimal security is naturally a debt contract. The key insight from Proposition 2 is that the face value of the debt depends in equilibrium on both the local market power of investors λ_m and the market power of the intermediary relative to the investors χ_m. The following corollary characterizes the relationship between each of these objects and the debt contract that the intermediary designs.

Corollary 1 *The security W_m that the intermediary designs in market m has the following properties:*

1. *The threshold state $\bar{s}_m$ defined by (16) is decreasing in λ_m. Further, $\frac{\partial E_1(W_m)}{\partial \lambda_m} < 0$ and $\frac{\partial \mathcal{V}_1(W_m)}{\partial \lambda_m} < 0$, while $\frac{\partial}{\partial \lambda_m}\left(\frac{E_1(W_m)}{\sqrt{\mathcal{V}_1(W_m)}}\right) > 0$.*

2. *The threshold state $\bar{s}_m$ defined by (16) is increasing in χ_m for any $\chi_m \leq \frac{\eta_m}{n_m}$. Further, $\frac{\partial E_1(W_m)}{\partial \chi_m} > 0$ and $\frac{\partial \mathcal{V}_1(W_m)}{\partial \chi_m} > 0$, while $\frac{\partial}{\partial \chi_m}\left(\frac{E_1(W_m)}{\sqrt{\mathcal{V}_1(W_m)}}\right) < 0$.*

The first part of Corollary 1 shows that the intermediary designs a less variable security when investors' local market power λ_m increases, as in the model of Babus and Hachem (2020) with only local markets. Specifically, the intermediary decreases the lowest state $\bar{s}_m$ in which the security W_m pays the flat payoff. This decreases the variance of the security by more than it decreases the mean, raising the expected payoff of the security per unit of standard deviation. In contrast, the second part of Corollary 1 shows the effect of an increase in the market power χ_m that the addition of an exchange affords the intermediary. As the intermediary gains more market power, the lowest state $\bar{s}_m$ in which the security W_m pays the flat payoff increases, up to a certain point. This results in an equilibrium security with higher mean but also higher variance. Overall, the security has a lower expected payoff per unit of standard deviation.

Of course, the amount K_m of the asset Z_m that backs the optimal security W_m in Proposition 2 is endogenous. The next proposition summarizes the equilibrium origination decision K_m, which is taken into account when deriving the properties of W_m in Corollary 1.

Proposition 3 *The equilibrium amount K_m of asset Z_m that is acquired by intermediary m satisfies*

$$\delta K_m - (\mu_\theta - \beta) \frac{\int_0^{\bar{s}_m} z_m(s)\left[z_m(\bar{s}_m) - z_m(s)\right] dF(s)}{\int_0^{\bar{s}_m} \left[z_m(\bar{s}_m) - z_m(s)\right] dF(s)} = \beta E_1(Z_m),$$

where δ is the cost function parameter.

Allowing the intermediary to choose the quantity K_m of the asset Z_m that he acquires affects the design of the security W_m. In particular, increasing K_m relaxes the feasibility constraint (1), which is to say the intermediary has more returns, in any given state, from which to design the payoff of the asset-backed security. This allows him to create a security with higher average payoff, without increasing the variability of those payoffs across states.

4 Centralized Trading as Regulation

One of the central pieces of regulation introduced after the 2007-09 financial crisis concerns the creation of exchange facilities to trade contracts that have traditionally been traded in over-the-counter markets. Swaps have been the prime target of this regulation because of the outsized role they played in amplifying the crisis, but at the highest level, the goal of the regulation is simply to ensure impartial access to markets and hence reduce other frictions such as low liquidity arising from fragmentation (e.g., Giancarlo (2015)). Through the lens of our model, we can explore how introducing an exchange to improve market access affects the security design of intermediaries and the overall welfare of investors.

4.1 Effect on Security Design

Our results on security design in Section 3.2 were derived allowing each intermediary m to issue his security W_m in both a local market m and a centralized market e. To evaluate the effect of a regulation that mandates the introduction of an exchange, we need to start from the equilibrium security that prevails in the absence of a centralized market.

The model without an exchange corresponds to $\eta_m = 0$ and is studied in Babus and Hachem (2020). Let W_m^0 denote the security that intermediary m designs in this case for his local market. The optimal W_m^0 is a debt security and the lowest state $\overline{s}_m^0$ in which the investor receives the flat payoff is mathematically equivalent to Eq. (16) with $\chi_m = 0$.[3]

The introduction of an exchange then corresponds to a movement from $\eta_m = 0$ to $\eta_m > 0$, for an arbitrary $\eta_m > 0$. To simplify the exposition, we fix the amount of the security issued by each intermediary m when there exists an exchange at one unit per capita in both his local market and the centralized market, i.e., $a_m = n_m$ and $a_m^e = \eta_m$. Naturally, this implies that the intermediary issues a quantity $A_m = n_m + \eta_m$ of the security in his local market when there is no exchange.

[3] We refer the reader to Babus and Hachem (2020) for a formal proof. The intermediary's market power χ_m is not well-defined in the absence of the exchange, so we cannot simply set $\eta_m = 0$ in Eq. (16).

The following proposition contrasts the properties of the equilibrium security with and without the exchange:

Proposition 4 *Let W_m be the optimal security described in Proposition 2 and W_m^0 be the equilibrium security designed in the absence of an exchange. Then, $\bar{s}_m^0 < \bar{s}_m$, $E\left(W_m^0\right) < E\left(W_m\right)$, $\mathcal{V}_1\left(W_m^0\right) < \mathcal{V}_1\left(W_m\right)$, and $\frac{E\left(W_m^0\right)}{\sqrt{\mathcal{V}\left(W_m^0\right)}} > \frac{E\left(W_m\right)}{\sqrt{\mathcal{V}\left(W_m\right)}}$.*

In words, Proposition 4 states that the optimal security in the absence of an exchange ($\eta_m = 0$) has a lower mean, but also a lower variance, resulting in a higher expected payoff per unit of standard deviation as compared to the optimal security when there is an exchange of any size ($\eta_m > 0$). The proof of Proposition 4 also establishes $K_m^0 < K_m$. That is, the intermediary acquires a larger quantity of the underlying asset Z_m after the introduction of the exchange, but not large enough to achieve $\bar{s}_m = \bar{s}_m^0$.

4.2 Welfare without Investor Participation in the Exchange

To fix ideas, we first consider an intermediate version of market access where investors trade in local markets and only the competitive fringe trades in the exchange. This allows us to isolate two forces that affect aggregate welfare: market participation and security design.

The expected payoff of investor $i \in \mathcal{N}_m$ in this case is

$$E_0\left(V_{m,local}^i\right) = \frac{1+2\lambda_m}{2}\left(\frac{\sigma_\theta^2}{\gamma}\frac{n_m-1}{n_m}\frac{1}{\left(1+\lambda_m\right)^2}\frac{\left(E_1\left(W_m\right)\right)^2}{\mathcal{V}_1\left(W_m\right)} + \gamma\mathcal{V}_1\left(W_m\right)\right) \tag{18}$$

for each local market m, where we have used the simplification that intermediary m issues $a_m = n_m$ units of the security W_m in his local market. The next corollary formalizes the welfare effect of the changes in security design in Proposition 4 for investors.

Corollary 2 *Investors are made worse off by the introduction of an exchange in which they do not trade.*

The corollary highlights the security design cost of introducing the exchange. Specifically, moving from $\eta_m = 0$ to $\eta_m > 0$ changes the equilibrium security from W_m^0 to the riskier W_m, lowering the expected payoff of investors trading in local markets, $E_0\left(V_{m,local}^i\right)$.

Turning next to the competitive fringe, the expected payoff of a trader $k \in \eta_m$ is

$$E_0\left(V_m^k\right) = \frac{1}{2}\left(\frac{\sigma_\theta^2}{\gamma}\frac{\left(E_1\left(W_m\right)\right)^2}{\mathcal{V}_1\left(W_m\right)} + \gamma\mathcal{V}_1\left(W_m\right)\right) \tag{19}$$

Fringe traders are trivially better off in the presence of the exchange as their welfare increases from 0 to $E_0\left(V_m^k\right) > 0$ regardless of the security traded. This is the market access benefit of introducing the exchange.

The overall welfare of market participants sums across investors and the competitive fringe. The effect of the exchange on welfare is therefore ambiguous; the welfare gain from broadening market access to the competitive fringe is at least partly offset by the welfare loss to investors in local markets who now have to trade a riskier equilibrium security.

4.3 Welfare with Investor Participation in the Exchange

Are investors still worse off if they can access the exchange alongside the competitive fringe? The expected payoff of an investor $i \in \mathcal{N}_m$ is now the sum of the component due to trading in the local market and a component due to trading in the centralized market:

$$E_0\left(V_m^i\right) = E_0\left(V_{m,local}^i\right) + \underbrace{\frac{1}{2}\sum_{W_{\ell_j}\in\mathcal{E}^i}\left(\frac{\sigma_\theta^2}{\gamma}\frac{\left(E\left(W_{\ell_j}\right)\right)^2}{\mathcal{V}_1\left(W_{\ell_j}\right)} + \gamma\mathcal{V}_1\left(W_{\ell_j}\right)\right)}_{\text{Centralized market component}}, \tag{20}$$

where we have used $a_m = n_m$ and $a_m^e = \eta_m$ for each intermediary m. The introduction of the exchange worsens the local component of the investor's value function for the reasons discussed above. However, the total effect on the investor's welfare, as defined by the sum of payoffs across markets in Eq. (20), is ambiguous. Since the investor can trade other securities on the exchange, her overall payoff may be higher or lower depending on the mean and variance of the securities she trades on the exchange.

Consider the symmetric case in which each security W_m is traded by $n_m = n$ investors in the local market m and by a competitive fringe of mass $\eta_m = \eta$ in the centralized market e. Each intermediary m then acquires a quantity $K_m = K$ of the underlying asset ($Z_m = Z$ with $F_m = F$) and each security W_m in equilibrium delivers a flat payoff in any state above

$\overline{s}_m = \overline{s}$. All intermediaries offer a debt security with the same face value, hence the state-by-state payoffs of a security traded by investor i in the centralized market are the same as the state-by-state payoffs of the security she trades in her local market m, i.e., $W_{\ell_j} = W_m$ for all $W_{\ell_j} \in \mathcal{E}^i$ in Eq. (20). The securities still have independently realized payoffs, even in the symmetric case where $w_m(s) = w(s)$ for all s, as the idiosyncratic states s are drawn independently from the cumulative distribution F. The centralized market component in Eq. (20) is thus equivalent to $e^i \times E_0\left(V_m^k\right)$.

We set $e^i = 1$ for illustration. That is, each investor trades only one security in the centralized market in addition to the security she trades in her local market. Overall welfare is then

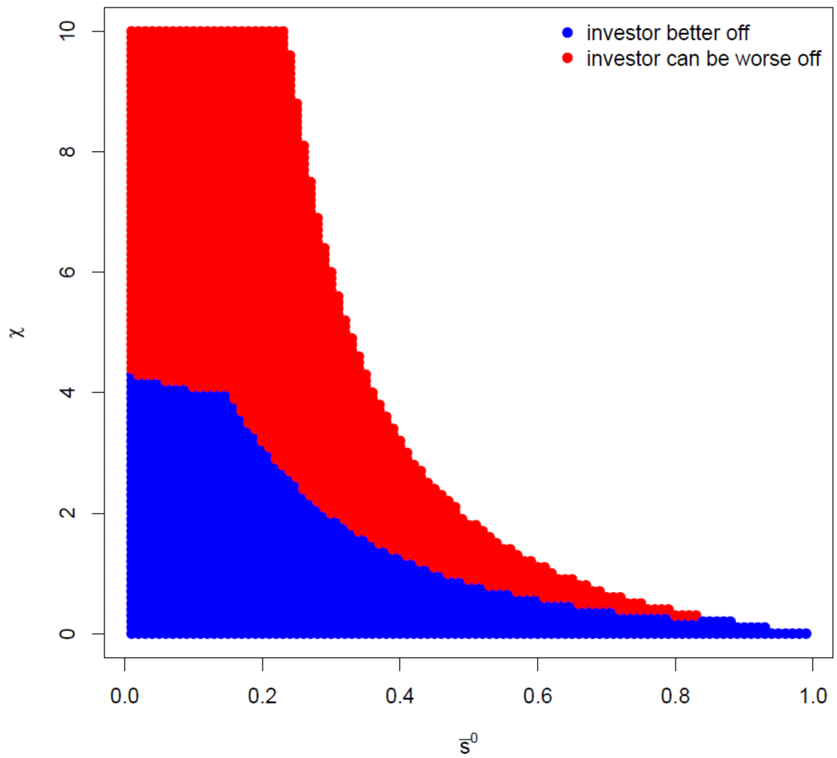
$$nM \times E_0\left(V_{m,local}^i\right) + (\eta + n)\, M \times E_0\left(V_m^k\right)$$

with $E_0\left(V_{m,local}^i\right)$ and $E_0\left(V_m^k\right)$ as defined in Eqs. (18) and (19). Once again, the competitive fringe is trivially better off in the presence of the exchange. In contrast, investors are better off if and only if $E_0\left(V_{m,local}^i\right) + E_0\left(V_m^k\right)$ evaluated at the security W_m exceeds $E_0\left(V_{m,local}^i\right)$ evaluated at the security W_m^0.

We illustrate this comparison in Figure 1, as a function of the threshold state $\overline{s}^0$ prior to the introduction of the exchange and the market power of the intermediaries χ after the exchange is introduced. Note that when the intermediary issues a per capita amount of the security in both the local and the centralized market, his market power becomes $\chi = \eta/n$. Varying his market power is then a statement about varying relative market size (i.e. what mass trades in the centralized market for each investor that trades in the local market). Figure 1 considers small local markets, with $n = 3$ investors in each, so that investors' local market power is high. We further consider a uniform distribution of states on the interval $[0, 1]$. The formal derivations for Figure 1 are presented in Appendix B.

Figure 1 demonstrates that the introduction of an exchange does not always benefit investors, even if it affords them market access. In the blue region, introducing an exchange makes the investor unambiguously better off. However, in the red region, investors can be worse off (i.e., there are values of σ_θ^2 such that they are worse off).

Figure 1: Effect of Trade Centralization on Investors



Notes: The figure is drawn for $n = 3$ and $\mu_\theta/\beta = 1.25$. The horizontal axis varies the security offered by the intermediary in the absence of an exchange (e.g., higher $\overline{s}^0$ arises for lower γ). The vertical axis varies the size of the exchange introduced by the regulator relative to the local market size.

If intermediary market power is not too large, as is the case in the blue region, introducing an exchange makes the investor better off because she is now able to trade a reasonably similar, albeit somewhat riskier, security in a larger, more liquid market. If the security that investors would trade in the absence of an exchange is not too risky, i.e., if $\overline{s}^0$ is low, then the introduction of even a relatively large exchange benefits investors despite the emergence of intermediary market power. However, if the security that investors would trade in the absence of an exchange is risky, i.e., if $\overline{s}^0$ is high, then investors can only tolerate the introduction of a small exchange before they become worse off. This is illustrated in Figure 1 by the shrinking height of the blue region. As the market power of intermediaries increases, they design riskier securities relative to the security that investors would trade in the absence of an exchange. The increase in the riskiness of the security can overcome any benefits that the investors obtain from trading in a liquid exchange, and it does so even for the introduction of a small exchange if the security that investors would otherwise trade is already risky.

Empirically, the introduction of an exchange (as represented by all-to-all electronic trading platforms) for securities that have traditionally traded over-the-counter has been associated with low volumes (see O'Hara and Zhou (2020) and Collin-Dufresne et al (2020)). Although we do not model an investor's choice of a trading venue here, it is clear from Eq. (20) that investors would always want to participate in the exchange, conditional on the exchange having been introduced. This is true regardless of the size of the exchange. However, if investors could choose, they would want to be in the blue region in Figure 1, where intermediaries do not have too much relative market power and the exchange makes investors better off relative to the case of no exchange. In this way, our model is consistent with the empirical observations: if investors could choose, they would prefer a smaller exchange (i.e. low volume).

4.4 Coordinated Policy

Even when the exchange makes investors worse off, a regulator could restore investors' welfare by shaping the incentives of intermediaries. The following proposition formalizes this result.

Proposition 5 *For any parameters such that the introduction of the exchange makes investors worse off (by altering security design in the local market), there exists a cost function* $u\left(K_m\right)=\frac{\delta K_m^2}{2}$ *that neutralizes the effect.*

We interpret δ as a tax that the regulator could lower, or an expense that he could subsidize. A change in δ affects the equilibrium security through the intermediary's choice of the quantity K_m of the underlying asset Z_m. Intuitively, decreasing δ increases K_m, which relaxes the feasibility constraint in security design. As discussed after Proposition 3, a larger pool of underlying assets Z_m gives the intermediary more returns to work with when designing the asset-backed security W_m. Accordingly, he can increase the expected payoff per unit of standard deviation of the security that he designs.

Lowering δ to neutralize the effect of the exchange on security design is clearly not a budget neutral solution for the regulator. An alternative would be to impose a constraint $K_m \geq K_m^{reg}$ on each intermediary m. In words, the regulator would dictate the minimum size of the underlying pool of assets Z_m for any asset-backed security issuance W_m of size $(n_m + \eta_m)$. We show in the proof of Proposition 5 that the regulator would need to set

$$K_m^{reg} = \frac{\mu_\theta - \beta}{2\gamma} \frac{n_m (n_m - 2)}{n_m - 1} \frac{(1 + \chi_m)^2}{1 + \frac{n_m - 2}{n_m - 1}\chi_m} \frac{1}{\int_0^{\bar{s}_m^0} \left[z_m \left(\bar{s}_m^0 \right) - z_m(s) \right] dF(s)}$$

to deliver $W_m = W_m^0$ when an exchange that gives the intermediary market power χ_m is introduced.

We conclude that endogenous security design presents a challenge for introducing a centralized market. Our results motivate a coordinated policy, i.e., the introduction of the exchange together with actions that mitigate the negative effect on security design, to promote investor welfare. While a simple constraint $K_m \geq K_m^{reg}$ on the quantity of underlying assets originated (or purchased) by the intermediary would be budget neutral for the regulator, it could lead to attempts to circumvent the constraint should a shadow banking technology become available. Compliance would then have to be carefully supervised, which is itself potentially costly. This speaks to implementation challenges of a coordinated policy.

Note that limiting investor participation by splitting the one centralized market into multiple perfectly competitive platforms does not alter our conclusion about the effect of mandating trade centralization on security design. To see this, consider two exchanges each of size $\frac{\eta_m}{2}$, with the intermediary supplying $\frac{a_m^e}{2}$ units of W_m to each exchange. The intermediary's problem still aggregates to Eq. (8) and hence the effects on security design are unchanged.

5 The Effects of Trade Centralization on Origination Quality

The analysis so far has assumed a fixed payoff profile for the underlying asset Z_m. In reality, intermediaries can choose between underlying assets of different quality. For the purposes of our analysis, we are interested in how the introduction of an exchange affects an intermediary's incentive to originate higher quality assets. This is important to consider because we found above that the loss of local market power by investors when an exchange is introduced leads to a deterioration in the quality of the asset-backed securities sold by intermediaries to investors. If the introduction of an exchange leads to the origination of better underlying assets, perhaps the securities backed by these assets will also be of better quality, even without the disciplining effect of investor market power in local markets on security design.

To gain insight into this question, we fix the quantity of the asset Z_m originated by intermediary m at $\overline{K}_m$. The intermediary instead chooses the payoffs $w_m(\cdot)$ of the security he designs based on Z_m as well as the underlying payoffs $z_m(\cdot)$. Specifically, we consider that

$$z_m(s) = r_m^2 + r_m s$$

where r_m is chosen by the intermediary at a cost $u(r_m)$ with standard properties, i.e., increasing and convex. To fix ideas, consider $u(r_m) = \frac{\tau r_m^2}{2}$ with $\tau > 0$. The underlying asset originated by the intermediary then has an expected payoff per unit of standard deviation

$$\frac{E_1(Z_m)}{\sqrt{\mathcal{V}_1(Z_m)}} = \frac{r_m + E_1(s)}{\sqrt{\mathcal{V}_1(s)}}$$

which is to say the quality of the asset Z_m is increasing in r_m. The intermediary chooses $w_m(\cdot)$ and r_m to maximize his expected profit at $t = 0$ subject to the feasibility constraint on security design $A_m w_m(\cdot) \leq \overline{K}_m z_m(\cdot)$.

Consider what happens now when the exchange is introduced. We are interested specifically in the effect on (i) the asset Z_m and the asset-backed security W_m and (ii) the investor's value function as we move from no exchange ($\eta_m = 0$) to a government-mandated exchange ($\eta_m > 0$). The difference relative to Section 4 is that both $\frac{E_1(Z_m)}{\sqrt{\mathcal{V}_1(Z_m)}}$ and $\frac{E_1(W_m)}{\sqrt{\mathcal{V}_1(W_m)}}$ are now endogenous, not just $\frac{E_1(W_m)}{\sqrt{\mathcal{V}_1(W_m)}}$.

Proposition 6 *Consider $\tau >> 2\mu_\theta \overline{K}_m$. Introducing the exchange leads to the origination of better underlying assets, as captured by higher $\frac{E_1(Z_m)}{\sqrt{\mathcal{V}_1(Z_m)}}$, but the creation of worse securities backed by those assets, as captured by lower $\frac{E_1(W_m)}{\sqrt{\mathcal{V}_1(W_m)}}$.*

The intuition for higher r_m, which is the driving force behind higher $\frac{E_1(Z_m)}{\sqrt{\mathcal{V}_1(Z_m)}}$ after the introduction of the exchange, is as follows. The marginal benefit of increasing r_m is to relax the feasibility constraint $A_m w_m(s) \leq \overline{K}_m z_m(s)$ in the intermediary's security design problem. The marginal cost comes from $\tau > 0$. The introduction of the exchange does not affect the marginal cost, so, for the exchange to lead to an increase in r_m, it must be that introducing the exchange increases the marginal benefit. As in Section 4, the exchange leads to an increase in $\overline{s}_m$. The intuition for higher $\overline{s}_m$, which is the main driving force behind lower $\frac{E_1(W_m)}{\sqrt{\mathcal{V}_1(W_m)}}$ after the introduction of the exchange, is similar to before. By increasing $\overline{s}_m$, the intermediary increases $E_1(W_m)$, which will fetch him a higher price, and he will not be as penalized for the associated increase in $\mathcal{V}_1(W_m)$ because investors have less market power after the introduction of the exchange. The feasibility constraint therefore binds in more states for the security designed after the introduction of the exchange, hence the marginal benefit to increasing r_m and relaxing the constraint is indeed higher.

The key insight from this section is that introducing the exchange can increase $\frac{E_1(Z_m)}{\sqrt{\mathcal{V}_1(Z_m)}}$ but decrease $\frac{E_1(W_m)}{\sqrt{\mathcal{V}_1(W_m)}}$. As before, the decrease in $\frac{E_1(W_m)}{\sqrt{\mathcal{V}_1(W_m)}}$, which we interpret as a deterioration in the quality of asset-backed securities sold by intermediaries to investors, reflects the loss of market power by investors in the local market. What we learn here is (1) the exchange leads to better quality origination and (2) the market power of investors is a powerful disciplining device on the intermediary's security design, so much so that even with better quality underlying assets, the asset-backed security can still be worse.

Next, consider the effect of introducing the exchange on the investor's value function. As before, the local market component of the investor's value function will be negatively affected by the reduction in $\frac{E_1(W_m)}{\sqrt{\mathcal{V}_1(W_m)}}$. This is not a statement that the investor is worse off, but rather that he could be worse off, in which case the following policy option is available:

Proposition 7 *For any parameters such that the introduction of the exchange makes investors worse off (by altering security design in the local market), the regulator can decrease τ (e.g., via subsidy) to mitigate the effect.*

Intuitively, lower τ increases r_m, which increases the payoff $z_m(\cdot)$ in each state and therefore relaxes the feasibility constraint. This leads to a better asset-backed security, all else constant, which helps to offset the deterioration in the quality of the asset-backed security that results from the dilution of investor market power after the introduction of the exchange. In summary, introducing the exchange increases $z_m(\cdot)$ but dilutes the investor's market power. The effect of the latter on security design is stronger than the effect of the former, at least in the example constructed here. A decrease in τ serves to further increase $z_m(\cdot)$ without affecting the investor's market power, which helps offset the negative effect of the exchange on W_m.[4]

6 Conclusion

The vast majority of regulatory debates about the benefits of centralized trading assume that the set of securities designed by financial intermediaries is immune to the market structure in which trade occurs. Will all securities trading in decentralized markets migrate to a centralized platform rather than ceasing to be issued? How can a regulator ensure that they do migrate? This paper has presented a framework to study these questions.

In particular, we considered a regulator who redesigns the market structure for certain financial contracts by introducing an exchange to increase liquidity, understanding that security design is endogenous. For a given market structure, investors would like to trade a less risky security and, for a given security, they would like to trade in a larger market. We find that intermediaries design lower quality securities for investors, in the sense of a lower expected payoff per unit of standard deviation, after the introduction of the exchange. This reflects the relative dilution of investor market power, as investors have zero price impact on the exchange and hence less influence on intermediary security design. In an extension of

[4] In principle, an alternative would be to impose a constraint $r_m \geq r_m^{reg}$ on each intermediary m. We omit the proof for brevity and because the choice of r_m may be harder for the regulator to verify than the choice of K_m.

the model where intermediaries can choose the quality of the assets that back the securities issued to investors, we find that introducing the exchange leads to the origination of better underlying assets but the creation of worse securities backed by those assets.

With a large enough exchange, the decline in the quality of the securities designed by intermediaries is so severe that investors can be worse off as a result of the introduction of the exchange, even though the exchange broadens their access to asset-backed securities and allows them to trade in a more liquid market. In this case, the regulator can offer origination subsidies to intermediaries to influence the pool of underlying assets. More origination of a given quality or the origination of higher quality underlying assets means that the intermediary has more returns, in any given state, from which to design the payoff of the asset-backed security. This allows him to create a security with higher average payoff, without increasing the variability of those payoffs across states. The regulator could therefore use origination subsidies to counter the negative effects of introducing the exchange on security design and investor welfare. Alternatively, the regulator could impose explicit floors on intermediaries' origination decisions (or asset purchases) and supervise to ensure compliance. Either way, without such additional action, mandating centralized trade will result in a higher market share for issuers of riskier securities.

Our exposition of these issues has considered that the underlying assets, and consequently the securities that intermediaries design, have independent payoffs. When there is correlation between assets, traders' demands are not generally separable across assets and there are cross-asset price impact effects (e.g., Malamud and Rostek (2017)). In this case, each intermediary in our model would need to take into account the securities of other intermediaries when designing his own. This introduces an additional layer of strategic thinking for the intermediary and could be an interesting direction for future work.

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Appendix A – Proofs

Proof of Proposition 1

Rearrange the first order condition of investor i in Eq. (9) to isolate:

$$\begin{bmatrix} q_m^i \\ \mathbf{x}_{\mathcal{E}^i} \end{bmatrix} = \left(\Lambda^i + \gamma\Sigma^i\right)^{-1} \left\{\theta^i E_1 \left(\begin{bmatrix} W_m \\ \mathbf{W}_{\mathcal{E}^i} \end{bmatrix} \right) - \begin{bmatrix} p_m \\ \mathbf{p}_{\mathcal{E}^i} \end{bmatrix} \right\} \tag{A.1}$$

for any $i \in \mathcal{N}_m$.

Since assets Z_m are independent, any securities backed by Z_m are also independent. Hence, the matrix Σ^i is diagonal. We then conjecture and verify that Λ^i has entry $\frac{\partial p_{m,-i}}{\partial q_m^i}$ first row, first column, and 0 elsewhere. This implies then that

$$q_m^i = \frac{\theta^i E_1 \left(W_m\right) - p_m}{\frac{\partial p_{m,-i}}{\partial q_m^i} + \gamma \mathcal{V}_1 \left(W_m\right)}, \tag{A.2}$$

and

$$x_{\ell_j}^i = \frac{\theta^i E_1 \left(W_{\ell_j}\right) - p_{\ell_j}}{\gamma \mathcal{V}_1 \left(W_{\ell_j}\right)}. \tag{A.3}$$

Given that investor i trades security W_{ℓ_j} in a perfectly competitive centralized market, it is straightforward that (A.3) gives the equilibrium demand (10). Further, substituting Eq. (10) into the market clearing condition (5) then delivers the equilibrium price $p_{\ell_j}^e$ in Eq. (11).

Since this holds in every market, we use the corresponding expression for (A.2) to substitute out $Q_m^j(\cdot)$ in Eq. (4) for all investors $j \neq i$ in market m:

$$q_m^i + \sum_{j \in m, j \neq i} \frac{\theta^j E_1 \left(W_m\right) - p_m}{\frac{\partial p_{m,-j}}{\partial q_m^j} + \gamma \mathcal{V}_1 \left(W_m\right)} = a_m \tag{A.4}$$

We focus on symmetric linear equilibria in which the price impact $\frac{\partial p_{m,-j}}{\partial q_m^j}$ does not vary across investors within the same market. This permits rearranging Eq. (A.4) to isolate:

$$p_m = \frac{\sum_{j \in m, j \neq i} \theta^j}{n_m - 1} E_1 \left(W_m\right) - \frac{a_m - q_m^i}{n_m - 1} \left(\frac{\partial p_{m,-j}}{\partial q_m^j} + \gamma \mathcal{V}_1 \left(W_m\right)\right)$$

which then implies:

$$\frac{\partial p_{m,-i}}{\partial q_m^i} = \frac{1}{n_m - 1}\left(\frac{\partial p_{m,-j}}{\partial q_m^j} + \gamma \mathcal{V}_1 (W_m)\right)$$

Invoking symmetry ($\frac{\partial p_{m,-i}}{\partial q_m^i} = \frac{\partial p_{m,-j}}{\partial q_m^j}$), we obtain:

$$\frac{\partial p_{m,-i}}{\partial q_m^i} = \lambda_m \gamma \mathcal{V}_1 (W_m) \tag{A.5}$$

where $\lambda_m \equiv \frac{1}{n_m - 2}$.

Substituting Eq. (A.5) into Eq. (A.1) delivers the equilibrium demand function $Q_m^i \left(p_m; \theta^i\right)$ in Eq. (12). Substituting Eq. (12) into the market clearing condition (4) then delivers the equilibrium price p_m in Eq. (13).

Note that the equilibrium demands (12) and (10) verify our conjecture about Λ^i. ■

Proof of Propositions 2 and 3

Intermediary m's expected payoff is:

$$\begin{aligned} & V_m (W_m, K_m | n_m, \eta_m, A_m, a_m^e, Z_m) \\ = \; & E_1 (p_m) (A_m - a_m^e) + p_m^e a_m^e + \beta \left[K_m E_1 (Z_m) - A_m E_1 (W_m)\right] - u (K_m) \end{aligned}$$

where we obtain p_m^e from Eq. (11) and $E_1 (p_m)$ from taking expectations of Eq. (13), i.e.,

$$p_m^e = \mu_\theta E_1 (W_m) - \gamma \mathcal{V}_1 (W_m) \frac{a_m^e}{\eta_m} \tag{A.6}$$

$$E_1 (p_m) = \mu_\theta E_1 (W_m) - \gamma \mathcal{V}_1 (W_m) (1 + \lambda_m) \frac{A_m - a_m^e}{n_m} \tag{A.7}$$

Therefore,

$$\begin{aligned} & V_m (W_m, K_m | n_m, \eta_m, A_m, a_m^e, Z_m) \\ = \; & (\mu_\theta - \beta) E_1 (W_m) A_m - \gamma \mathcal{V}_1 (W_m) \left((1 + \lambda_m) \frac{(A_m - a_m^e)^2}{n_m} + \frac{(a_m^e)^2}{\eta_m}\right) + \beta K_m E_1 (Z_m) - u (K_m) \end{aligned}$$

The intermediary chooses $w_m(\cdot)$ and K_m to maximize $V_m(\cdot)$ subject to the feasibility constraint (1). Letting $\psi_m(s) \geq 0$ denote the Lagrange multiplier on the feasibility constraint in state s, the Lagrangian for intermediary m's problem is

$$\begin{aligned}
\mathcal{L}_k &= (\mu_\theta - \beta) A_m \int_0^S w_m(s)\, dF(s) \\
&\quad -\gamma \left((1+\lambda_m) \frac{(A_m - a_m^e)^2}{n_m} + \frac{(a_m^e)^2}{\eta_m} \right) \left[\int_0^S (w_m(s))^2\, dF(s) - \left(\int_0^S w_m(s)\, dF(s) \right)^2 \right] \\
&\quad +\beta K_m E_1(Z_m) - u(K_m) + \int_0^S \psi_m(s) \left[K_m z_m(s) - A_m w_m(s) \right] dF(s)
\end{aligned}$$

The first order condition with respect to $w_m(s)$ is

$$\psi_m(s) = \mu_\theta - \beta - \frac{2\gamma}{A_m} \left((1+\lambda_m) \frac{(A_m - a_m^e)^2}{n_m} + \frac{(a_m^e)^2}{\eta_m} \right) \left[w_m(s) - E_1(W_m) \right]$$

or equivalently

$$\psi_m(s) = \mu_\theta - \beta - 2\gamma A_m \frac{1+\lambda_m+\chi_m}{\left(\sqrt{\eta_m \chi_m} + \sqrt{n_m} \right)^2} \left[w_m(s) - E_1(W_m) \right] \tag{A.8}$$

after using the definition of χ_m to substitute out all occurrences of a_m^e.

If $\psi_m(s) > 0$, then $w_m(s) = \frac{K_m}{A_m} z_m(s)$ by complementary slackness, so, to confirm $\psi_m(s) > 0$, we would need

$$z_m(s) < \frac{A_m}{K_m} E_1(W_m) + \frac{\mu_\theta - \beta}{2\gamma K_m} \frac{\left(\sqrt{\eta_m \chi_m} + \sqrt{n_m} \right)^2}{1+\lambda_m+\chi_m} \equiv z_m(\overline{s}_m) \tag{A.9}$$

where we have defined the right-hand side assuming an interior solution $\overline{s}_m \in (0, S)$. If instead $\psi_m(s) = 0$, then Eq. (A.8) pins down $w_m(s) = \frac{K_m}{A_m} z_m(\overline{s}_m)$. The optimal security is therefore characterized by Eq. (15) with $\overline{s}_m$ as defined in Eq. (A.9). Note that we can also write

$$\int_0^{\overline{s}_m} \left[z_m(\overline{s}_m) - z_m(s) \right] dF(s) \equiv \frac{\mu_\theta - \beta}{2\gamma K_m} \frac{\left(\sqrt{\eta_m \chi_m} + \sqrt{n_m} \right)^2}{1+\lambda_m+\chi_m} \tag{A.10}$$

after using Eq. (15) to replace $E_1(W_m)$ in the definition of $\overline{s}_m$ in Eq. (A.9).

The first order condition with respect to K_m is

$$u'(K_m) = \beta E_1(Z_m) + \int_0^S \psi_m(s) z_m(s) dF(s)$$

so we need to use Eq. (A.8) to sub out $\psi_m(s)$, which is positive if and only if $s < \overline{s}_m$. Doing so gives

$$u'(K_m) = \beta E_1(Z_m) + \int_0^{\overline{s}_m} \left(\mu_\theta - \beta - 2\gamma A_m \frac{1+\lambda_m+\chi_m}{\left(\sqrt{\eta_m \chi_m} + \sqrt{n_m}\right)^2} \left[\frac{K_m}{A_m} z_m(s) - E_1(W_m) \right] \right) z_m(s) dF(s)$$

or equivalently

$$u'(K_m) = \beta E_1(Z_m) + 2\gamma K_m \frac{1+\lambda_m+\chi_m}{\left(\sqrt{\eta_m \chi_m} + \sqrt{n_m}\right)^2} \int_0^{\overline{s}_m} z_m(s) \left[z_m(\overline{s}_m) - z_m(s) \right] dF(s) \tag{A.11}$$

Combining Eq. (A.11) with $u'(K_m) = \delta K_m$ and Eq. (A.10) then delivers the expression in the statement of Proposition 3.

We now return to whether $\overline{s}_m$ is in fact interior. Use Eq. (A.10) to substitute K_m out of the expression in the statement of Proposition 3. The result is:

$$\begin{aligned} & \int_0^{\overline{s}_m} z_m(s) \left[z_m(\overline{s}_m) - z_m(s) \right] dF(s) + \frac{\beta E_1(Z_m)}{\mu_\theta - \beta} \int_0^{\overline{s}_m} \left[z_m(\overline{s}_m) - z_m(s) \right] dF(s) \\ = \; & \frac{\delta}{2\gamma} \frac{\left(\sqrt{\eta_m \chi_m} + \sqrt{n_m}\right)^2}{1+\lambda_m+\chi_m} \end{aligned} \tag{A.12}$$

The left-hand side of Eq. (A.12) is increasing in $\overline{s}_m$ and thus takes on a maximum value

$$\int_0^S z_m(s) \left[z_m(S) - z_m(s) \right] dF(s) + \frac{\beta E_1(Z_m)}{\mu_\theta - \beta} \int_0^S \left[z_m(S) - z_m(s) \right] dF(s)$$

or equivalently

$$\frac{\mu_\theta}{\mu_\theta - \beta} E_1(Z_m) \left[z_m(S) - E_1(Z_m) \right] - \mathcal{V}_1(Z_m)$$

With $1 + \lambda_m = \frac{n_m - 1}{n_m - 2}$, the right-hand side of Eq. (A.12) is increasing in n_m. Therefore $\overline{s}_m$ is interior for $n_m < \overline{n}_m$, where $\overline{n}_m$ solves Eq. (17). ■

Proof of Corollary 1

Use Eq. (A.12). As above, the left-hand side of Eq. (A.12) is increasing in $\overline{s}_m$. For the right-hand side,

$$\frac{\partial}{\partial \chi_m}\left(\frac{\left(\sqrt{n_m}+\sqrt{\eta_m \chi_m}\right)^2}{\frac{n_m-1}{n_m-2}+\chi_m}\right)=\frac{\sqrt{n_m}+\sqrt{\eta_m \chi_m}}{\left(1+\lambda_m+\chi_m\right)^2}\sqrt{\frac{n_m}{\chi_m}}\left(\sqrt{\frac{\eta_m}{n_m}}\left(1+\lambda_m\right)-\sqrt{\chi_m}\right)$$

$$\frac{\partial}{\partial n_m}\left(\frac{\left(\sqrt{n_m}+\sqrt{\eta_m \chi_m}\right)^2}{\frac{n_m-1}{n_m-2}+\chi_m}\right)=\frac{\sqrt{n_m}+\sqrt{\eta_m \chi_m}}{1+\lambda_m+\chi_m}\left(\frac{1}{\sqrt{n_m}}+\frac{\sqrt{n_m}+\sqrt{\eta_m \chi_m}}{1+\lambda_m+\chi_m}\frac{1}{\left(n_m-2\right)^2}\right)>0$$

where we have used $1+\lambda_m=\frac{n_m-1}{n_m-2}$. It then follows immediately that (i) $\frac{\partial \overline{s}_m}{\partial \chi_m}>0$ if and only if $\chi_m<\frac{\eta_m}{n_m}\left(1+\lambda_m\right)^2$ and (ii) $\frac{\partial \overline{s}_m}{\partial n_m}>0$. Note that $\frac{\partial \overline{s}_m}{\partial n_m}>0$ can also be expressed as $\frac{\partial \overline{s}_m}{\partial \lambda_m}<0$.

From the intermediary's security design problem,

$$E_1\left(W_m\right)=\frac{K_m}{A_m}\left(z_m\left(\overline{s}_m\right)-\int_0^{\overline{s}_m}\left[z_m\left(\overline{s}_m\right)-z_m\left(s\right)\right]dF\left(s\right)\right)$$

$$\mathcal{V}_1\left(W_m\right)=\left(\frac{K_m}{A_m}\right)^2\left[\int_0^{\overline{s}_m}\left[z_m\left(\overline{s}_m\right)-z_m\left(s\right)\right]^2dF\left(s\right)-\left(\int_0^{\overline{s}_m}\left[z_m\left(\overline{s}_m\right)-z_m\left(s\right)\right]dF\left(s\right)\right)^2\right]$$

Therefore,

$$\frac{E_1\left(W_m\right)}{\sqrt{\mathcal{V}_1\left(W_m\right)}}=\frac{z_m\left(\overline{s}_m\right)-\int_0^{\overline{s}_m}\left[z_m\left(\overline{s}_m\right)-z_m\left(s\right)\right]dF\left(s\right)}{\sqrt{\int_0^{\overline{s}_m}\left[z_m\left(\overline{s}_m\right)-z_m\left(s\right)\right]^2dF\left(s\right)-\left(\int_0^{\overline{s}_m}\left[z_m\left(\overline{s}_m\right)-z_m\left(s\right)\right]dF\left(s\right)\right)^2}}$$

where

$$\frac{\partial}{\partial \overline{s}_m}\left(\frac{E_1\left(W_m\right)}{\sqrt{\mathcal{V}_1\left(W_m\right)}}\right)=-\frac{z_m'\left(\overline{s}_m\right)\left[1-F\left(\overline{s}_m\right)\right]\int_0^{\overline{s}_m}z_m\left(s\right)\left[z_m\left(\overline{s}_m\right)-z_m\left(s\right)\right]dF\left(s\right)}{\left(\int_0^{\overline{s}_m}\left[z_m\left(\overline{s}_m\right)-z_m\left(s\right)\right]^2dF\left(s\right)-\left(\int_0^{\overline{s}_m}\left[z_m\left(\overline{s}_m\right)-z_m\left(s\right)\right]dF\left(s\right)\right)^2\right)^{\frac{3}{2}}}<0$$

i.e., any increase in $\overline{s}_m$ implies a decrease in $\frac{E_1\left(W_m\right)}{\sqrt{\mathcal{V}_1\left(W_m\right)}}$.

Next, use Proposition 3 to sub K_m out of the expression for $E_1\left(W_m\right)$. This gives

$E_1(W_m)$ as a function of only $\overline{s}_m$, namely,

$$E_1(W_m) = \frac{1}{\delta A_m}\left((\mu_\theta - \beta)\frac{\int_0^{\overline{s}_m} z_m(s)\left[z_m(\overline{s}_m) - z_m(s)\right] dF(s)}{\int_0^{\overline{s}_m}\left[z_m(\overline{s}_m) - z_m(s)\right] dF(s)} + \beta E_1(Z_m)\right) \times \left(z_m(\overline{s}_m) - \int_0^{\overline{s}_m}\left[z_m(\overline{s}_m) - z_m(s)\right] dF(s)\right)$$

where

$$\begin{aligned} & \frac{\partial}{\partial \overline{s}_m}\left(\frac{\int_0^{\overline{s}_m} z_m(s)\left[z_m(\overline{s}_m) - z_m(s)\right] dF(s)}{\int_0^{\overline{s}_m}\left[z_m(\overline{s}_m) - z_m(s)\right] dF(s)}\right) \\ = \; & z_m'(\overline{s}_m)\frac{\frac{1}{F(\overline{s}_m)}\int_0^{\overline{s}_m}(z_m(s))^2 dF(s) - \left(\frac{1}{F(\overline{s}_m)}\int_0^{\overline{s}_m} z_m(s) dF(s)\right)^2}{\left(z_m(\overline{s}_m) - \frac{1}{F(\overline{s}_m)}\int_0^{\overline{s}_m} z_m(s) dF(s)\right)^2} > 0 \end{aligned}$$

and

$$\frac{\partial}{\partial \overline{s}_m}\left(z_m(\overline{s}_m) - \int_0^{\overline{s}_m}\left[z_m(\overline{s}_m) - z_m(s)\right] dF(s)\right) = z_m'(\overline{s}_m)\left[1 - F(\overline{s}_m)\right]$$

Thus, $\frac{\partial E_1(W_m)}{\partial \overline{s}_m} > 0$. We then deduce $\frac{\partial \mathcal{V}_1(W_m)}{\partial \overline{s}_m} > 0$ from $\frac{\partial E_1(W_m)}{\partial \overline{s}_m} > 0$ and $\frac{E_1(W_m)}{\sqrt{\mathcal{V}_1(W_m)}} < 0$. ■

Proof of Proposition 4

Use Eq. (A.12). With the exchange, $\overline{s}_m$ is given by Eq. (A.12) evaluated at $\chi_m = \frac{\eta_m}{n_m}$, i.e.,

$$\begin{aligned} & \int_0^{\overline{s}_m} z_m(s)\left[z_m(\overline{s}_m) - z_m(s)\right] dF(s) + \frac{\beta E_1(Z_m)}{\mu_\theta - \beta}\int_0^{\overline{s}_m}\left[z_m(\overline{s}_m) - z_m(s)\right] dF(s) \\ = \; & \frac{\delta}{2\gamma}\frac{n_m(n_m - 2)}{n_m - 1}\frac{(1 + \chi_m)^2}{1 + \frac{n_m - 2}{n_m - 1}\chi_m} \end{aligned} \tag{A.13}$$

Without the exchange, $\overline{s}_m^0$ is given by Eq. (A.12) evaluated at $\chi_m = 0$, i.e.,

$$\begin{aligned} & \int_0^{\overline{s}_m^0} z_m(s)\left[z_m(\overline{s}_m^0) - z_m(s)\right] dF(s) + \frac{\beta E_1(Z_m)}{\mu_\theta - \beta}\int_0^{\overline{s}_m^0}\left[z_m(\overline{s}_m^0) - z_m(s)\right] dF(s) \\ = \; & \frac{\delta}{2\gamma}\frac{n_m(n_m - 2)}{n_m - 1} \end{aligned} \tag{A.14}$$

where we have used $1 + \lambda_m = \frac{n_m - 1}{n_m - 2}$. The left-hand side of Eq. (A.12) is increasing in $\overline{s}_m$, hence $\overline{s}_m^0 < \overline{s}_m$ for any $\chi_m > 0$. The rest follows from the derivatives in the proof of

Corollary 1.

In both cases (i.e., with or without the exchange), the equilibrium amount K_m of the asset Z_m acquired by the intermediary is governed by the expression in Proposition 3. The term that depends on $\bar{s}_m$ in this expression is increasing in $\bar{s}_m$ (see the proof of Corollary 1). Thus, $K_m^0 < K_m$ follows from $\bar{s}_m^0 < \bar{s}_m$. ■

Proof of Corollary 2

The expected payoff of an investor $i \in \mathcal{N}_m$ who only trades the security W_m in her local market m is:

$$\begin{aligned} E_0\left(V_{m,local}^i\right) &= E_0\left(\left(\theta^i E_1\left(W_m\right) - p_m\right) Q_m^i - \frac{\gamma}{2}\mathcal{V}_1\left(W_m\right)\left(Q_m^i\right)^2\right) \\ &= \frac{1}{2}\frac{1}{\gamma\mathcal{V}_1\left(W_m\right)}\frac{1+2\lambda_m}{\left(1+\lambda_m\right)^2} E_0\left(\left[\theta^i E_1\left(W_m\right) - p_m\right]^2\right) \\ &= \frac{1+2\lambda_m}{2}\left(\frac{\sigma_\theta^2}{\gamma}\frac{n_m-1}{n_m}\frac{1}{\left(1+\lambda_m\right)^2}\frac{\left(E_1\left(W_m\right)\right)^2}{\mathcal{V}_1\left(W_m\right)} + \gamma\mathcal{V}_1\left(W_m\right)\left(\frac{a_m}{n_m}\right)^2\right) \end{aligned}$$

where the second line substitutes in the equilibrium demand function from Eq. (12) and the third line substitutes in the equilibrium price from Eq. (13). Evaluating at $a_m = n_m$ delivers the expression for $E_0\left(V_{m,local}^i\right)$ in the main text, although we do not need that simplification here.

With $\lambda_m^{-1} \equiv (n_m - 2)$,

$$E_0\left(V_{m,local}^i\right) = \frac{1}{2}\left(\frac{\sigma_\theta^2}{\gamma}\frac{\left(E_1\left(W_m\right)\right)^2}{\mathcal{V}_1\left(W_m\right)}\frac{n_m-2}{n_m-1} + \gamma\mathcal{V}_1\left(W_m\right)\frac{n_m}{n_m-2}\left(\frac{a_m}{n_m}\right)^2\right)$$

where

$$\begin{aligned} &\frac{\partial}{\partial\bar{s}_m}\left(\frac{\sigma_\theta^2}{\gamma}\frac{\left(E_1\left(W_m\right)\right)^2}{\mathcal{V}_1\left(W_m\right)}\frac{n_m-2}{n_m-1} + \gamma\mathcal{V}_1\left(W_m\right)\frac{n_m}{n_m-2}\left(\frac{a_m}{n_m}\right)^2\right) \\ = &\frac{\sigma_\theta^2}{\gamma}\left(2\frac{dE_1\left(W_m\right)}{d\bar{s}_m} - \frac{E_1\left(W_m\right)}{\mathcal{V}_1\left(W_m\right)}\frac{d\mathcal{V}_1\left(W_m\right)}{d\bar{s}_m}\right)\frac{E_1\left(W_m\right)}{\mathcal{V}_1\left(W_m\right)}\frac{n_m-2}{n_m-1} + \frac{\gamma n_m}{n_m-2}\left(\frac{a_m}{n_m}\right)^2\frac{d\mathcal{V}_1\left(W_m\right)}{d\bar{s}_m} \end{aligned}$$

$$
\begin{aligned}
&= \frac{2\gamma z_m'\left(\overline{s}_m\right)\left(\frac{\frac{\mu_\theta-\beta}{2\gamma}A_m}{\frac{(n_m-1)a_m^2}{n_m(n_m-2)}+\frac{(a_m^e)^2}{\eta_m}}\right)^2}{\int_0^{\overline{s}_m}\left[z_m\left(\overline{s}_m\right)-z_m\left(s\right)\right]dF\left(s\right)} \\
&\times\left[\begin{array}{l}\left(\frac{\sigma_\theta}{\gamma}\right)^2\left(\begin{array}{l}\frac{\frac{(n_m-1)a_m^2}{n_m(n_m-2)}+\frac{(a_m^e)^2}{\eta_m}}{\frac{\mu_\theta-\beta}{2\gamma}A_m}\left(1-\frac{z_m(\overline{s}_m)F(\overline{s}_m)}{\int_0^{\overline{s}_m}[z_m(\overline{s}_m)-z_m(s)]dF(s)}\right) \\ -\frac{E_1(W_m)}{\mathcal{V}_1(W_m)}\frac{\left(\int_0^{\overline{s}_m}[z_m(\overline{s}_m)-z_m(s)]dF(s)\right)^2-F(\overline{s}_m)\int_0^{\overline{s}_m}[z_m(\overline{s}_m)-z_m(s)]^2dF(s)}{\left(\int_0^{\overline{s}_m}[z_m(\overline{s}_m)-z_m(s)]dF(s)\right)^2}\end{array}\right)\frac{E_1(W_m)}{\mathcal{V}_1(W_m)}\frac{n_m-2}{n_m-1} \\ +\frac{n_m}{n_m-2}\left(\frac{a_m}{n_m}\right)^2\frac{\left(\int_0^{\overline{s}_m}[z_m(\overline{s}_m)-z_m(s)]dF(s)\right)^2-F(\overline{s}_m)\int_0^{\overline{s}_m}[z_m(\overline{s}_m)-z_m(s)]^2dF(s)}{\left(\int_0^{\overline{s}_m}[z_m(\overline{s}_m)-z_m(s)]dF(s)\right)^2}\end{array}\right] \\
&= \frac{2\gamma z_m'\left(\overline{s}_m\right)\left(\frac{\frac{\mu_\theta-\beta}{2\gamma}n_m}{\frac{(n_m-1)a_m^2}{n_m(n_m-2)}+\frac{(a_m^e)^2}{\eta_m}}\right)^2}{\int_0^{\overline{s}_m}\left[z_m\left(\overline{s}_m\right)-z_m\left(s\right)\right]dF\left(s\right)}\left[\begin{array}{l}-\frac{\left(\frac{\sigma_\theta}{\gamma}\right)^2\frac{\frac{a_m^2}{n_m}+\frac{n_m-2}{n_m-1}\frac{(a_m^e)^2}{\eta_m}}{\frac{\mu_\theta-\beta}{2\gamma}A_m}\frac{E_1(W_m)}{\mathcal{V}_1(W_m)}[1-F(\overline{s}_m)]\int_0^{\overline{s}_m}z_m(s)[z_m(\overline{s}_m)-z_m(s)]dF(s)}{\int_0^{\overline{s}_m}[z_m(\overline{s}_m)-z_m(s)]^2dF(s)-\left(\int_0^{\overline{s}_m}[z_m(\overline{s}_m)-z_m(s)]dF(s)\right)^2} \\ -\frac{\frac{n_m}{n_m-2}\left(\frac{a_m}{n_m}\right)^2\mathcal{V}_1(Z_m|s\leq\overline{s}_m)}{\left(\frac{1}{F(\overline{s}_m)}\int_0^{\overline{s}_m}[z_m(\overline{s}_m)-z_m(s)]dF(s)\right)^2}\end{array}\right] \\
&< 0
\end{aligned}
$$

where $\mathcal{V}_1\left(Z_m|s\leq\overline{s}_m\right)\equiv\frac{1}{F(\overline{s}_m)}\int_0^{\overline{s}_m}\left(z_m\left(s\right)\right)^2dF\left(s\right)-\left(\frac{1}{F(\overline{s}_m)}\int_0^{\overline{s}_m}z_m\left(s\right)dF\left(s\right)\right)^2$. A riskier security W_m, as captured by higher $\overline{s}_m$, therefore decreases $E_0\left(V_{m,local}^i\right)$. The statement of the corollary then follows immediately from Proposition 4. ■

Proof of Proposition 5

Let δ_0 denote the origination cost parameter before the introduction of the exchange and δ' the origination cost parameter implemented by the regulator (e.g., via a change in taxes) alongside the introduction of the exchange. Then Eq. (A.13) is evaluated at δ', Eq. (A.14) is evaluated at δ_0, and

$$\delta'=\frac{1+\frac{n_m-2}{n_m-1}\chi_m}{\left(1+\chi_m\right)^2}\delta_0<\delta_0$$

induces $\overline{s}_m=\overline{s}_m^0$ from Eqs. (A.13) and (A.14).

To highlight the direction of the policy that implements $\overline{s}_m=\overline{s}_m^0$ after the introduction of the exchange, fix δ and consider instead a regulatory floor K_m^{reg} on asset purchases, i.e., the regulator mandates $K_m\geq K_m^{reg}$. The Lagrangian for intermediary m's problem is then

$$\widetilde{\mathcal{L}}_k=\mathcal{L}_k+\phi_m\left(K_m-K_m^{reg}\right)$$

where $\mathcal{L}_k$ is the Lagrangian from the proof of Proposition 2 and $\phi_m \geq 0$ is the Lagrange multiplier on the new constraint $K_m \geq K_m^{reg}$.

The first order condition with respect to $w_m(s)$ is the same as in the proof of Proposition 2, leading to $\overline{s}_m$ as defined in Eq. (A.10). The first order condition with respect to K_m is

$$\delta K_m = \beta E_1(Z_m) + (\mu_\theta - \beta) \frac{\int_0^{\overline{s}_m} z_m(s) [z_m(\overline{s}_m) - z_m(s)] \, dF(s)}{\int_0^{\overline{s}_m} [z_m(\overline{s}_m) - z_m(s)] \, dF(s)} + \phi_m$$

which is similar to the expression in Proposition 3 but with an extra term ϕ_m that captures the shadow cost of the regulatory floor.

If $\phi_m > 0$, then $K_m = K_m^{reg}$ so, with $\chi_m = \frac{\eta_m}{n_m}$ and $1 + \lambda_m = \frac{n_m - 1}{n_m - 2}$, Eq. (A.10) becomes

$$\int_0^{\overline{s}_m} [z_m(\overline{s}_m) - z_m(s)] \, dF(s) = \frac{\mu_\theta - \beta}{2\gamma K_m^{reg}} \frac{n_m(n_m - 2)}{n_m - 1} \frac{(1 + \chi_m)^2}{1 + \frac{n_m - 2}{n_m - 1}\chi_m}$$

Thus, given n_m and χ_m, the regulator should set

$$K_m^{reg} = \frac{\mu_\theta - \beta}{2\gamma} \frac{n_m(n_m - 2)}{n_m - 1} \frac{(1 + \chi_m)^2}{1 + \frac{n_m - 2}{n_m - 1}\chi_m} \frac{1}{\int_0^{\overline{s}_m^0} \left[z_m\left(\overline{s}_m^0\right) - z_m(s)\right] dF(s)}$$

to neutralize the effect of the exchange on security design, where $\overline{s}_m^0$ solves Eq. (A.14). It is straightforward to confirm $\phi_m > 0$ at this K_m^{reg}. ■

Proof of Proposition 6

Intermediary m's expected payoff is:

$$\begin{aligned} & V_m\left(W_m, r_m | n_m, \eta_m, A_m, a_m^e, \overline{K}_m\right) \\ = \; & E_1(p_m)(A_m - a_m^e) + p_m^e a_m^e + \beta\left[\overline{K}_m E_1(Z_m) - A_m E_1(W_m)\right] - u(r_m) \end{aligned}$$

where p_m^e and $E_1(p_m)$ are as in Eqs. (A.6) and (A.7). Letting $\psi_m(s) \geq 0$ denote the Lagrange multiplier on the feasibility constraint $A_m w_m(s) \leq \overline{K}_m z_m(s)$, the Lagrangian for intermediary m's problem is

$$\begin{aligned}\mathcal{L}_k &= (\mu_\theta - \beta) A_m \int_0^S w_m(s)\, dF(s) \\ &\quad -\gamma \left(\frac{n_m - 1}{n_m - 2} \frac{(A_m - a_m^e)^2}{n_m} + \frac{(a_m^e)^2}{\eta_m} \right) \left[\int_0^S (w_m(s))^2\, dF(s) - \left(\int_0^S w_m(s)\, dF(s) \right)^2 \right] \\ &\quad + \beta \overline{K}_m E_1(Z_m) - u(r_m) + \int_0^S \psi_m(s) \left[\overline{K}_m z_m(s) - A_m w_m(s) \right] dF(s)\end{aligned}$$

where we have used $1 + \lambda_m = \frac{n_m - 1}{n_m - 2}$ to sub λ_m out of Eq. (A.7).

The first order conditions with respect to $w_m(s)$ and r_m are respectively

$$0 = \frac{\partial \mathcal{L}_k}{\partial w_m(s)} = \left[(\mu_\theta - \beta - \psi_m(s)) A_m - 2\gamma \left(\frac{n_m - 1}{n_m - 2} \frac{(A_m - a_m^e)^2}{n_m} + \frac{(a_m^e)^2}{\eta_m} \right) (w_m(s) - E_1(W_m)) \right] f(s) \tag{A.15}$$

$$0 = \frac{\partial \mathcal{L}_k}{\partial r_m} = \beta \overline{K}_m \frac{\partial E(Z_m)}{\partial r_m} - u'(r_m) + \int_0^S \psi_m(s) \overline{K}_m \frac{\partial z_m(s)}{\partial r_m} dF(s)$$

where, using $z_m(s) = r_m^2 + r_m s$ and $u(r_m) = \frac{\tau}{2} r_m^2$, the latter becomes

$$0 = \frac{\partial \mathcal{L}_k}{\partial r_m} = \beta \overline{K}_m (2r_m + E_1(s)) - \tau r_m + \int_0^S \psi_m(s) \overline{K}_m (2r_m + s)\, dF(s) \tag{A.16}$$

Rewrite Eq. (A.15) as

$$\psi_m(s) = \mu_\theta - \beta - 2\gamma A_m \frac{\frac{n_m - 1}{n_m - 2} + \chi_m}{\left(\sqrt{n_m} + \sqrt{\eta_m \chi_m} \right)^2} \left(w_m(s) - \int_0^S w_m(s)\, dF(s) \right)$$

If $\psi_m(s) > 0$, then $w_m(s) = \frac{\overline{K}_m}{A_m} z_m(s)$ by complementary slackness, so, to confirm $\psi_m(s) > 0$, we would need

$$z_m(s) < \frac{A_m}{\overline{K}_m} \int_0^S w_m(s)\, dF(s) + \frac{\mu_\theta - \beta}{2\gamma \overline{K}_m} \frac{\left(\sqrt{n_m} + \sqrt{\eta_m \chi_m} \right)^2}{\frac{n_m - 1}{n_m - 2} + \chi_m} \equiv z_m(\overline{s}_m)$$

where we have defined the right-hand side assuming an interior solution $\overline{s}_m \in (0, S)$. If instead $\psi_m(s)=0$, then $w_m(s)=\frac{\overline{K}_m}{A_m}z_m(\overline{s}_m)$. Therefore

$$w_m(s)=\begin{cases}\frac{\overline{K}_m}{A_m}z_m(s) & if \quad s<\overline{s}_m\\ \frac{\overline{K}_m}{A_m}z_m(\overline{s}_m) & if \quad s\geq\overline{s}_m\end{cases}$$

and

$$\int_0^S w_m(s)\,dF(s)=\frac{\overline{K}_m}{A_m}\left(\int_0^{\overline{s}_m}z_m(s)\,dF(s)+z_m(\overline{s}_m)\left[1-F(\overline{s}_m)\right]\right)$$

so the definition of $\overline{s}_m$ simplifies to

$$\int_0^{\overline{s}_m}\left[z_m(\overline{s}_m)-z_m(s)\right]dF(s)=\frac{\mu_\theta-\beta}{2\gamma\overline{K}_m}\frac{\left(\sqrt{n_m}+\sqrt{\eta_m\chi_m}\right)^2}{\frac{n_m-1}{n_m-2}+\chi_m}$$

and thus

$$r_m\int_0^{\overline{s}_m}(\overline{s}_m-s)\,dF(s)=\frac{\mu_\theta-\beta}{2\gamma\overline{K}_m}\frac{\left(\sqrt{n_m}+\sqrt{\eta_m\chi_m}\right)^2}{\frac{n_m-1}{n_m-2}+\chi_m}\tag{A.17}$$

after subbing out for $z_m(\cdot)$ in terms of r_m.

Now return to Eq. (A.16) and sub out the multiplier $\psi_m(\cdot)$, which is positive if and only if $s<\overline{s}_m$, to get

$$\beta\overline{K}_m(2r_m+E_1(s))-\tau r_m+2\gamma\overline{K}_m^2\frac{\frac{n_m-1}{n_m-2}+\chi_m}{\left(\sqrt{n_m}+\sqrt{\eta_m\chi_m}\right)^2}\int_0^{\overline{s}_m}\left[z_m(\overline{s}_m)-z_m(s)\right](2r_m+s)\,dF(s)=0$$

and thus

$$\beta\overline{K}_m(2r_m+E_1(s))-\tau r_m+2\gamma\overline{K}_m^2\frac{\frac{n_m-1}{n_m-2}+\chi_m}{\left(\sqrt{n_m}+\sqrt{\eta_m\chi_m}\right)^2}r_m\int_0^{\overline{s}_m}(\overline{s}_m-s)(2r_m+s)\,dF(s)=0\tag{A.18}$$

after again subbing out for $z_m(\cdot)$ in terms of r_m.

Use Eq. (A.17) to isolate r_m and rewrite Eq. (A.18) as

$$\beta\overline{K}_m(2r_m+E_1(s))-\tau r_m+\overline{K}_m(\mu_\theta-\beta)\frac{1}{\int_0^{\overline{s}_m}(\overline{s}_m-s)\,dF(s)}\int_0^{\overline{s}_m}(\overline{s}_m-s)(2r_m+s)\,dF(s)=0$$

which then simplifies to

$$r_m = \frac{\overline{K}_m}{\tau - 2\mu_\theta \overline{K}_m} \left(\beta E_1(s) + (\mu_\theta - \beta) \frac{\int_0^{\overline{s}_m} s(\overline{s}_m - s)\, dF(s)}{\int_0^{\overline{s}_m} (\overline{s}_m - s)\, dF(s)} \right) \tag{A.19}$$

Finally, equate r_m from Eqs. (A.17) and (A.19) to get

$$\int_0^{\overline{s}_m} s(\overline{s}_m - s)\, dF(s) + \frac{\beta E_1(s)}{\mu_\theta - \beta} \int_0^{\overline{s}_m} (\overline{s}_m - s)\, dF(s) = \frac{\tau - 2\mu_\theta \overline{K}_m}{2\gamma \overline{K}_m^2} \frac{\left(\sqrt{n_m} + \sqrt{\eta_m \chi_m}\right)^2}{\frac{n_m - 1}{n_m - 2} + \chi_m} \tag{A.20}$$

The intermediary's first order conditions are thus characterized by Eqs. (A.19) and (A.20). Assume $\tau > 2\mu_\theta \overline{K}_m$ for a well-defined solution (i.e., if τ is too low, then global max is for intermediary to choose r_m arbitrarily large).

Note

$$\frac{\partial}{\partial \overline{s}_m} \left(\frac{\int_0^{\overline{s}_m} s(\overline{s}_m - s)\, dF(s)}{\int_0^{\overline{s}_m} (\overline{s}_m - s)\, dF(s)} \right) \overset{sign}{=} \frac{1}{F(\overline{s}_m)} \int_0^{\overline{s}_m} s^2 dF(s) - \left(\frac{1}{F(\overline{s}_m)} \int_0^{\overline{s}_m} s dF(s) \right)^2 > 0 \tag{A.21}$$

and therefore $\frac{\partial}{\partial \overline{s}_m} \left(\frac{E_1(Z_m)}{\sqrt{\mathcal{V}_1(Z_m)}} \right) > 0$ after using Eq. (A.19) to sub out r_m from the expression for $\frac{E_1(Z_m)}{\sqrt{\mathcal{V}_1(Z_m)}}$ in the main text.

For the asset-backed security sold to investors by the intermediary,

$$\frac{E_1(W_m)}{\sqrt{\mathcal{V}_1(W_m)}} = \frac{r_m + \overline{s}_m - \int_0^{\overline{s}_m} (\overline{s}_m - s)\, dF(s)}{\sqrt{\int_0^{\overline{s}_m} (\overline{s}_m - s)^2 dF(s) - \left(\int_0^{\overline{s}_m} (\overline{s}_m - s)\, dF(s) \right)^2}}$$

where, after using Eq. (A.19) to sub out r_m, we can show

$$\begin{aligned} &\frac{\partial}{\partial \overline{s}_m} \left(\frac{E_1(W_m)}{\sqrt{\mathcal{V}_1(W_m)}} \right) \overset{sign}{=} \\ &-[1 - F(\overline{s}_m)] \int_0^{\overline{s}_m} s(\overline{s}_m - s)\, dF(s) \\ &+ \frac{(\mu_\theta - \beta)\overline{K}_m}{\tau - 2\mu_\theta \overline{K}_m} \left[\begin{array}{c} \left(F(\overline{s}_m) \int_0^{\overline{s}_m} s^2 dF(s) - \left(\int_0^{\overline{s}_m} s dF(s) \right)^2 \right) \left(\frac{\int_0^{\overline{s}_m} (\overline{s}_m - s)^2 dF(s)}{\left(\int_0^{\overline{s}_m} (\overline{s}_m - s) dF(s) \right)^2} - 1 \right) \\ -[1 - F(\overline{s}_m)] \left[\int_0^{\overline{s}_m} s(\overline{s}_m - s)\, dF(s) + \frac{\beta E_1(s)}{\mu_\theta - \beta} \int_0^{\overline{s}_m} (\overline{s}_m - s)\, dF(s) \right] \end{array} \right] \end{aligned}$$

Therefore, $\frac{\partial}{\partial \overline{s}_m}\left(\frac{E_1(W_m)}{\sqrt{\mathcal{V}_1(W_m)}}\right) < 0$ if $\tau >> 2\mu_\theta \overline{K}_m$.

With the exchange, $\overline{s}_m$ is given by Eq. (A.20) evaluated at $\chi_m = \frac{\eta_m}{n_m}$, i.e.,

$$\int_0^{\overline{s}_m} s\left(\overline{s}_m - s\right) dF(s) + \frac{\beta E_1(s)}{\mu_\theta - \beta}\int_0^{\overline{s}_m}\left(\overline{s}_m - s\right) dF(s) = \frac{\tau - 2\mu_\theta \overline{K}_m}{2\gamma \overline{K}_m^2}\frac{n_m}{1+\lambda_m}\frac{\left(1+\chi_m\right)^2}{1+\frac{\chi_m}{1+\lambda_m}}$$

Without the exchange, $\overline{s}_m^0$ is given by Eq. (A.20) evaluated at $\chi_m = 0$, i.e.,

$$\int_0^{\overline{s}_m^0} s\left(\overline{s}_m^0 - s\right) dF(s) + \frac{\beta E_1(s)}{\mu_\theta - \beta}\int_0^{\overline{s}_m^0}\left(\overline{s}_m^0 - s\right) dF(s) = \frac{\tau - 2\mu_\theta \overline{K}_m}{2\gamma \overline{K}_m^2}\frac{n_m}{1+\lambda_m}$$

The left-hand side of Eq. (A.20) is increasing in $\overline{s}_m$, so clearly $\overline{s}_m > \overline{s}_m^0$.

With or without the exchange, r_m is governed by Eq. (A.19) evaluated at the appropriate value of $\overline{s}_m$. From $\overline{s}_m > \overline{s}_m^0$ and Eq. (A.19) with (A.21), we conclude that introducing the exchange increases r_m, i.e., $r_m > r_m^0$. Accordingly, introduction of the exchange increases $\frac{E_1(Z_m)}{\sqrt{\mathcal{V}_1(Z_m)}}$. However, from $\tau >> 2\mu_\theta \overline{K}_m$ and $\overline{s}_m > \overline{s}_m^0$, it also decreases $\frac{E_1(W_m)}{\sqrt{\mathcal{V}_1(W_m)}}$. ■

Proof of Proposition 7

Follows immediately from Eq. (A.20). On the margin, lowering τ lowers $\overline{s}_m$, which helps combat $\overline{s}_m > \overline{s}_m^0$. ■

Appendix B – Construction of Figure 1

Suppose all securities are identical and the investor can trade one security on the exchange (in addition to the security in his local market).

Investor's value function before the introduction of the exchange:

$$E\left(\widetilde{V}_m^h\right) = \frac{1}{2}\left(\frac{\sigma_\theta^2}{\gamma}\frac{\left(E\left(W_m^0\right)\right)^2}{\mathcal{V}\left(W_m^0\right)}\frac{n_m-2}{n_m-1} + \gamma\mathcal{V}\left(W_m^0\right)\frac{n_m}{n_m-2}\left(\frac{A_m}{n_m}\right)^2\right)$$

Investor's value function after the introduction of the exchange:

$$\begin{aligned} E\left(V_m^h\right) &= \frac{1}{2}\left(\frac{\sigma_\theta^2}{\gamma}\frac{\left(E\left(W_m\right)\right)^2}{\mathcal{V}\left(W_m\right)}\left(\frac{n_m-2}{n_m-1}+1\right) + \gamma\mathcal{V}\left(W_m\right)\left(\frac{n_m}{n_m-2}\left(\frac{A_m-a_m^e}{n_m}\right)^2 + \left(\frac{a_m^e}{\eta_m}\right)^2\right)\right) \\ &= \frac{1}{2}\left(\frac{\sigma_\theta^2}{\gamma}\frac{\left(E\left(W_m\right)\right)^2}{\mathcal{V}\left(W_m\right)}\left(\frac{n_m-2}{n_m-1}+1\right) + \gamma\mathcal{V}\left(W_m\right)\left(\frac{1}{n_m-2}\frac{1}{\chi_m}+\frac{1}{\eta_m}\right)\frac{1}{\eta_m}\frac{\left(A_m\right)^2}{\left(1+\sqrt{\frac{n_m}{\eta_m}\frac{1}{\chi_m}}\right)^2}\right) \end{aligned}$$

Fix per capita supplies $\frac{A_m-a_m^e}{n_m} = \frac{a_m^e}{\eta_m} = 1$ in the post-exchange world. Then $A_m = n_m+\eta_m$ and $\chi_m = \frac{\eta_m}{n_m}$, with a per capita supply of $\frac{A_m}{n_m} = 1+\frac{\eta_m}{n_m} > 1$ when only the local market is available to the investor (i.e., the pre-exchange world). The per capita assumption means we are considering the introduction of an exchange with a market power $\chi_m = \frac{\eta_m}{n_m}$ for the intermediary; we cannot consider independent variations in χ_m since an assumption about a_m^e has already been made.

With $A_m = n_m+\eta_m$ and $\chi_m = \frac{\eta_m}{n_m}$:

$$E\left(\widetilde{V}_m^h\right) = \frac{1}{2}\left(\frac{\sigma_\theta^2}{\gamma}\frac{\left(E\left(W_m^0\right)\right)^2}{\mathcal{V}\left(W_m^0\right)}\frac{n_m-2}{n_m-1} + \gamma\mathcal{V}\left(W_m^0\right)\frac{n_m}{n_m-2}\left(1+\chi_m\right)^2\right)$$

$$E\left(V_m^h\right) = \frac{1}{2}\left(\frac{\sigma_\theta^2}{\gamma}\frac{\left(E\left(W_m\right)\right)^2}{\mathcal{V}\left(W_m\right)}\left(\frac{n_m-2}{n_m-1}+1\right) + \gamma\mathcal{V}\left(W_m\right)\left(\frac{n_m}{n_m-2}+1\right)\right)$$

where we recall that $E\left(\widetilde{V}_m^h\right)$ is the investor's utility before introduction of exchange, but evaluated at the A_m consistent with per capita supply in each market after introduction of the exchange, hence the appearance of χ_m.

Thus, the investor is worse off with the introduction of this exchange, i.e., $E\left(V_m^h\right) <$

$E\left(\widetilde{V}_m^h\right)$, if and only if

$$\left(\frac{\sigma_\theta}{\gamma}\right)^2\left[\left(\frac{E\left(W_m^0\right)}{\sqrt{\mathcal{V}\left(W_m^0\right)}}\right)^2-\left(\frac{E\left(W_m\right)}{\sqrt{\mathcal{V}\left(W_m\right)}}\right)^2\left(1+\frac{n_m-1}{n_m-2}\right)\right] \tag{A.22}$$
$$> \left[\mathcal{V}\left(W_m\right)\left(1+\frac{n_m-2}{n_m}\right)-\mathcal{V}\left(W_m^0\right)\left(1+\chi_m\right)^2\right]\frac{n_m\left(n_m-1\right)}{\left(n_m-2\right)^2}$$

To fix ideas, suppose state $s \in [0,1]$ is uniformly distributed with $S=1$ and $z_m(s)=s$. Then the equilibrium security in Proposition 2 is

$$w_m(s)=\begin{cases}\frac{K_m}{A_m}s & if \quad s<\overline{s}_m\\ \frac{K_m}{A_m}\overline{s}_m & if \quad s\geq\overline{s}_m\end{cases}$$

with

$$E\left(W_m\right)=\int_0^S w_m(s)\,dF(s)\Longrightarrow E\left(W_m\right)=\frac{K_m}{A_m}\overline{s}_m\left(1-\frac{\overline{s}_m}{2}\right)$$

$$\mathcal{V}\left(W_m\right)=\int_0^S\left(w_m(s)\right)^2dF(s)-\left(\int_0^S w_m(s)\,dF(s)\right)^2\Longrightarrow\mathcal{V}\left(W_m\right)=\left(\frac{K_m}{A_m}\right)^2\overline{s}_m^3\left(\frac{1}{3}-\frac{\overline{s}_m}{4}\right)$$

and

$$K_m=\frac{\mu_\theta-\beta}{\gamma\overline{s}_m^2}\frac{\left(\sqrt{\eta_m\chi_m}+\sqrt{n_m}\right)^2}{1+\lambda_m+\chi_m}$$

from Eq. (A.10).

The pre-exchange security W_m^0 has

$$K_m^0=\frac{\mu_\theta-\beta}{\gamma\left(\overline{s}_m^0\right)^2}\frac{n_m}{1+\lambda_m}$$

and the post-exchange security W_m has

$$K_m=\frac{\mu_\theta-\beta}{\gamma\overline{s}_m^2}\frac{n_m}{1+\lambda_m}\frac{\left(1+\chi_m\right)^2}{1+\frac{\chi_m}{1+\lambda_m}}$$

where $1+\lambda_m = \frac{n_m-1}{n_m-2}$. Therefore, condition (A.22) becomes

$$\begin{aligned}
&\frac{\left(2-\overline{s}_m^0\right)^2}{\overline{s}_m^0\left(\frac{4}{3}-\overline{s}_m^0\right)} - \frac{\left(2-\overline{s}_m\right)^2}{\overline{s}_m\left(\frac{4}{3}-\overline{s}_m\right)}\left(1+\frac{n_m-1}{n_m-2}\right) \\
> \quad & \left(\frac{\mu_\theta-\beta}{\sigma_\theta}\right)^2\left[2\left(\frac{1+\chi_m}{1+\frac{n_m-2}{n_m-1}\chi_m}\right)^2\left(\frac{1}{3\overline{s}_m}-\frac{1}{4}\right)-\left(\frac{1}{3\overline{s}_m^0}-\frac{1}{4}\right)\frac{n_m}{n_m-1}\right]
\end{aligned}$$

where, using Eq. (A.12),

$$\left(\overline{s}_m^0+\frac{3}{2\left(\frac{\mu_\theta}{\beta}-1\right)}\right)\left(\overline{s}_m^0\right)^2 = \frac{3\delta}{\gamma}\frac{n_m\left(n_m-2\right)}{n_m-1}$$

$$\left(\overline{s}_m+\frac{3}{2\left(\frac{\mu_\theta}{\beta}-1\right)}\right)\overline{s}_m^2 = \frac{3\delta}{\gamma}\frac{n_m\left(n_m-2\right)}{n_m-1}\frac{\left(1+\chi_m\right)^2}{1+\frac{n_m-2}{n_m-1}\chi_m}$$

The condition fails (i.e., introducing the exchange makes the investor better off) for every σ_θ if and only if both of the following are true

$$\frac{\left(2-\overline{s}_m^0\right)^2}{\overline{s}_m^0\left(\frac{4}{3}-\overline{s}_m^0\right)} < \frac{\left(2-\overline{s}_m\right)^2}{\overline{s}_m\left(\frac{4}{3}-\overline{s}_m\right)}\left(1+\frac{n_m-1}{n_m-2}\right)$$

$$2\left(\frac{1+\chi_m}{1+\frac{n_m-2}{n_m-1}\chi_m}\right)^2\left(\frac{1}{3\overline{s}_m}-\frac{1}{4}\right) > \left(\frac{1}{3\overline{s}_m^0}-\frac{1}{4}\right)\frac{n_m}{n_m-1}$$

Otherwise, there exist values of σ_θ such that the investor is worse off with the introduction of the exchange.