Intermediation as Rent Extraction*

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December 21, 2018

Abstract

This paper shows that intermediation in asset markets may emerge exclusively because of rent extraction motives. Among traders with heterogeneous bargaining skills, those with superior skills become intermediaries and those with inferior skills become final users. Intermediation is privately profitable because agents with superior bargaining skills can take positions and unwind them in the future at a better price than final users could. Intermediation arises endogenously despite being socially worthless and the resources invested in bargaining skills are wasted. Using a dataset on the Indonesian interbank market, we document that prices vary with the centrality of buyers and sellers in a way that is uniquely consistent with our theory.

JEL Codes: D40.

Keywords: Intermediation, Search frictions, Rent extraction.

*We thank our audiences at various seminars and conferences. The paper was previously circulated under the title "Tough Middlemen." The views expressed here are those of the authors, nor those of the IMF or the Bank of Indonesia.

1 Introduction

Intermediation of trade is a pervasive phenomenon in many asset markets. Private collectors often sell artwork to dealers who then resell them to other collectors. Car owners often sell their old cars to dealers who then showcase them and resell them. Investors sell municipal bonds to dealers who then re-trade them to either other dealers or other investors. In all of these cases, intermediaries purchase assets with the main purpose of reselling them for a profit to somebody else. In other cases, such as in the housing market, intermediation does not involve a dealer buying and selling the asset, but a broker who acts as an agent on behalf of the seller without acquiring the property of the asset. There are several reasons why intermediation may be profitable. As argued by Rubinstein and Wolinsky (1987) and Duffie, Gârleanu and Pedersen (2005) intermediaries may be better at searching the market than final users. Intermediaries may be able to hold the asset at a lower cost than final users. Alternatively, intermediaries may be better at assessing the quality of the assets than final users.

In this paper, we propose a novel theory of intermediation as rent extraction. According to our theory, intermediation is profitable because intermediaries are agents with better bargaining skills than final users. An intermediary purchases the asset from a final seller because, thanks to his superior bargaining skills, he can trade the asset to somebody else for a price higher than the one the final seller could get. Similarly, an intermediary sells the asset to a final buyer because he can purchase another unit of the asset at a lower price than the buyer could. According to our theory, the driver of intermediation is a dynamic rent extraction motive. Bid-ask spreads are not the reward for the services provided by an intermediary, but the root cause of intermediation.

In the first part of the paper, we develop our theory of intermediation as rent extraction. We show that, in a frictional market in which agents only differ with respect to their bargaining skills, those with lesser skills act as final users and those with better skills act as intermediaries. We endogenize the agents' decision of investing in bargaining skills and show that, in general, investment and, hence, the extent of intermediation is too high. We then examine how the extent of intermediation is affected by trading frictions and interest rates. In the second part of the paper, we put our theory to test using a rich transaction dataset from the Indonesian interbank market for Central Bank reserves. We show that the prices in transactions between different types of borrowers and lenders are consistent with our theory of intermediation as rent extraction, and not with a benchmark version of the standard theory of intermediation as speed of trade.

We develop our theory in the context of the market for an asset in fixed supply. The market is subject to search frictions, in the sense that an individual agent cannot trade the asset in a central exchange but he needs to locate a counterparty with whom to trade. We model the search process as an arrival rate of a randomly-drawn counterparty. The agents populating the market are heterogeneous along two dimensions. First, some agents have a high valuation for the asset, in the sense that they enjoy a high flow payoff from holding it, while others have a low valuation, in the sense that they enjoy a low flow payoff. Agents' valuations change over time, so as to create a sustained motive for trade. Second, some agents have better bargaining skills than others. Agents' bargaining skills are permanent. Inspired by the game-theoretic literature on bargaining, e.g. Rubinstein (1982), we model differences in bargaining skills as differences in the ability to commit to take-it-or-leave-it offers. Some agents can commit to offers and end up extracting a larger share of the gains from trade. Other agents cannot commit to offers and end up extracting a smaller share of the gains from trade.

We start by characterizing the properties of equilibrium for an exogenously given proportion of agents with commitment. We find that the equilibrium displays a rich pattern of trade. Unsurprisingly, the equilibrium is such that low-valuation agents sell the asset to high-valuation ones. More surprisingly, the equilibrium is such that agents with commitment buy the asset from low-valuation agents without commitment, even when they themselves have a low valuation. Similarly, agents with commitment sell the asset to high-valuation agents without commitment, even when they themselves have a high valuation. Overall, the equilibrium is such that agents without commitment act as final users—in the sense that they only buy the asset when their valuation is high and only sell it when their valuation is low—while agents with commitment act as intermediaries—in the sense that they buy and sell the asset irrespective of their valuation.

Agents with commitment intermediate the asset exclusively because of dynamic rent extraction considerations. The gains from trade between a low-valuation buyer with commitment and a low-valuation seller without commitment are positive only because the buyer, thanks to his superior bargaining power, can get for the asset a higher price than the seller could. Similarly, the gains from trade between a high-valuation seller with commitment and a high-valuation buyer without commitment are positive only because the seller, thanks to his superior bargaining power, can repurchase the asset at a lower price than the buyer could. Thus, our model is a theory of intermediation as rent extraction.

The intermediation activity carried out by agents with commitment is privately valuable but socially neutral, as it does not lead to any improvement or worsening of the allocation of the asset among low and high valuation agents. We show, however, that even small perturbations of the environment turn the intermediation activity from socially neutral to detrimental. This is the case if, for instance, there are transaction costs, heterogeneity in the meeting rate of different agents, or richer heterogeneity in the valuation of different agents.

We proceed by characterizing the properties of equilibrium when the proportion of agents with commitment is endogenous. To this aim, we assume that, upon entering the market, agents can pay a cost to acquire a commitment technology (e.g., delegating bargaining to traders without discretion over prices, hiring more sophisticated traders, etc...). We find that, in general, there are multiple equilibria which differ in the fraction of agents with commitment (intermediaries). Multiple equilibria emerge because the benefit of acquiring the commitment technology is hump-shaped in the number of intermediaries. On the one hand, an increase in the number of intermediaries increases the value of the commitment technology because it lowers the outside option of final users. On the other hand, it reduces the value of the commitment technology because it lowers the probability of finding a final user to exploit. The first effect dominates when the fraction of intermediaries is low. The second effect dominates when the fraction of intermediaries is high. Importantly, the source of multiplicity is different from those typically highlighted in search theory, such as increasing returns (Diamond 1982, Mortensen 1999) and external effects of matching decisions on the pool of searchers (Burdett and Coles 1997, Kaplan and Menzio 2016).

Different equilibria are ranked, as welfare is strictly decreasing in the fraction of intermediaries in the market. Indeed, because intermediation is a pure rent extraction activity which benefits the intermediary but does not improve the allocation of the asset, any equilibrium in which agents spend resources to acquire the commitment technology is inefficient. And the more resources agents devote to acquire the technology, the lower is welfare. Note that equilibria with a positive fraction of intermediaries are inefficient for a reason that is different from the standard reason why search equilibria are inefficient. Typically, search equilibria are inefficient because the concavity of the matching function creates a gap between private and social returns to searching (Mortensen 1982, Hosios 1990). Here, equilibria are inefficient because there is a gap between the private and the social returns to acquiring bargaining skills.

Our most surprising findings concern the effect of declining search frictions. It would be natural to conjecture that, as trading frictions become smaller, rent-extraction intermediation becomes less prevalent and eventually disappears. After all, in a Walrasian equilibrium, there is no scope for rent extraction as a competitive market perfectly shields traders from exploitation. On the contrary, we find that rent-extraction intermediation becomes more prevalent as trading frictions become smaller. Indeed, as trading frictions become smaller, the amount of rents that an intermediary can extract from a final user falls but this effect is outweighed by the increase in the frequency at which an intermediary meets a final user. Thus, the return from becoming a rent-extraction intermediary increases. Under the view of intermediation as rent extraction, the recent rise in intermediation (Philippon 2015) is a natural consequence of the decline in trading frictions brought about by progress in communication and information technology.

Even more surprisingly, we find that a decline in trading frictions lowers welfare (as long as the fraction of intermediaries is interior). As trading frictions become smaller, there are some welfare gains associated with the improvement in the allocation of the asset. However, these welfare gains are smaller than the welfare losses caused by the increase in the resources wasted in acquiring the technology for becoming rent-extraction intermediaries. Indeed, as trading frictions keep falling, they reach a point where all traders become intermediaries. At this point, final users capture none of the gains from trade and, hence, welfare is just the same as in autarky. Rent extraction motives can entirely wipe out the social value of trade.

Similarly, we find that a decline in the rate of return on investments that are alternative to the commitment technology causes rent-extraction intermediation to become more prevalent and social welfare to fall. This is a novel channel through which a decline in the interest rate can have unintended and undesirable effects on the economy. This channel is related but distinct from the "reaching for yield" mechanism proposed by Rajan (2006), according to which, when the interest rate on safe assets falls, agents are attracted to inefficiently risky investments.

Our theory of intermediation as rent extraction is, along many dimensions, observationally equivalent to the standard theory of intermediation as speeding up trade in the spirit of by Rubinstein and Wolinsky (1987). Both theories predict that intermediaries charge bid-ask spreads to final users. Both theories predict that intermediaries trade more often than final users. To empirically discriminate, we build on a simple benchmark model of intermediation that distills the key force in our theory and contrast it with the analogous case where intermediation is driven by speed. Doing so reveals that there is one dimension that distinguishes the two forces. According to our theory, more central intermediaries are those who, because of better bargaining skills, can extract a larger share of the gains from trade. Hence, a given seller will sell the asset at a lower price to a more central intermediary, and a given buyer will purchase the asset at a higher price from a more central intermediary. We show that, if intermediation is driven by speed instead, more central intermediaries are those who can locate trading partners more quickly. Hence, a given seller will sell the asset at a higher price to a more central intermediary (as the net value of the asset to a more central intermediary is higher) and a given buyer will purchase the asset at a higher price from a more central intermediary (as the intermediary has a better outside option). Intuitively, if more central intermediaries can reallocate the asset more quickly, trading with them generates more surplus and sellers should receive a higher price from them. If more central intermediaries extract more of the surplus, sellers should receive a lower price from them.

We implement this test using a novel dataset on the Indonesian interbank market for Central Bank reserves, a market that is described well by a model of random search, bilateral trade and bargaining. We find that, among lenders of a given centrality, those who lend to more central borrowers receive a lower interest rate. Among borrowers of a given centrality, those who borrow from more central lenders pay a higher interest rate. Put differently, we find that the terms of trade for a particular agent become less favorable the more central is the counterparty. These findings cannot be explained by trade volume, relationship lending, or calendar day. In fact, when we include controls for volume, bilateral relationship and calendar day, in a regression of interest rates on the centrality of lender and borrower, we recover the same pattern as in the raw data. The fact that a lender gets a lower interest rate (and a borrower receives a higher rate) when trading with a more central borrower is consistent with our theory of intermediation as rent extraction and suggests that central intermediaries can indeed extract a larger share of the gains from trade.

Our paper contributes to the theoretical literature on trade intermediation. Rubinstein and Wolinsky (1987, henceforth RW) show that agents who neither produce nor consume a good act as middlemen if and only if they have a better search technology than producers and consumers. Nosal, Wong and Wright (2015, 2016) generalize the analysis of RW (1987) by allowing search technology, holding costs and bargaining power to be different for producers, consumers and potential middlemen. Masters (2007) shows, using a version of Diamond (1982), that agents who have both high costs of production and high bargaining power end up acting as intermediaries in the product market.[1] Our paper contributes to this literature by showing, in the context of an asset market, that agents with superior bargaining skills naturally emerge as intermediaries, even when they have the same preferences, search technology and holding cost as everybody else. This insight leads to a theory of intermediation as rent extraction which has distinctive features in terms of equilibrium, welfare and policy.

Our paper also contributes to the theoretical literature on trade intermediation in asset markets, which was pioneered by Duffie, Gârleanu and Pedersen (2005, henceforth DGP). In DGP, the market is populated by investors and dealers. Investors search for other investors and dealers in a frictional market, while dealers have access to a frictionless interdealer market. DGP show that dealers charge bid-ask spreads and characterize the relationship between these spreads and the fundamentals of the economy. Farboodi, Jarosch and Shimer (2018) show that the market structure proposed by DGP emerges endogenously when ex-ante identical agents choose how much to invest in the quality of their search technology. Lagos and Rocheteau (2007, 2009) characterize the equilibrium in a version of DGP with divisible assets. In all of these models, just as in RW, the difference between intermediaries and final users is their search technology. Departing from these models, Hugonnier, Lester and Weill (2016) show that differences in valuation across agents naturally lead to asset intermediation. Specifically, they show that agents with average valuations naturally arise as intermediaries for agents with extreme valuations.

[1] As far as we know, Masters (2007) is the only other paper that connects heterogeneity in bargaining skills with intermediation. However, his model and ours are very different. In the context of his product market model, gains from trade are fundamentally static. In the context of our asset market model, gains from trade are dynamic. This is why, for instance, agents who have superior bargaining skills become intermediaries if they also have higher production costs in Masters (2007), while agents only need superior bargaining skills to become intermediaries in our model.

Üslü (2018) characterizes the equilibrium in a general environment in which agents differ with respect to search technology and valuation. In contrast to this literature, we develop a theory of asset intermediation in which final users and intermediaries differ only with respect to their bargaining skills. Bethune, Sultanum and Trachter (2018) develop a theory that–in reduced form–is similar to ours. Agents differ in their ability to identify the private valuation of the asset of other traders and, hence, can leave smaller informational rents to their counterparties.

Finally, our paper contributes to the empirical literature on over-the-counter markets for financial assets. We study the Indonesian interbank market—which is well described by a model of random search and bargaining—and find that a seller trades at a lower price with a more central buyer, while a buyer trades at a higher price with a more central seller. We show that, in a simplified benchmark setup of intermediation driven by differences in both bargaining power and speed, these observations are consistent only with the former which suggests that the traders at the more central institutions in our empirical setting are more able negotiators and extract a larger share of the gains from trade.

We believe that our empirical findings are new. Di Maggio, Kermani and Song (2017) document that, in the US corporate bond market, dealers charge lower spreads (defined as sell prices net of prior purchase prices) when selling to other dealers than to clients. Among dealers, central dealers charge higher spreads than peripheral dealers. Conversely, central dealers pay lower spreads than peripheral ones. These findings may be consistent with ours, but the spread potentially confounds variation in the sell price with variation in the prior purchase price. They also document that dealers charge lower spreads to those dealers with whom they have the strongest ties. It is this last observation that motivates us to carry out our empirical analysis with controls for repeated relationships between borrowers and lenders. Green, Hollifield and Schürhoff (2007) document the markups charged by dealers to customers in the US municipal bonds market, and they analyze the determinants of these markups. They document that volume matters and, for this reason, we carry out our empirical analysis with controls for size. Schürhoff and Li (2014) document that, in the US market for municipal bonds, more central dealers charge higher markups than peripheral dealers. Hollifield, Neklyudov and Spatt (2016) document that, in the US market for securities, central dealers charge lower bid-ask spreads than peripheral dealers. Our empirical findings are novel and complementary to these studies since markups and spreads include two prices.

2 Environment

We consider the market for an indivisible asset. The supply of the asset is fixed and of measure $A = 1/2$. The market for the asset is populated by a measure 1 of heterogeneous agents. An agent's type is described by a couple $\{i, j\}$, where $i = \{S, T\}$ denotes the agent's commitment power and $j = \{L, H\}$ denotes the agent's valuation of the asset. The labels S and T stand for *Soft* and *Tough*. The labels L and H stand for *Low* and *High*. The first dimension of an agent's type is permanent. The measure of agents without commitment power S is ϕ_S, with $\phi_S \in [0,1]$, and the measure of agents with commitment power T is $\phi_T = 1 - \phi_S$. The second dimension of an agent's type is transitory. In particular, an agent's valuation switches at Poisson rate $\sigma > 0$. An agent can either hold 0 or 1 units of the asset. An agent of type $\{i, j\}$ gets flow utility u_j when holding the asset, with $u_H > u_L > 0$ and $\Delta u \equiv u_H - u_L$. An agent gets flow utility 0 when he does not hold the asset. Agents have linear utility with respect to a numeraire good, which is used as a medium of exchange. Agents discount future utilities at the rate $r > 0$.

Trade is bilateral and frictional. In particular, one agent meets another randomly-selected agent at Poisson rate $\lambda > 0$. If the meeting involves two agents with identical asset holdings, there is no opportunity to trade. If an agent with the asset meets an agent without the asset, there is a trading opportunity. The terms of trade depend on the commitment power of the two agents. In particular, if an agent of type T meets an agent of type S, the agent of type T makes a take-it-or-leave-it offer to the agent of type S. The offer consists of P units of the numeraire good to be exchanged for the ownership of the asset. If two agents of type T meet, one is randomly selected to make a take-it-or-leave-it offer to the other. If two agents of type S meet, they play an alternating-offer bargaining game Ã la Rubinstein (1982) with a risk of breakdown $\delta > 0$. We assume that the bargaining game takes place in virtual time and consider the limit for $\delta \to 0$.[2]

A few comments about the environment are in order. First, we assume that agents differ with respect to their valuation of the asset and that an agent's valuation changes over time. The assumption is common in the literature and is meant to capture either, literally, variation across agents and over time in the utility obtained from holding the asset or, in reduced-form, variation across agents and over time in the ability to hedge any risk associated with the dividend of the asset. This assumption is needed to guarantee that the asset is traded. Indeed, if all agents had the same valuation, the asset would not be traded. If agents had different valuations but these valuations were constant over time, the asset would eventually end up in the hands of the high-valuation agents and trade would stop.

Second, we assume that agents differ with respect to their ability to commit to take-it-or-leave-it offers. The assumption is the main difference between our environment and the previous literature and, as we shall see, it generates non-fundamental trades. The assumption can be

[2]We assume that search is random, in the sense that agents cannot direct their search towards traders of a particular type or, in the case of traders with commitment, towards those posting a particular menu of prices. The assumption is common to all the literature on intermediation (see, e.g., RW, Nosal, Wong and Wright 2015, etc...) and on over-the-counter financial markets (see, e.g, DGP, Lagos and Rocheteau 2009, etc...) that we reviewed in the introduction. We believe that many of our findings would be qualitatively unchanged as long as some fraction of agents search randomly.

interpreted as saying that some agents can commit to posted prices–because, e.g., they can delegate trade to representatives without the authority to accept/propose any price different from the one pre-specified by the agent–while some agents cannot commit to post prices and, hence, end up bargaining over the terms of trade.

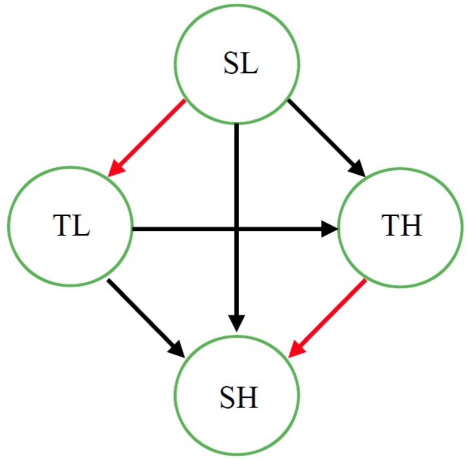
Third, we assume that the measure of the asset is half the measure of the population and that the stochastic process for the agent's valuation guarantees that, in a stationary equilibrium, exactly half of the agents have a high valuation and half have a low valuation. These assumptions are made for tractability, as they allow us to focus on symmetric equilibria. That is, equilibria in which the measure of agents with high valuation without the asset is equal to the measure of agents with low valuation with the asset.

The model is deliberately simple and abstract. Its purpose is to provide a framework in which to think about the effect of heterogeneity in bargaining skills (originating from heterogeneity in commitment power) in a decentralized asset market.[3] There are many examples of decentralized asset market in which agents may have different commitment power. One example is the housing markets. In this market, trade is decentralized, agents have different and time-varying utilities from living in a particular house, and some agents–say developers and flippers–may be able to commit to take-it-or-leave-it offers, while other agents may bargain. Another example is the fine art market. In this market, trade is typically decentralized, agents have different and time-varying valuations for the same piece of art, and some agents–say art gallerists–may be able to commit to take-it-or-leave-it offers. Finally, as pointed out by DGP, there are some financial asset markets (over-the-counter markets) that operate in a decentralized fashion. It is not far-fetched to think that, in these markets, some agents may have more commitment power than others.

3 Market Equilibrium

In this section, we characterize the equilibrium of the asset market while taking as given the measure of agents of type S and T. We refer to this as the *market equilibrium*. We first establish the existence and uniqueness of a symmetric stationary market equilibrium in which agents of type S act as *final users*–buying the asset only when their valuation is H and selling the asset only when their valuation is L–and agents of type T act as *intermediaries*–buying the asset from types (S,L) and selling it to types (S,H) irrespective of their own valuation. This pattern of

[3] We assume that heterogeneity in bargaining skills is due to the fact that some agents can commit to their offers and some cannot. We choose this to be the source of heterogeneity in bargaining skills because it is consistent with a game-theoretic approach to bargaining. Alternatively, we could have followed the axiomatic approach to bargaining and directly assumed that agents are heterogeneous with respect to their bargaining power. In this alternative environment, agents with high bargaining skills trading with agents with low bargaining skills may capture any fraction of the gains from trade in (1/2,1] rather than 1 as in our model. We believe that our results would extend to this alternative environment.



Notes: Dark arrows are fundamental trades, where low-valuation sell to high-valuation agents. Light arrows are intermediation trades, where the asset is exchanged by agents with the same valuation.

Figure 1: Pattern of Trade

trade is illustrated in Figure 1. We then rule out the existence of symmetric stationary equilibria with any other pattern of trade. Finally, we discuss the key properties of equilibrium. The main finding in this section is that heterogeneity in the commitment power of different agents naturally generates a theory of intermediation as a pure rent-extraction activity.

3.1 Conditions for Market Equilibrium

We want to establish the existence of a symmetric stationary market equilibrium where trade follows the pattern in Figure 1. We denote as $V_{i,j}$ the equilibrium lifetime utility of an agent of type (i,j) who owns the asset, as $U_{i,j}$ the lifetime utility of an agent of type (i,j) who does not own the asset, and as $D_{i,j} \equiv V_{i,j} - U_{i,j}$ the net value of asset ownership. We denote as $P_{i,j}(m,n)$ the equilibrium price at which an agent of type (i,j) sells the asset to an agent of type (m,n). We denote as $\mu_{i,j}$ and $\nu_{i,j}$ denote the equilibrium measure of agents of type (i,j) who, respectively, own and do not own the asset. Since the equilibrium we are seeking is symmetric, the measure $\mu_{i,L}$ of low-valuation agents of type i with the asset must equal the measure $\nu_{i,H}$ of high-valuation agents of type $i = \{S,T\}$ without the asset. Similarly, $\mu_{i,H}$ must equal $\nu_{i,L}$. Hence, $\lambda\mu_{i,L} = \lambda\nu_{i,H} \equiv \lambda_i$ and $\lambda\mu_{i,H} = \lambda\nu_{i,L} \equiv \hat{\lambda}_i$. We refer to λ_i as the rate at which a trader meets a mismatched agent of type i and to $\hat{\lambda}_i$ as the rate at which a trader meets a well-matched agent of type i.

3.1.1 Value Functions: Soft Agent

The equilibrium lifetime utility of an agent of type (S,L) who owns the asset satisfies

$$\begin{aligned} rV_{SL} &= u_L + \sigma\left(V_{S,H} - V_{S,L}\right) + \lambda_S\left(P_{S,L}(S,H) - D_{S,L}\right) \\ &\quad + \lambda_T\left(P_{S,L}(T,H) - D_{S,L}\right) + \hat{\lambda}_T\left(P_{S,L}(T,L) - D_{S,L}\right). \end{aligned} \tag{3.1}$$

The agent enjoys a flow utility u_L. At rate σ, the agent's valuation of the asset switches from L to H and the agent experiences a change in lifetime utility $V_{S,H} - V_{S,L}$. The agent meets a trader of type (S,H) without the asset at rate λ_S, a trader of type (T,H) without the asset at rate λ_T and a trader of type (T,L) without the asset at rate $\hat{\lambda}_T$. When the agent meets any of these traders, he sells the asset at the price $P_{S,L}(m,n)$, where (m,n) denotes the trader's type, and experiences a change in lifetime utility $-D_{S,L}$.

The price $P_{S,L}(m,n)$ at which the agent (S,L) sells the asset depends on the buyer's type. If the buyer is of type (S,H), the price $P_{S,L}(S,H)$ is determined as the outcome of the Rubinstein (1982) alternating-offer bargaining game. The outcome of the bargaining game is trade at a price $P_{S,L}(S,H)$ such that the gains from trade accruing to the buyer equal the gains from trade accruing to the seller. That is, $P_{S,L}(S,H) - D_{S,L} = -P_{S,L}(S,H) + D_{S,H}$ or, equivalently, $P_{S,L}(S,H) = (D_{S,H} + D_{S,L})/2$. If the buyer is of type (T,n), the price $P_{S,L}(T,n)$ is determined as a take-it-or-leave-it offer from the buyer. The buyer's take-it-or-leave-it offer is a price $P_{S,L}(T,n)$ that makes the seller indifferent between accepting and rejecting the trade and, hence, gives him none of the gains from trade. That is, $P_{S,L}(T,n) - D_{S,L} = 0$ or, equivalently, $P_{S,L}(T,n) = D_{S,L}$. Substituting these prices in (3.1), we obtain[4]

$$rV_{S,L} = u_L + \sigma\left(V_{S,H} - V_{S,L}\right) + \lambda_S\left(D_{S,H} - D_{S,L}\right)/2. \tag{3.2}$$

The equilibrium lifetime utility of an agent of type (S,L) who does not own the asset satisfies

$$rU_{S,L} = \sigma\left(U_{S,H} - U_{S,L}\right). \tag{3.3}$$

The agent enjoys a flow utility of 0. At rate σ, the agent's valuation of the asset switches from L to H and the agent experiences a change in lifetime utility $U_{S,H} - U_{S,L}$. The agent meets traders at rate λ. However, no matter whom the agent meets, he does not buy the asset.

[4] As it is apparent from (3.2), the lifetime utility of an agent is identical whether the agent captures none of the surplus upon meeting a particular type of trader, or whether he never meets that type of trader. This observation, which has been previously made by Postel-Vinay and Robin (2002) and Lagos and Rocheteau (2009), *does not* imply that the equilibrium of a model in which the agent does not capture any of the surplus upon meeting a particular trader is the same as the equilibrium in which the agent never meets that trader. In fact, the two equilibria are described by different systems of equations, as the lifetime utility of the agent's counterparty is different. In the first case, the lifetime utility of the trader includes a term related to meetings with the agent (because the trader captures all of the surplus in that meeting). In the second case, the lifetime utility of the trader does not include a term related to meetings with the agent (because, if the agent never meets the trader, then the trader never meets the agent).

Subtracting (3.3) from (3.2), we find that the net value of asset ownership for an agent of type (S,L) satisfies

$$rD_{S,L} = u_L + \sigma\left(D_{S,H} - D_{S,L}\right) + \lambda_S\left(D_{S,H} - D_{S,L}\right)/2. \tag{3.4}$$

The net value of the asset to the agent can be expressed as the sum of three terms. The first term is the difference in the agent's flow utility when he does and does not own the asset. The second term is the difference in the change in the agent's lifetime utility caused by a preference switch when he does and does not own the asset. The third term is the value to the agent of the option of selling the asset. Since an agent of type S captures half of the gains from trade when selling to a trader of type S and none of the gains from trade when selling to a trader of type T, the option value is the rate at which the agent meets a mismatched trader of type (S,H) times half of the gains from trade associated with that meeting.

The equilibrium lifetime utilities of an agent of type (S,H) who owns and does not own the asset respectively satisfy

$$rV_{S,H} = u_H + \sigma\left(V_{S,L} - V_{S,H}\right). \tag{3.5}$$

and

$$\begin{aligned} rU_{S,H} &= \sigma\left(U_{S,L} - U_{S,H}\right) + \lambda_S\left(-P_{S,L}(S,H) + D_{S,H}\right) \\ &\quad + \lambda_T\left(-P_{T,L}(S,H) + D_{S,H}\right) + \hat{\lambda}_T\left(-P_{T,H}(S,H) + D_{S,H}\right). \end{aligned} \tag{3.6}$$

The expression (3.5) is analogous to (3.3). The agent enjoys a flow utility u_H. At rate σ, the agent's valuation switches to L. The agent meets traders at the rate λ. However, no matter whom he meets, the agent does not sell the asset. The expression (3.6) is analogous to (3.2). The agents enjoys a flow utility of 0. At rate σ, the agent's valuation switches to L. The agent meets a trader of type (S,L) with the asset at rate λ_S. When this happens, the agent buys the asset at the price $P_{S,L}(S,H) = (D_{S,H} + D_{S,L})/2$. The agent meets a trader of type (T,L) with the asset at rate $\hat{\lambda}_T$ and a trader of type (T,H) with the asset at rate λ_T. When either event happens, the agent receives a take-it-or-leave-it offer $P_{T,n}(S,H) = D_{S,H}$.

Replacing the equilibrium prices in (3.6) and subtracting (3.6) from (3.5), we find that the net value of asset ownership for an agent of type (S,H) satisfies

$$rD_{S,H} = u_H + \sigma\left(D_{S,L} - D_{S,H}\right) - \lambda_S\left(D_{S,H} - D_{S,L}\right)/2. \tag{3.7}$$

The expression in (3.7) is analogous to (3.4), except that the last term in (3.7) represents the value to the agent of foregoing the option of buying the asset, rather than the value to the agent of acquiring the option of selling the asset.

3.1.2 Value Functions: Tough Agent

The equilibrium lifetime utility of an agent of type (T,L) who owns the asset satisfies

$$\begin{aligned} rV_{TL} &= u_L + \sigma\left(V_{TH} - V_{TL}\right) \\ &+ \lambda_S\left(P_{T,L}(S,H) - D_{T,L}\right) + \lambda_T\left(\mathbb{E}[P_{T,L}(T,H)] - D_{T,L}\right). \end{aligned} \tag{3.8}$$

The agent enjoys a flow utility u_L. At rate σ, the agent's valuation switches from L to H and the agent experiences a lifetime utility change $V_{T,H} - V_{T,L}$. At rate λ_S, the agent meets a trader of type (S,H) without the asset. When this happens, the agent makes a take-it-or-leave-it offer $P_{T,L}(S,H) = D_{S,H}$ to the trader, sells the asset, and experiences a lifetime utility change $-D_{T,L}$. At rate λ_T, the agent meets a trader of type (T,H) without the asset. When this happens, the agent gets to make a take-it-or-leave-it offer with probability $1/2$ and receives a take-it-or-leave it offer with probability $1/2$. In the first case, the agent sells at the price $D_{T,H}$, which leaves none of the gains from trade to the buyer. In the second case, the agent sells at the price $D_{T,L}$ which leaves him with none of the gains from trade. In expectation, the agent sells at the price $\mathbb{E}[P_{T,L}(T,H)] = (D_{T,L} + D_{T,H})/2$ and captures half of the gains from trade.

The equilibrium lifetime utility of an agent of type (T,L) who does not own the asset satisfies

$$rU_{T,L} = \sigma\left(U_{T,H} - U_{T,L}\right) + \lambda_S\left(-P_{S,L}(T,L) + D_{T,L}\right). \tag{3.9}$$

The agent enjoys a flow utility of 0. At rate σ, the agent's valuation switches from L to H. At the rate λ_S, the agent meets a trader of type (S,L) with the asset. When this happens, the agent makes a take-it-or-leave-it offer $P_{S,L}(T,L) = D_{S,L}$ to the trader, buys the asset and experiences a change in lifetime utility $D_{T,L}$.

Replacing the equilibrium prices in (3.8) and (3.9) and subtracting (3.8) from (3.9), we find that the net value of asset ownership for an agent of type (T,L) satisfies

$$\begin{aligned} rD_{T,L} &= u_L + \sigma\left(D_{T,H} - D_{T,L}\right) \\ &+ \lambda_S\left(D_{S,H} - D_{T,L}\right) + \lambda_T\left(D_{T,H} - D_{T,L}\right)/2 - \lambda_S\left(D_{T,L} - D_{S,L}\right). \end{aligned} \tag{3.10}$$

The first term in (3.10) is the difference in the agent's flow utility when he does and does not own the asset. The second term is the difference in the change in the agent's lifetime utility caused by a preference switch when he does and does not own the asset. The third and fourth terms together represent the value to the agent of the option of selling the asset. The third term is the rate at which the agent meets a mismatched trader of type (S,H) times the gains from trade associated with that meeting. The fourth term is the rate at which the agent meets a mismatched trader of type (T,H) times half of the gains from trade. The last term represents the value of the foregone option of buying the asset, which is given by the rate at which the agent meets a mismatched trader of type (S,L) times all of the gains from trade.

The lifetime utilities for an agent of type (T,H) who owns and does not own the asset satisfy

$$rV_{T,H} = u_H + \sigma\left(V_{T,L} - V_{T,H}\right) + \lambda_S\left(D_{S,H} - D_{T,H}\right). \tag{3.11}$$

and

$$rU_{T,H} = \sigma\left(U_{TL} - U_{TH}\right) + \lambda_S\left(D_{T,H} - D_{S,L}\right) + \lambda_T\left(D_{T,H} - D_{T,L}\right)/2. \tag{3.12}$$

The above expressions are easy to understand and imply that the net value of asset ownership for an agent of type (T,H) satisfies

$$\begin{aligned} rD_{T,H} \quad &= u_H + \sigma\left(D_{T,L} - D_{T,H}\right) \\ &+\lambda_S\left(D_{S,H} - D_{T,H}\right) - \lambda_T\left(D_{T,H} - D_{T,L}\right)/2 - \lambda_S\left(D_{T,H} - D_{S,L}\right). \end{aligned} \tag{3.13}$$

3.1.3 Individual Rationality of the Pattern of Trade

We formulated the value functions taking as given the pattern of trade in Figure 1. This pattern of trade is consistent with equilibrium if and only if the gains from trade are positive in every meeting in which the asset is supposed to be exchanged, and they are negative in every meeting in which the asset is supposed not to be exchanged. It is straightforward to see that these conditions are satisfied iff the following chain of inequalities holds

$$D_{S,L} \leq D_{T,L} \leq D_{T,H} \leq D_{S,H}. \tag{3.14}$$

Albeit intuitive, let us explain why the pattern of trade is consistent with equilibrium if and only if the gains from trade are positive (*negative*) in all the meetings where the asset is supposed to be (*not to be*) exchanged. First, consider a meeting between two agents of type S. The agents engage in an alternating-offer bargaining game. If the gains from trade are positive, the outcome of the game is such that the asset is exchanged at a price that equalizes the gains from trade accruing to buyer and seller. If the gains from trade are negative, the outcome of the game is that the asset is not exchanged. Next, consider a meeting between an agent of type S and one of type T. If the gains from trade are positive, the agent of type T finds it optimal to make a take-it-or-leave-it offer that leaves the agent of type S just indifferent between accepting and rejecting the trade, and the agent of type S accepts the trade. If the gains from trade are negative, the agent of type T finds it optimal to make a take-it-or-leave-it offer that the agent of type S will reject. Finally, consider a meeting between two agents of type T. Irrespective of who makes the take-it-or-leave-it offer, the asset is exchanged if and only if the gains from trade are positive.

3.1.4 Stationarity of the Distribution

The distribution of agents $\{\mu_{i,j}, \nu_{i,j}\}$ is stationary if and only if the measure of agents who, during an arbitrarily small interval of time of length dt, become asset (*non*-)holders of type (i, j) equals the measure of agents who, during the same interval of time, cease to be asset (*non*-)holders of type (i, j).

The inflow-outflow equation for agents of type (i, j) who hold the asset is

$$\mu_{i,j}\sigma + \mu_{i,j}\sum_{m,n}\left[\lambda \nu_{m,n}\theta_{i,j}(m,n)\right] = \mu_{i,\neg j}\sigma + \nu_{i,j}\sum_{m,n}\left[\lambda \mu_{m,n}\theta_{m,n}(i,j)\right]. \tag{3.15}$$

The left-hand side is the flow out of the group, which is given by the sum of two terms. The first term is the measure $\mu_{i,j}\sigma$ of agents of type (i, j) with the asset whose valuation switches from j to $\neg j$. The second term is the measure $\mu_{i,j}\lambda\nu_{m,n}\theta_{i,j}(m,n)$ of agents of type (i, j) with the asset who meet a trader of type (m,n) without the asset and sell, where $\theta_{i,j}(m,n)$ is an indicator function that takes the value 1 if (i, j) sells to (m,n) according to the equilibrium pattern of trade and 0 otherwise. The right-hand side is the flow into the group, which is also given by the sum of two terms. The first term is the measure $\mu_{i,\neg j}\sigma$ of agents of type $(i,\neg j)$ with the asset whose valuation switches from $\neg j$ to j. The second term is the measure $\nu_{i,j}\lambda\mu_{m,n}\theta_{m,n}(i, j)$ of agents of type (i, j) without the asset who meet a trader of type (m,n) with the asset and buy.

The inflow-outflow equation for agents of type (i, j) who do not hold the asset is

$$\nu_{i,j}\sigma + \nu_{i,j}\sum_{m,n}\left[\lambda \mu_{m,n}\theta_{m,n}(i,j)\right] = \nu_{i,\neg j}\sigma + \mu_{i,j}\sum_{m,n}\left[\lambda \nu_{m,n}\theta_{i,j}(m,n)\right]. \tag{3.16}$$

The left-hand side is the flow out of the group, which is given by the sum of the measure of agents of type (i, j) without the asset whose valuation switches to $\neg j$ and the measure of agents of type (i, j) without the asset who buy. The right-hand side is the flow into the group, which is given by the sum of the measure of agents of type $(i,\neg j)$ without the asset whose valuation switches to j and the measure of agents of type (i, j) with the asset who sell.

The distribution of agents has also to satisfy some consistency conditions

$$\sum_j(\mu_{S,j} + \nu_{S,j}) = \phi_S, \tag{3.17}$$

$$\sum_j(\mu_{T,j} + \nu_{T,j}) = \phi_T, \tag{3.18}$$

$$\sum_j(\mu_{S,j} + \mu_{T,j}) = 1/2. \tag{3.19}$$

The first condition requires the distribution $\{\mu_{i,j}, \nu_{i,j}\}$ to be such that the sum of the measure of agents of type S with and without the asset is equal to the measure ϕ_S of agents of type S. The second condition requires the distribution to be such that the measure of agents of type T with and without the asset is equal to the measure ϕ_T of agents of type T. The third condition requires the distribution to be such that the sum of the measure of agents with the asset is equal to the measure $1/2$ of the asset in the market.

3.1.5 Definition of Market Equilibrium

We are now in the position to formally define a market equilibrium.

Definition 1 *A Stationary Symmetric Market Equilibrium in which trade follows the pattern of Figure 1 is given by net values for asset ownership $\{D_{i,j}\}$ and a distribution of agents $\{\mu_{i,j}, \nu_{i,j}\}$ such that:*
(i) Net asset value satisfies Bellman Equations: $\{D_{i,j}\}$ satisfy (3.4), (3.7), (3.10) and (3.13);
(ii) Trade is individually rational: $\{D_{i,j}\}$ satisfies condition (3.14);
(iii) Distribution is stationary: $\{\mu_{i,j}, \nu_{i,j}\}$ satisfies conditions (3.15)-(3.19);
(iv) Distribution is symmetric: $\{\mu_{i,j}, \nu_{i,j}\}$ is such that $\mu_{i,L} = \nu_{i,H}$ and $\mu_{i,H} = \nu_{i,L}$ for $i = \{S,T\}$.

3.2 Existence and Uniqueness of Market Equilibrium

The first step in establishing the existence of a market equilibrium is to verify that there exists a solution to the system of Bellman Equations (3.4), (3.7), (3.10) and (3.13) for the net values of asset ownership $\{D_{i,j}\}$ that satisfies condition (3.14) for the individual rationality of the pattern of trade illustrated in Figure 1.

To this aim, consider the gains from trade $D_{S,H} - D_{S,L}$ between an agent of type (S,H) without the asset and one of type (S,L) with the asset. From (3.4) and (3.7), it follows that the gains from trade are given by

$$D_{S,H} - D_{S,L} = \frac{\Delta u}{r + 2\sigma + \lambda_S} > 0. \tag{3.20}$$

The gains from trade are strictly positive. They are proportional to the difference Δu in the valuation of the asset between the prospective buyer and seller. The factor of proportionality is $1/(r + 2\sigma + \lambda_S)$. The term $r + 2\sigma$ captures the effective duration of the difference in valuation between prospective buyer and seller. The term λ_S captures the outside options of prospective buyer and seller. The outside option of the prospective buyer, which arrives at the rate λ_S, is to buy the asset from some other agent of type (S,L) and capture half of the gains from trade $D_{S,H} - D_{S,L}$. The outside option of the prospective seller, which also arrives at the rate λ_S, is to sell to some other agent of type (S,H) and capture half of the gains from trade $D_{S,H} - D_{S,L}$.

Next, consider the gains from trade $D_{T,H} - D_{T,L}$ between an agent of type (T,H) without the asset and one of type (T,L) with the asset. From (3.10) and (3.13), it follows that the gains from trade are given by

$$D_{T,H} - D_{T,L} = \frac{\Delta u}{r + 2\sigma + 2\lambda_S + \lambda_T} > 0. \tag{3.21}$$

The gains from trade are strictly positive. They are proportional to the difference Δu in the valuation of the asset between the prospective buyer and seller. The factor of proportionality is smaller than in (3.20) because the outside options of the prospective buyer and seller are better. In particular, the outside option of the prospective buyer includes purchasing the asset from an agent of type (S,L) and capturing all the gains from trade as well as purchasing the asset from some other agent of type (T,L) and capturing half of the gains from trade. Similarly, the outside option of the prospective seller includes selling the asset to an agent of type (S,H) and capturing all of the gains from trade as well as selling the asset to some other agent of type (T,H) and capturing half of the gains from trade.

Now, consider the gains from trade $D_{T,L} - D_{S,L}$ between an agent of type (T,L) without the asset and one of type (S,L) with the asset. From (3.10) and (3.13), it follows that the gains from trade are given by

$$D_{T,L} - D_{S,L} = \frac{1}{2}\left[\frac{\lambda_T\left(D_{T,H} - D_{T,L}\right) + \lambda_S\left(D_{S,H} - D_{S,L}\right)}{r + 2\sigma + 2\lambda_S}\right] > 0. \tag{3.22}$$

The gains from trade are strictly positive. They are not positive because the prospective buyer has a higher valuation for the asset than the prospective seller. They are positive because the prospective buyer can exchange the asset for a higher price than the prospective seller. In fact, the prospective buyer, who has commitment power, can sell the asset to an agent of type (T,H) and capture half rather than none of the gains from trade, and he can sell the asset to an agent of type (S,H) and capture all rather than half of the gains from trade. For this reason, $D_{T,L} - D_{S,L}$ is proportional to $\lambda_T\left(D_{T,H} - D_{T,L}\right)/2 + \lambda_S\left(D_{S,H} - D_{S,L}\right)/2$.

Finally, it is easy to show that the gains from trade $D_{S,H} - D_{T,H}$ between an agent of type (S,H) without the asset and one of type (T,H) with the asset are equal to $D_{T,L} - D_{S,L}$ and, hence, strictly positive. Again, the gains from trade are positive not because of difference in valuation between prospective buyer and seller, but because the prospective seller, who has commitment power, can repurchase the asset at a lower price than the prospective buyer.

For arbitrary λ_S and λ_T, the solution for $\{D_{i,j}\}$ to the Bellman Equations (3.4), (3.7), (3.10) and (3.13) exists and is unique, as $D_{S,L}$ is uniquely determined by (3.4) and (3.20) and the other values are uniquely determined by (3.20)-(3.22). Moreover, the solution to the Bellman Equations (3.4), (3.7), (3.10) and (3.13) is such that $D_{S,L} < D_{T,L} < D_{T,H} < D_{S,H}$, as we established above that $D_{S,L} < D_{T,L}$, $D_{T,L} < D_{T,H}$ and $D_{T,H} < D_{S,H}$. We have thus verified that, for arbitrary λ_S and λ_T, there is a unique solution for $\{D_{i,j}\}$ to the Bellman Equations and that this solution satisfies condition (3.14) for the individual rationality of the pattern of trade.

The second step in establishing the existence of a market equilibrium is to verify that there is a symmetric distribution of agents $\{\mu_{i,j}, \nu_{i,j}\}$ that satisfies the stationarity conditions (3.15)-

(3.19). It is tedious but straightforward to show that the unique solution to (3.15)-(3.19) is

$$\mu_{S,L} = \nu_{S,H} = \sqrt{\left(\frac{\sigma}{\lambda}\right)^2 + \frac{\sigma}{2\lambda} + \frac{\phi_T^2}{16}} - \left(\frac{\sigma}{\lambda} + \frac{\phi_T}{4}\right), \tag{3.23}$$

$$\mu_{T,L} = \nu_{T,H} = \frac{\phi_T}{4} + \sqrt{\left(\frac{\sigma}{\lambda}\right)^2 + \frac{\sigma}{2\lambda}} - \sqrt{\left(\frac{\sigma}{\lambda}\right)^2 + \frac{\sigma}{2\lambda} + \frac{\phi_T^2}{16}}, \tag{3.24}$$

$$\nu_{i,L} = \phi_i/2 - \mu_{i,L}, \text{ for } i = \{S,T\}, \tag{3.25}$$

$$\mu_{i,H} = \phi_i/2 - \nu_{i,H}, \text{ for } i = \{S,T\}. \tag{3.26}$$

The expression in (3.23) shows that the measure of agents of type (S,L) with the asset is equal to the measure of agents of type (S,H) without the asset. The common measure of mismatched agents of type S is strictly increasing in the ratio σ/λ between the arrival rate of preference shocks and the arrival rate of trading partners. For $\sigma/\lambda \to 0$, the measure of mismatched agents of type S converges to 0. For $\sigma/\lambda \to \infty$, the measure converges to $\phi_S/4$, which is what one would obtain if the asset was assigned at random. Similarly, the expression in (3.24) shows that the measure of agents of type (T,L) with the asset is equal to the measure of agents of type (T,H) without the asset. The common measure of mismatched agents of type T is strictly increasing in σ/λ. For $\sigma/\lambda \to 0$, the measure of mismatched agents of type T converges to zero. For $\sigma/\lambda \to \infty$, the measure converges to $\phi_T/4$.

The expression in (3.25) shows that the measure of agents of type (i,L) with the asset plus the measure of agents of type (i,L) without the asset is equal to half of the measure of agents of type $i = \{S,T\}$. This finding is intuitive, as the symmetry of the preference shocks guarantee that half of the population of agents of type i has low valuation. For the same reason, (3.26) states that the measure of agents of type (i,H) with and without the asset is equal to half of the measure of agents of type $i = \{S,T\}$.

For arbitrary $\{D_{i,j}\}$, the distribution $\{\mu_{i,j}, \nu_{i,j}\}$ that satisfies the stationarity conditions (3.15)-(3.19) exists and is uniquely given by (3.23)-(3.26). Moreover, the distribution in (3.23)-(3.26) is symmetric, as $\mu_{i,L} = \nu_{i,H}$ and $\mu_{i,H} = \nu_{i,L}$ for $i = \{S,T\}$. We have thus verified that, for arbitrary $\{D_{i,j}\}$, there exists a unique distribution of agents $\{\mu_{i,j}, \nu_{i,j}\}$ that satisfies the stationarity conditions (3.15)-(3.19) and that such distribution is symmetric.

This completes the proof of existence and uniqueness of a symmetric stationary equilibrium in which trade follows the pattern illustrated in Figure 1. In Appendix A, we also prove that there is no symmetric stationary market equilibrium with a different pattern of trade. These findings are summarized in the proposition below.

Proposition 2 ***Existence and Uniqueness of Market Equilibrium***.

(i) For any given $\phi_T \in [0,1]$, there exists a unique stationary symmetric market equilibrium in

which trade follows the pattern illustrated in Figure 1.
(ii) For any given $\phi_T \in [0,1]$*, there exists no other symmetric stationary market equilibrium.*

3.3 Properties of Market Equilibrium

The first notable property of the market equilibrium is that market participants endogenously sort themselves into intermediaries and final users. The agents of type S, who do not have the ability to commit to prices, become final users, in the sense that they buy the asset only when their valuation is high and they sell it only when their valuation turns low. The agents of type T, who have the ability to commit to prices, become intermediaries, in the sense that they buy and sell the asset to final users independently of their own valuation for the asset.

The second notable property of equilibrium is that intermediation is a rent-extraction activity. In the equilibrium pattern of trade illustrated in Figure 1, there are six types of trades. Four of these trades are *fundamental trades* (SL to SH, SL to TH, TL to TH and TL to SH), in the sense that the asset is sold by a low-valuation agent and bought by a high-valuation agent. Two of these trades are *intermediation trades* (SL to TL and TH to SH), in the sense that the asset is exchanged even though buyer and seller have the same valuation for the asset. Both types of intermediation trades are generated by the T-agents' superior ability to extract rents in future trades. When a low-valuation agent of type T purchases the asset from a low-valuation agent of type S, he does not do so because he values the asset more or because he can find a high-valuation buyer more quickly. The low-valuation agent of type T purchases the asset because he can use his commitment power to sell the asset to a high-valuation buyer at a higher price. Similarly, when a high-valuation agent of type T sells the asset to a high-valuation agent of type S, he does not do so because he values the asset less or because he can find another unit of the asset more quickly. The high-valuation agent of type T sells the asset because he can go back to the market and purchase another unit of the asset at a lower price.

The incentives for agents of type T to become intermediaries are embodied in the equilibrium prices

$$\begin{aligned}
P_{S,L}(S,H) &= \mathbb{E}[P_{T,L}(T,H)] = \frac{u_L+u_H}{2r}, \\
P_{S,L}(T,n) &= \frac{u_L+u_H}{2r} - \frac{1}{r+2\sigma+\lambda_S}\frac{\Delta u}{2}, \\
P_{T,n}(S,H) &= \frac{u_L+u_H}{2r} + \frac{1}{r+2\sigma+\lambda_S}\frac{\Delta u}{2}.
\end{aligned}$$

The average price for the asset is $(u_L+u_H)/2r$. If an agent of type S sells to another agent of type S, the exchange take place at the average price. If, instead, an agent of type T sells to an agent of type S, the exchange takes place at the average price plus a premium. Similarly, if an agent of type S buys from another agent of type S, the exchange takes place at the average price. If, instead, an agent of type T buys from an agent of type S, he does so at the average price minus a discount. The fact that agents of type T can buy and sell at more favorable prices than agents of type S gives them the incentive to become intermediaries.[5]

Lastly, we examine the efficiency of the market equilibrium. When the measure of agents of type S and T is exogenous, efficiency only requires that, every time two agents meet, the property of the asset goes to the one who has the highest valuation. In the equilibrium, every time a low-valuation agent meets a high-valuation agent, the asset goes to the high-valuation agent. Thus, the market equilibrium is efficient.

However, efficiency is not a robust property of the market equilibrium. To see why, note that the equilibrium does not only feature fundamental trades–which are the trades that guarantee efficiency, as the asset goes from low-valuation to high-valuation agents–but it also features intermediation trades–which are trades that contribute nothing to efficiency, as the asset is exchanged by two agents with the same valuation. Since intermediation trades have no value in terms of efficiency but have positive value to the two agents involved in them, the efficiency of equilibrium will not be robust to small perturbation the environment.

We illustrate the fragility of the efficiency of equilibrium by means of three examples.

1. Transaction cost: Consider a version of the model with transaction costs. In particular, every time the asset is exchanged, the buyer and the seller both incur a cost of $c/2 > 0$ units of the numeraire good. The cost c may represent the cost of filling the paperwork required to exchange the ownership of the asset, the cost of physically moving the asset from the seller's location to the buyer's location, etc… In Appendix B.1, we show that, as long as c is not too large, the equilibrium features the same pattern of trade as in Figure 1. Hence, the equilibrium features both fundamental and intermediation trades. This is intuitive, as a small c does not change the sign of the bilateral gains associated with different types of trades. In contrast, efficiency requires the asset being always traded from low to high-valuation agents (i.e. fundamental trades are efficient) and never being traded by agents with the same valuation (i.e. intermediation trades are not efficient). This is also intuitive, as the intermediation trades contribute negatively to efficiency in the presence of a transaction cost. Therefore, as long as c is not too large, the equilibrium is inefficient.

2. Richer preferences: Consider a version of the model in which the flow utility from holding the asset for an agent of type (i, j) is $u_{i,j}$ with $0 < u_{S,L} < u_{S,H}$, $u_{T,L} = u_{S,L} - \varepsilon$, $u_{T,H} = u_{S,H} + \varepsilon$ and $\varepsilon > 0$. In words, agents of type T have more extreme preferences for the asset than agents

[5] The bid-ask spread charged by agents of type T to agents of type S is $\Delta u/(r + 2\sigma + \lambda_S)$, which is increasing in the difference Δu in the flow utility between high and low-valuation agents, decreasing in the rate σ at which agents' preferences change, and decreasing in the rate λ_S at which agents of type S get an opportunity to trade with other agents of type S.

of type S. In Appendix B.2, we show that, as long as ε is not too large, the equilibrium pattern of trade is the one illustrated in Figure 1. In particular, the equilibrium pattern of trade is such that (S,L) sells to (T,L) and (T,H) sells to (S,H). Intuitively, an agent of type (S,L) sells the asset to an agent of type (T,L) even though he has a higher valuation because the buyer can sell the asset at a higher price to somebody else. Similarly, an agent of type (T,H) sells the asset to an agent of type (S,H) even though he has a higher valuation because he can go back to the market and purchase another unit of the asset at a lower price. Efficiency requires that, in any meeting between two agents, the property of the asset always goes to the one with the highest valuation. In particular, efficiency requires that (T,L) sells to (S,L) and (S,H) sells to (T,H). Hence, the equilibrium pattern of trade is inefficient.

The inefficiency illustrated in the above example arises naturally whenever the set of valuations for the asset is rich enough. In fact, in an environment where an agent's valuation is a continuous variable (as in Hugonnier, Lester and Weill 2016) that may or may not be correlated with his commitment type, there will typically be meetings between an agent of type S with the asset and an agent of type T without the asset where the S-agent has a higher valuation than the T-agent and, yet, the gains from trade are strictly positive because of the difference in their commitment power.

3. Heterogeneity in contact rates: Consider a version of the model in which agents of type S contact trading partners at the rate λ, while agents of type T contact trading partners at the rate $\omega\lambda$, with $\omega \in (0,1)$. In words, consider a version of the model in which agents of type T have a lower contact rate than agents of type S. In Appendix B.3, we show that, as long as ω is close enough to 1, the equilibrium pattern of trade is the same as in Figure 1. In particular, the equilibrium pattern of trade is such that agents of type T act as intermediaries and agents of type S act as final users. Intuitively, agents of type T act as intermediaries for agents of type S (i.e., TL buys from SL and TH sells to SH) even though they are less likely to find a trading partner because, if they do so, they can trade at a more favorable price. In contrast, it is easy to show that efficiency requires the agents with the highest contact rate to act as intermediaries and the agents with the lower contact rate to act as final users. Intuitively, efficiency requires agents of type S to act as intermediaries for agents of type T (i.e., SL buys from TL and SH sells to TH) because this leads to a better allocation of the asset.

4 Extent and Determinants of Intermediation

In this section, we characterize the equilibrium measures of agents of type T, who act as intermediaries, and of agents of type S, who act as final users. We refer to this as the *intermediation equilibrium*. We assume that, upon entering the market, agents choose whether to invest in a technology that allows them to commit to take-it-or-leave-it offers or not. In Section 4.1, we compute the benefit to an agent from having commitment power, and characterize the set of intermediation equilibria. In Section 4.2, we examine the welfare properties of equilibrium. We find that equilibrium is inefficient whenever there is a positive measure of intermediaries. In Section 4.3, we study the effect of a decline in trading frictions on the extent of intermediation. We find that the intermediation becomes more prevalent as trading frictions become smaller. In Section 4.4, we study the effect of a decline in the interest rate on investments alternative to the commitment technology. We find that intermediation grows as interest rates fall. In order to sidestep issues related to transitional dynamics, we carry out the analysis for $r \to 0$.

4.1 Intermediation Equilibrium

4.1.1 Cost of Commitment

We assume that, upon entering the asset market, agents can acquire a technology that gives them the power to commit to take-it-or-leave-it offers and, hence, to become intermediaries. The cost of the commitment technology is $c > 0$ units of the numeraire good per unit of time.

A couple of comments about the way we model the choice of acquiring commitment power are in order. We model the choice as an investment in a costly technology. This is very abstract, but it does capture several realistic scenarios. For example, an agent may attain commitment power by delegating all of his negotiations to representatives who have no authority over pricing decisions (e.g., hiring a salesperson). Under this view, the cost of commitment are the wages paid to the agent's representatives. An agent may achieve commitment power by making the history of prices at which he transacts public and, by doing so, building a reputation for sticking to take-it-or-leave-it offers. Under this view, the cost of commitment is the price of the resources required to maintain a public record of transactions. It may also be the case that all agents have the ability to commit to take-it-or-leave-it offers, but that they decide to do so only if they understand the mechanics of strategic bargaining. Under this view, the cost of commitment is the cost of hiring better traders. It may even be the case that all agents in the market have the ability to commit to take-it-or-leave-it offers and they all understand the value of doing so. Yet, there might be a social stigma associated with using commitment power. Under this view, the cost of commitment is the disutility of being regarded as a pushy trader.[6]

We assume that every agent faces the same cost c of acquiring commitment power. The assumption simplifies the exposition but is not essential to any of the qualitative results contained in this section. In a previous version of the paper (see Farboodi, Jarosch and Menzio 2016), we generalize these results to the case in which agents are heterogeneous with respect to the cost at which they can acquire commitment power.

[6]In the 2014 Harris Survey, the occupation ranked lowest by prestige is "real estate broker". The occupations ranked just above are "union leader" and "stockbroker" (see Harris Poll 2014) These are all occupations that involve some form of intermediation and require negotiation skills.

4.1.2 Benefit of Commitment

The annuitized lifetime utility of an agent without commitment power is

$$rU_{S,j} = \lambda_S \left(D_{S,H} - D_{S,L}\right)/4, \tag{4.1}$$

$$rV_{S,j} = \left(u_H + u_L\right)/2 + \lambda_S \left(D_{S,H} - D_{S,L}\right)/4. \tag{4.2}$$

The expression in (4.1) is easy to understand. When his valuation is L, an agent of type S without the asset enjoys an expected utility of zero per unit of time. When his valuation is H, the agent enjoys an expected utility of $\lambda_S(D_{S,H} - D_{S,L})/2$ per unit of time. In the limit for $r \to 0$, the lifetime utility of the agent is given by the average of his expected utility per unit of time in the two valuation states. The intuition behind (4.2) is analogous.

The annuitized lifetime utility of an agent with commitment power is

$$rV_{T,j} = \lambda_S \left(D_{SH} - D_{SL}\right)/2 + \lambda_T \left(D_{TH} - D_{TL}\right)/4, \tag{4.3}$$

$$rV_{T,j} = \left(u_L + u_H\right)/2 + \lambda_S \left(D_{SH} - D_{SL}\right)/2 + \lambda_T \left(D_{TH} - D_{TL}\right)/4. \tag{4.4}$$

Consider the expression in (4.3). When his valuation is L, an agent of type T without the asset enjoys an expected utility of $\lambda_S(D_{T,L} - D_{S,L})$ per unit of time. When his valuation is H, the agent enjoys an expected utility of $\lambda_S(D_{T,H} - D_{S,L}) + \lambda_T(D_{T,H} - D_{T,L})$ per unit of time. In the limit for $r \to 0$, the lifetime utility of the agent is the average of his expected utility across the two valuation states. The expression in (4.3) follows from this observation and the fact that $D_{T,H} - D_{S,L} = D_{S,H} - D_{T,L}$. The intuition behind (4.4) is similar.

The benefit of acquiring commitment power, b, is given by the difference between the annuitized lifetime utility of an agent of type T and the annuitized lifetime utility of an agent of type S with the same valuation for the asset and the same inventory of the asset. From (4.1)-(4.4), it follows that the benefit of commitment is given by

$$b = \left[\lambda_S \left(D_{S,H} - D_{S,L}\right) + \lambda_T \left(D_{T,H} - D_{T,L}\right)\right]/4. \tag{4.5}$$

The above expression is easy to understand. The first term on the right-hand side of (4.5) are the additional rents that an agent of type T can extract when trading with agents of type S, which is equal to $1/4$ of $D_{S,H} - D_{S,L}$. The second term are the additional rents that an agent of type T can extract when trading with other agents of type T, which is equal to $1/4$ of $D_{T,H} - D_{T,L}$.

Substituting $D_{S,H} - D_{S,L}$ with (3.20) and $D_{T,H} - D_{T,L}$ with (3.21), we can rewrite the benefit of commitment as

$$b = \left\{\frac{\lambda_S}{2\sigma + \lambda_S} + \frac{\lambda_T}{2\sigma + 2\lambda_S + \lambda_T}\right\}\frac{\Delta u}{4}, \tag{4.6}$$

where the meeting rates λ_S and λ_T are respectively given by

$$\begin{aligned} \lambda_T &= \lambda\phi_T/4 + \sqrt{\sigma^2+\lambda\sigma/2} - \sqrt{\sigma^2+\lambda\sigma/2+(\lambda\phi_T)^2/16}, \\ \lambda_S &= \kappa - \lambda_T, \quad \kappa \equiv \sqrt{\sigma^2+\lambda\sigma/2} - \sigma. \end{aligned} \tag{4.7}$$

The function $b(\phi_T)$ implicitly defined by (4.6) and (4.7) has two important properties. First, the benefit of commitment power to an individual is the same whether nobody else has commitment or whether everyone else does, i.e. $b(0) = b(1)$. Second, the benefit of commitment power to an individual is strictly increasing in the measure of agents with commitment for all $\phi_T < \phi_T^*$ and strictly decreasing for all $\phi_T > \phi_T^*$, where $\phi_T^* \in (0,1)$. Taken together, these two properties imply that the benefit of commitment power to an individual attains its minimum, $\underline{b}$, when $\phi_T = \{0,1\}$ and its maximum, $\overline{b}$, when $\phi_T = \phi_T^*$. The properties of $b(\phi_T)$ are illustrated in Figure 2.

The above properties of $b(\phi_T)$ are central to understand the equilibrium extent of intermediation and, thus, deserve an explanation. To understand the first property, consider the value of commitment to an individual agent living either in a market populated only by agents of type S or in a market populated only by agents of type T. In either scenario, the outside option of the traders contacted by the agent is the same. In the first scenario, the agent contacts agents of type S, whose outside option is trading with anybody else and capturing half of the surplus. In the second scenario, the agent contacts agents of type T, whose outside option is also trading with anybody else and capturing half of the surplus. Since the trader's outside option is the same in either scenario, the surplus in a meeting between the agent and a trader is also the same. Moreover, in either scenario, the agent captures 50% more of the surplus by having commitment power. In the first scenario, the agent captures 100 rather than 50% of the surplus. In the second scenario, the agent captures 50% rather than none of the surplus. Overall, the benefit to the agent of having commitment power is the same whether nobody else or everybody else has commitment power.

To understand the second property of $b(\phi_T)$, consider the derivative of b with respect to ϕ_T

$$\begin{aligned} b'(\phi_T) = \quad & \left\{ \left(\frac{1}{2\sigma+2\lambda_S+\lambda_T} - \frac{1}{2\sigma+\lambda_S} \right) \right. \\ & \left. + \frac{\lambda_S}{(2\sigma+\lambda_S)^2} + \frac{\lambda_T}{(2\sigma+2\lambda_S+\lambda_T)^2} \right\} \frac{\Delta u}{4} \cdot \frac{\partial \lambda_T}{\partial \phi_T} \end{aligned} \tag{4.8}$$

where $\partial\lambda_T/\partial\phi_T > 0$. The first term on the right-hand side of (4.8) is a *composition effect*. It captures the effect of ϕ_T on the value of commitment to an individual agent through the increase in the probability that the agent meets a trader of type T and by the decline in the probability that the agent meets a trader of type S. This effect is always negative, as traders of type T have a better outside option than traders of type S and fewer rents can be extracted from them. The second and third terms on the right-hand side of (4.8) are *price effects*. They capture the effect of ϕ_T on the value of commitment to an individual agent through the change in the outside option of the traders with whom the agent comes into contact. This effect is always positive, as an increase in the fraction people of type T lowers the outside option of all types of traders and increases the rents that can be extracted from them.

When ϕ_T is small, the price effect dominates and $b'(\phi_T)$ is strictly positive. This is so because the outside option of traders of type S is relatively close to the outside option of traders of type T and, hence, the change in the composition of traders has a small effect on the value of commitment. In contrast, when ϕ_T is high, the composition effects dominates and $b'(\phi_T)$ is strictly negative. Intuitively, this is so because the outside option of traders of type S is much smaller than the outside option of traders of type T and, hence, a change in the composition of traders has a large effect on the value of commitment.

4.2 Intermediation Equilibrium

We are now in the position to define an equilibrium for the measure of intermediaries operating in the market.

Definition 3 *An Intermediation Equilibrium is a measure ϕ_T of agents of type T such that: (i) $b(\phi_T) = c$ if $\phi_T \in (0,1)$; (ii) $b(1) \geq c$ if $\phi_T = 1$; (iii) $b(0) \leq c$ if $\phi_T = 0$.*

The characterization of the set of equilibria is illustrated in Figure 2. If the cost c of acquiring commitment power is in the interval $(\underline{b}, \overline{b})$, there exist three equilibria which differ with respect to the extent of intermediation. In the first equilibrium (market as E_1 in Figure 2), the measure of agents with commitment power is $\phi_{T,1} = 0$. In this equilibrium, there is no intermediation. In the second equilibrium (marked as E_2), the measure of agents with commitment power is $\phi_{T,2} \in (0,1)$. In this equilibrium, there is a relatively small measure of agents who act as intermediaries and a relatively large measure of agents who act as final users. In the third equilibrium (marked as E_3), the measure of agents with commitment power is $\phi_{T,3} \in (\phi_{T,2}, 1)$. In this equilibrium, there is a relatively large measure of agents who act as intermediaries and a relatively small measure of agents who act as final users. If the cost c of acquiring commitment power is greater than $\overline{b}$, the unique equilibrium is such that $\phi_T = 0$. In this equilibrium, there is no intermediation. Conversely, if c is smaller than $\underline{b}$, the unique equilibrium is such that $\phi_T = 1$. In this equilibrium, everyone acts as an intermediary.

For intermediate values of the cost of commitment, there exist three equilibria. However, only two of them are stable. In fact, using the standard heuristic definition of a stable equilibrium as one in which the cost of acquiring commitment power is lower (*higher*) than the benefit in a left (*right*) neighborhood of equilibrium, only the equilibria E_1 and E_3 are stable.

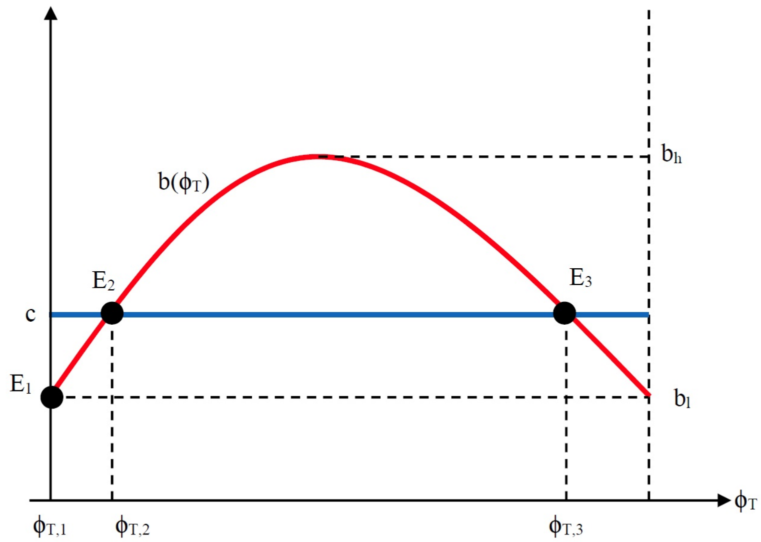


Figure 2: Equilibrium Intermediation

The equilibrium E_2 is an unstable one, as the benefit of commitment exceeds the cost in a right neighborhood of E_2.

The multiplicity of stable equilibria is caused by the fact that the benefit of commitment is hump-shaped in the measure of intermediaries expected to be in the market. In fact, if an agent expects nobody to become an intermediary, his benefit from acquiring commitment power is lower than the cost, as he expects the outside option of final users to be relatively strong. For this reason, the agent will find it optimal not to become an intermediary, thus rationalizing his expectation. If, on the other hand, an agent expects a measure $\phi_{T,3}$ of agents to become intermediaries, his benefit from acquiring commitment power is equal to the cost, as he expects the outside option of final users to be relatively weak. For this reason, the agent will be willing to become an intermediary with probability $\phi_{T,3}$, thus rationalizing his expectation.

The above discussion is summarized by the following proposition.

Proposition 4 ***Existence and Multiplicity of Intermediation Equilibria.***
(i) For any cost of commitment $c \in (\underline{b}, \overline{b})$, there exist two stable intermediation equilibria with, respectively, $\phi_T = 0$ and $\phi_T \in (0,1)$.
(ii) For any $c > \overline{b}$, there exists a unique stable intermediation equilibrium with $\phi_T = 0$.
(iii) For any $c < \underline{b}$, there exists a unique stable intermediation equilibrium with $\phi_T = 1$.

Now, we turn to examine the welfare properties of equilibrium. We measure welfare as the sum of the flow payoffs of all agents. Then welfare in an intermediation equilibrium ϕ_T is

$$W(\phi_T) = \left(\mu_{S,L} + \mu_{T,L}\right) u_L + \left(\mu_{S,H} + \mu_{T,H}\right) u_H - c\phi_T. \tag{4.9}$$

where $\mu_{S,L}$, $\mu_{T,L}$, $\mu_{S,H}$ and $\mu_{T,H}$ are given as in (3.23)-(3.26). The first term in (4.9) is the sum of flow utilities for the measure $\mu_{S,L}+\mu_{T,L}$ of low-valuation agents with the asset. The second term is the sum of flow utilities for the measure $\mu_{S,H}+\mu_{T,H}$ of high-valuation agents with the asset. The third term is the sum of flow costs borne by the measure ϕ_T of agents to acquire the commitment technology and become intermediaries.

Substituting $\mu_{S,L}$, $\mu_{T,L}$, $\mu_{S,H}$ and $\mu_{T,H}$ with (3.23)-(3.26), we can rewrite (4.9) as

$$W(\phi_T) = \frac{u_H}{2} - \left[\sqrt{\frac{\sigma^2}{\lambda^2}+\frac{\sigma}{2\lambda}} - \frac{\sigma}{\lambda}\right]\Delta u - c\phi_T. \tag{4.10}$$

The expression in (4.10) reveals that the measures of low and high-valuation agents with the asset and, hence, the sum of their flow utilities is independent of the measure ϕ_T of intermediaries in the market. In contrast, the sum of flow costs paid to acquire the commitment technology is increasing in the measure ϕ_T of intermediaries in the market. These findings are intuitive. The measure of intermediaries in the market affects the rate at which the asset moves between agents with the same valuation, but has no effect on the rate at which the asset moves between agents with different valuations. Thus, the measure of intermediaries has no impact on the distribution of the asset between low and high-valuation agents. In contrast, the measure of intermediaries affects the amount of resources that are spent on acquiring the commitment technology.

When the measure of agents of type S and T is endogenous, efficiency requires that: (i) every time two agents meet, the property of the asset goes to the one with the highest valuation; (ii) the measure of agents who acquire commitment power is zero. The first condition for efficiency has been discussed in the previous section. The second condition for efficiency is obvious, since acquiring commitment power is costly but has no effect on the asset allocations that are feasible. Taken together, the two conditions imply that, in any efficient allocation, the sum of flow payoffs is

$$W^* = \frac{u_H}{2} - \left[\sqrt{\frac{\sigma^2}{\lambda^2}+\frac{\sigma}{2\lambda}} - \frac{\sigma}{\lambda}\right]\Delta u. \tag{4.11}$$

From (4.10) and (4.11), two results immediately follow. First, whenever there are multiple intermediation equilibria, they can be welfare-ranked according to the measure of intermediaries operating in the market. Specifically, the equilibrium with the lowest measure of intermediaries has the highest welfare, the equilibrium with the second lowest measure of intermediaries has the second highest welfare, etc.... Second, any equilibrium in which there is a positive measure of intermediaries is inefficient.

The above results on the welfare properties of the intermediation equilibrium are summarized in the following proposition.

Proposition 5 ***Welfare Properties of Intermediation Equilibrium*.**

(i) Let $\{\phi_{T,1}, \phi_{T,2}, \phi_{T,3}\}$ be intermediation equilibria with $\phi_{T,1} < \phi_{T,2} < \phi_{T,3}$. The welfare associated with these equilibria is such that $W(\phi_{T,1}) > W(\phi_{T,2}) > W(\phi_{T,3})$.
(ii) Let ϕ_T be an intermediation equilibrium. The welfare $W(\phi_T)$ associated with the equilibrium is equal to the welfare W^* associated with the efficient allocation iff $\phi_T = 0$.

The fact that any equilibrium with intermediation is inefficient is one of our main results. When intermediation is a pure rent-extraction activity, the presence of intermediaries in the market does not lead to any improvements in the asset allocation. Indeed, in the previous section, we brought up several examples in which the presence of intermediaries in the market leads to a worsening of the asset allocation. Whether intermediaries leave the asset allocation unchanged or worsen it, they do extract some rents from final users. In equilibrium, intermediaries dissipate these rents through costly investment in the commitment technology. Therefore, when intermediation is a rent-extraction activity, any amount of intermediation is a source of inefficiency.[7]

4.3 Trading Frictions and Intermediation

We now want to examine the effect of a decline in trading frictions, modeled as an increase in λ, on the extent of rent-extraction intermediation. This exercise is interesting for both theoretical and empirical reasons. Theoretically, the exercise is interesting because it is natural to wonder whether rent-extraction intermediation tends to disappear on its own as trading frictions become smaller and markets become more competitive. Empirically, the exercise is interesting because recent progress in Information Technology must have lowered trading frictions. To keep the notation light, we carry out the exercise under the assumption that $\sigma = 1$, which is without loss in generality as all the equilibrium objects depend only on the ratio λ/σ and not on λ and σ separately.

The effect of an increase in λ on the rate $\lambda_S = \lambda \mu_{S,L}$ at which an agent meets a mismatched trader of type S is

$$\frac{\partial \lambda_S}{\partial \lambda} = \frac{1/2 + \lambda \phi_T^2/8}{2\sqrt{1 + \lambda/2 + (\lambda \phi_T)^2/16}} - \frac{\phi_T}{4} > 0. \tag{4.12}$$

An increase in λ has two countervailing effects on λ_S. On the one hand, an increase in λ tends to increase λ_S because it increases the rate at which an agent meets a trader. On the other hand, an increase in λ tends to lower λ_S because it reduces the measure $\mu_{S,L}$ of traders of type S who are mismatched. It is easy to check that (4.12) is strictly positive, meaning that the first effect dominates the second one.

[7] In Farboodi, Jarosch and Menzio (2016), we show that an optimally chosen transaction tax can restore efficiency. The optimal transaction tax has the property of making the after-tax gains from trade between a low-valuation seller and a high-valuation buyer equal to zero. Given such tax, there is no motive for rent extraction and no resources are wasted acquiring the commitment technology.

The effect of an increase in λ on the rate $\lambda_T = \lambda\mu_{T,L}$ at which an agent meets a mismatched trader of type T is

$$\frac{\partial\lambda_T}{\partial\lambda} = \frac{\phi_T}{4} + \frac{1}{4\sqrt{1+\lambda/2}} - \frac{1/4+\lambda\phi_T^2/16}{\sqrt{1+\lambda/2+(\lambda\phi_T)^2/16}} > 0. \tag{4.13}$$

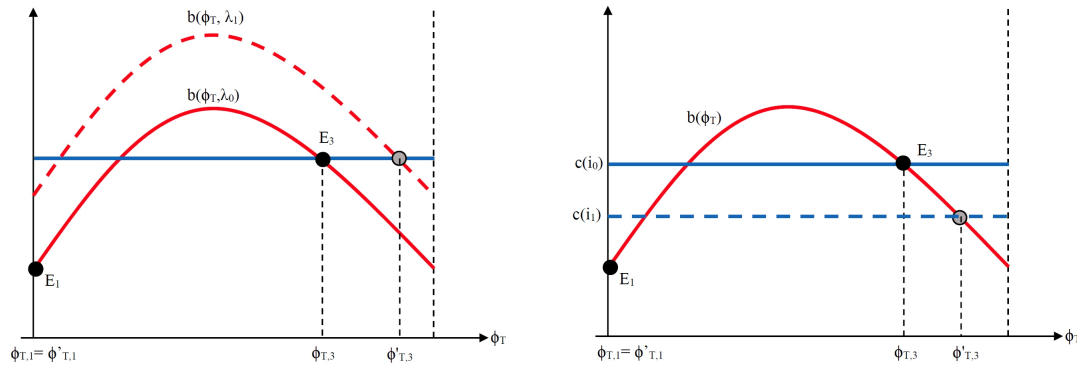
An increase in λ has also two countervailing effects on λ_T. An increase in λ tends to increase λ_T because it increases the rate at which an agent meets a trader, and it tends to lower λ_T because it reduces the measure $\mu_{T,L}$ of mismatched traders of type T. Again, it is easy to check that (4.13) is strictly positive, meaning that the first effect dominates the second one.

The effect of an increase in λ on the benefit $b(\phi_T)$ of acquiring commitment power is

$$\begin{aligned}\frac{\partial b(\phi_T)}{\partial\lambda} &= \left[\frac{1}{2+\lambda_S} - \frac{\lambda_S}{(2+\lambda_S)^2}\right]\frac{\partial\lambda_S}{\partial\lambda}\frac{\Delta u}{4} \\ &+ \left[\frac{1}{2+2\lambda_S+\lambda_T}\frac{\partial\lambda_T}{\partial\lambda} - \frac{\lambda_T}{(2+2\lambda_S+\lambda_T)^2}\left(2\frac{\partial\lambda_S}{\partial\lambda}+\frac{\partial\lambda_T}{\partial\lambda}\right)\right]\frac{\Delta u}{4}.\end{aligned} \tag{4.14}$$

The first line on the right-hand side of (4.14) measures the impact of an increase in λ on the additional rents that an agent can capture from traders of type S by having commitment power. The impact is given by the sum of two effects: a *volume effect* and a *margin effect*. The volume effect is positive, as an increase in λ raises the rate λ_S at which the agent meets a mismatched trader of type S. The margin effect is negative, as an increase in λ improves the outside option of a mismatched trader of type S and, thus, shrinks the additional rents $\Delta u/[4(2+\lambda_S)]$ that the agent can capture from him by having commitment power. It is immediate to see that the sign of the first line is positive, meaning that the volume effect dominates. Intuitively, this is because, while the rate at which an agent meets a mismatched S-trader is proportional to λ_S, the additional rents that an agent can extract are proportional to $1/(2+\lambda_S)$, where the 2 represents the discounting effect of preference changes on the overall gains from trade. The second line on the right-hand side of (4.14) is the impact of an increase in λ on the additional rents that an agent can capture from traders of type T by having commitment power. Also in this case, the impact can be decomposed into a volume and a margin effect. And, also in this case, the volume effect dominates so that the second line is positive From these observations, it follows that an increase in λ unambiguously increases the benefit of commitment power.

We are now in the position to analyze the effect of a decline in trading frictions on the extent of rent-extraction intermediation. To this aim, consider Figure 3(a) which depicts the case in which, for $\lambda = \lambda_0$, the cost of commitment c is in the interval $(\underline{b}, \overline{b})$ so that there are exist two stable equilibrium levels of intermediation $\phi_{T,1}$ and $\phi_{T,3}$ with $0 = \phi_{T,1} < \phi_{T,3} < 1$. An increase in the meeting rate from λ_0 to λ_1 leads to an increase in the benefit of commitment for all ϕ_T and, in turn, to an increase in the equilibrium levels of intermediation. If the increase in



(a) Trading Frictions (b) Interest Rates

Figure 3: Comparative Statics on Equilibrium Intermediation

λ is small enough, then the stable equilibrium levels of intermediation become $\phi'_{T,1}$ and $\phi'_{T,3}$ with $\phi'_{T,1} = \phi_{T,1} = 0$ and $\phi'_{T,3} > \phi_{T,3}$. Otherwise, the stable equilibrium level of intermediation becomes $\phi'_T = 1 > \phi_{T,3}$. In either case, a decline in trading frictions leads to an increase in the extent of rent-extraction intermediation. The same conclusions apply to the cases in which $c > \overline{b}$ or $c < \underline{b}$.

We have thus established the following proposition.

Proposition 6 ***Trading Frictions and Intermediation***. *Let $\{\phi_{T,i}\}$ be the intermediation equilibria given λ_0, with $\phi_{T,1} < ... < \phi_{T,N}$. Let $\{\phi'_{T,i}\}$ be the intermediation equilibria given $\lambda_1 > \lambda_0$, with $\phi'_{T,1} < ... < \phi'_{T,N'}$. Then $\{\phi'_{T,i}\}$ is greater than $\{\phi_{T,i}\}$, in the sense that $\phi'_{T,1} \geq \phi_{T,1}$ and $\phi'_{T,N'} \geq \phi_{T,N}$.*

Proposition 6 is surprising from the point of view of theory. After all, the following argument appears to be correct: As frictions decline, final users can locate trading partners more rapidly and, hence, the surplus that intermediaries can capture from them become smaller. As the rents that intermediaries can capture become smaller, fewer of them come into the market. However, this argument is incomplete because, as frictions become smaller, not only does the surplus that intermediaries can capture from final users becomes smaller but the frequency at which intermediaries encounter final users becomes larger. And, since this other effect dominates, more and more intermediaries come into the market as frictions become smaller.

Proposition 6 is interesting from an empirical point of view. Some readers may think that our theory is not relevant because "In this day and age, trading frictions are very small". Yet, Proposition 6 implies that rent-extraction intermediation is not a phenomenon that vanishes when trading frictions get smaller and smaller. To the contrary, Proposition 6 implies that rent-extraction intermediation is a phenomenon that becomes more and more relevant when trading frictions become smaller. Indeed, Proposition 6 suggests the possibility that the decline in trading frictions caused by the improvements in Information Technology may be one of the reasons for the dramatic rise in the financial intermediation sector that has taken place in the US since the 1950s (see, e.g., Philippon 2015).

The next natural step is to examine the effect of an increase in λ on welfare. From (4.10) and Proposition 6 it immediately follows that an increase in λ has two opposing effects on welfare. On the one hand, an increase in λ leads to a better allocation of the asset, in the sense that it increases the measure of high-valuation agents with the asset and it reduces the measure of low-valuation agents with the asset. On the other hand, an increase in λ leads to an increase in the measure of intermediaries and, in turn, to an increase in the amount of resources that are spent on the commitment technology.

In order to understand which effect dominates, it is useful to start from the observation that welfare–which we defined as the average flow payoffs among all market participants–is also equal to the average annuitized lifetime utilities among all market participants.[8] That is, $W(\phi_T)$ is equal to $r\sum_{i,j}[\mu_{i,j}U_{i,j} + \nu_{i,j}V_{i,j}] - c\phi_T$. Then, using (4.1)-(4.4) to substitute out $U_{i,j}$ and $V_{i,j}$, we can write welfare as

$$W(\phi_T) = \begin{cases} \dfrac{\sqrt{1+\lambda/2}-1}{\sqrt{1+\lambda/2}+1}\dfrac{\Delta u}{4} + \dfrac{u_L+u_H}{4}, & \text{if } \phi_T = 0, \\ \dfrac{\sqrt{1+\lambda/2}-1}{\sqrt{1+\lambda/2}+1}\dfrac{\Delta u}{4} + \dfrac{u_L+u_H}{4} - c, & \text{if } \phi_T = 1, \\ \dfrac{\lambda_S}{2+\lambda_S}\dfrac{\Delta u}{4} + \dfrac{u_L+u_H}{4}, & \text{if } \phi_T \in (0,1). \end{cases} \tag{4.15}$$

The first line on the right-hand side of (4.15) makes use of the fact that λ_S is equal to $(1+\lambda/2)^{1/2}-1$ in any intermediation equilibrium with $\phi_T = 0$. The second line makes use of the fact that λ_T is equal to $(1+\lambda/2)^{1/2}-1$ in any intermediation equilibrium with $\phi_T = 1$. The third line makes use of the fact that, in any intermediation equilibrium with $\phi_T \in (0,1)$, the cost of commitment c must be equal to the benefit of commitment $b(\phi_T)$.

In an intermediation equilibrium with $\phi_T = 0$, which exists when either $c > \overline{b}$ or $c \in (\underline{b}, \overline{b})$, a (small) increase in λ unambiguously increases welfare. Similarly, in an intermediation equilibrium with $\phi_T = 1$, which exists when $c < \underline{b}$, an increase in λ leads to higher welfare. These findings are intuitive. In the intermediation equilibria with $\phi_T \in \{0,1\}$, a (small) increase in λ improves the allocation of the asset but does not induce any additional entry of intermediaries and, hence, it does not lead to an additional resources being wasted in the commitment technology.

Now, consider an intermediation equilibrium with $\phi_T \in (0,1)$, which exists when $c \in (\underline{b}, \overline{b})$.

[8] All details are available upon request.

In this equilibrium, the rate λ_S at which an agent meets a mismatched trader of type S is such that the cost and benefit of commitment are equalized, i.e.

$$c = \left[\frac{\lambda_S}{2+\lambda_S} + \frac{\sqrt{1+\lambda/2}-1-\lambda_S}{\sqrt{1+\lambda/2}+1+\lambda_S}\right]\frac{\Delta u}{4}. \tag{4.16}$$

A stable intermediation equilibrium is associated with the smallest root of (4.16), whereas an unstable equilibrium is associated with the largest root of (4.16). The right-hand side of (4.16) is a concave function of λ_S and it is strictly increasing in λ. Thus, the smallest root of (4.16) is decreasing in λ. This means that an increase in λ lowers the value of λ_S at a stable intermediation equilibrium with $\phi_T \in (0,1)$. It then follows from (4.15) that an increase in λ unambiguously lowers welfare at a stable intermediation equilibrium with $\phi_T \in (0,1)$.

The above observations together with the monotonicity of the $b(\phi_T)$ with respect to λ lead us to the following proposition.

Proposition 7 ***Trading Frictions and Welfare***. *For any $c > 0$, there exists λ_1 and λ_2 with $0 < \lambda_1 < \lambda_2 \leq \infty$ such that:*
(i) For $\lambda < \lambda_1$, there is a unique stable intermediation equilibrium with $\phi_T = 0$. At this equilibrium welfare increases in λ.
(ii) For $\lambda \in (\lambda_1, \lambda_2)$, there are two stable equilibria with $\phi_{T,1} = 0$ and $\phi_{T,3} \in (0,1)$. Welfare increases in λ at the first equilibrium, and decreases at the second equilibrium.
(iii) For $\lambda > \lambda_2$, there is a unique stable equilibrium with $\phi_T = 1$. At this equilibrium welfare increases in λ.

Proposition 7 states that, if the fraction of rent-extraction intermediaries in the market is interior, welfare falls as trading frictions become smaller. This finding is surprising and it is useful to provide some intuition for it. As $\lambda \to \lambda_2$, the fraction of intermediaries at the interior equilibrium converges to 1. When $\phi_T \to 1$, agents of type S never capture any of the gains from trade and, hence, their lifetime utility converges to its autarky level. Since agents of type T have the same lifetime utility as agents of type S after taking into account the resources they spent on the commitment technology, it follows that equilibrium welfare converges to welfare in autarky. In contrast, for any $\lambda \in (\lambda_1, \lambda_2)$, agents of type S are strictly better off than in autarky and, hence, so are agents of type T. Therefore, for any $\lambda \in (\lambda_1, \lambda_2)$, welfare is strictly higher than in autarky.

4.4 Interest Rates and Intermediation

We conclude by examining the effect on rent-extraction intermediation of a decline in the interest rate on investments that are alternative to the investment in the commitment technology.

To carry out the exercise, we assume that there exists a continuous function $c(i)$ mapping the interest rate $i \geq 0$ on alternative investments on the opportunity cost of acquiring commitment power, with $c(0) = 0$ and $c'(i) > \varepsilon > 0$ for all $i \geq 0$.

Figure 3(b) illustrates the situation in which the interest rate i_0 is such that the opportunity cost of the commitment technology $c(i_0)$ is in the interval $(\underline{b}, \overline{b})$ so that there are two stable equilibrium levels of intermediation $\phi_{T,1}$ and $\phi_{T,3}$ with $0 = \phi_{T,1} < \phi_{T,3} < 1$. If the decline in the interest rate from i_0 to i_1 is small enough, then the stable equilibrium levels of intermediation become $\phi'_{T,1}$ and $\phi'_{T,3}$ with $\phi'_{T,1} = \phi_{T,1}$ and $\phi'_{T,3} > \phi_{T,3}$. Otherwise, the stable equilibrium level of intermediation becomes $\phi'_T = 1 > \phi_{T,3}$. In either case, a decline in the interest rate leads to an increase in the extent of rent-extraction intermediation. The same conclusion also applies to the situations in which the interest i_0 is such that $c(i_0) > \overline{b}$ or $c(i_0) < \underline{b}$.

Proposition 8 ***Interest Rates and Intermediation***. *Let $\{\phi_{T,i}\}$ be the intermediation equilibria given i_0, with $\phi_{T,1} < ... < \phi_{T,N}$. Let $\{\phi'_{T,i}\}$ be the intermediation equilibria given $i_1 < i_0$, with $\phi'_{T,1} < ... < \phi'_{T,N'}$. Then $\{\phi'_{T,i}\}$ is greater than $\{\phi_{T,i}\}$, in the sense that $\phi'_{T,1} \geq \phi_{T,1}$ and $\phi'_{T,N'} \geq \phi_{T,N}$.*

Next, we want to understand the effect of a decline in the interest rate i on welfare. From (4.10) and Proposition 8 it follows that a decline in i has two countervailing effects on welfare. On the one hand, a decline in i leads to a decline in the opportunity cost of the resources devoted by intermediaries to acquire the commitment technology. On the other hand, a decline in i leads to an increase in the measure of agents who decide to become intermediaries and, for this reason, devote resources to acquire the commitment technology.

In order to figure out which effect dominates, it is sufficient to return to the formula for welfare in (4.15). In an equilibrium with $\phi_T = 0$, which exists when either $c(i) > \overline{b}$ or $c(i) \in (\underline{b}, \overline{b})$, a decline in i unambiguously increases welfare. This is because, a decline in i lowers the opportunity cost of acquiring the commitment technology needed to intermediate without inducing any additional entry of intermediaries. For the same reason, in an equilibrium with $\phi_T = 1$, which exists when $c(i) < \underline{b}$, a decline in i leads to higher welfare.

In an intermediation equilibrium with $\phi_T \in (0,1)$, which exists when $c(i) \in (\underline{b}, \overline{b})$, the rate λ_S at which an agent meets a mismatched trader of type S is such that the cost and benefit of commitment are equalized, i.e.

$$c(i) = \left[\frac{\lambda_S}{2+\lambda_S} + \frac{\sqrt{1+\lambda/2} - 1 - \lambda_S}{\sqrt{1+\lambda/2} + 1 + \lambda_S}\right]\frac{\Delta u}{4}. \tag{4.17}$$

A stable intermediation equilibrium is associated with the smallest root of (4.17). The right-hand side of (4.17) is concave in λ_S and the left-hand side of (4.17) is increasing in i. Thus, the smallest root of (4.17) is increasing in i. This means that a decline in i lowers the value of λ_S at a stable intermediation equilibrium with $\phi_T \in (0,1)$. It then follows from (4.15) that a decline in i unambiguously lowers welfare at a stable intermediation equilibrium with $\phi_T \in (0,1)$.

The above observations together with the assumptions about the function $c(i)$ immediately imply the following.

Proposition 9 ***Interest Rates and Welfare***. *There exists i_1 and i_2 with $0 < i_1 < i_2$ such that:*
(i) For $i > i_2$, there is a unique stable intermediation equilibrium with $\phi_T = 0$. At this equilibrium, a decline in i increases welfare.
(ii) For $i \in (i_1, i_2)$, there are two stable equilibria with $\phi_{T,1} = 0$ and $\phi_{T,3} \in (0,1)$. A decline in i increases welfare at the first equilibrium, and lowers welfare at the second equilibrium.
(iii) For $i < i_1$, there is a unique stable equilibrium with $\phi_T = 1$. At this equilibrium, a decline in i increases welfare.

Proposition 8 states that the extent of rent-extraction intermediation grows when interest rates fall, and shrinks when interest rates rise. This is intuitive. When interest rates fall, agents face a lower opportunity cost of investing in the commitment technology–e.g., hiring a sales team, learning about effective bargaining techniques, or suffering the social stigma associated with being a tough trader–and for this reason more of them acquire commitment and engage in rent-extraction intermediation. Proposition 9 states that, if the fraction of rent-extraction intermediaries in the market is positive but less than one, the total welfare of the agents in the market declines when interest rates fall. This result is easy to understand when we think of welfare as the sum of the lifetime utilities of agents of type S and T. A decline in i leads to an increase in the measure of agents of type T, which unambiguously lowers the lifetime utility of agents of type S. Since agents of type T have, ex-ante, the same lifetime utility as agents of type S, total welfare must decline.

The findings in Propositions 8 and 9 are closely related to the hypothesis of "reaching for yield" formulated by Rajan (2006). According to this hypothesis, when the return on safe assets falls, investors rebalance their portfolios towards alternative assets with a higher return and risk.[9] If investors do not fully internalize the downside risk of the alternative assets, their portfolio rebalancing is socially undesirable. Here, we highlight a different channel through which low interest rates also lead to socially undesirable behavior by investors. Namely, low interest rates lead investors to reallocate their resources away from productive investments and towards investments that allow them to capture a larger share of the gains from trade.

[9]See Cociuba, Shukayev and Ueberfeldt (2016) for an overview of the literature on the "reaching for yield" hypothesis. See Jimenez et al. (2014) for some empirical evidence supporting this hypothesis.

5 Evidence of Intermediation as Rent Extraction

In this section, we offer a simple empirical strategy that allows us to assess whether the theory of intermediation as rent extraction proposed in this paper holds water. We implement this strategy using a novel dataset on the Indonesian interbank market for Central Bank reserves. We argue that the Indonesian interbank market features random search, bilateral trade and bargaining and, hence, is well described by our setup, but also by theories of speed driven intermediation in the spirit of RW and DGP. We show that, for the empirical pricing patterns we document to be consistent with a benchmark model of intermediation, more central agents must be better at rent extraction.

5.1 Empirical Test

Is it possible to empirically discriminate between rent extraction (the force studied in this paper) and speed (the key force in standard theories of intermediation in the spirit of RW and DGP) as drivers of intermediation?

Along several dimensions, the two theories make identical predictions. Both predict that intermediaries buy assets from final users at relatively low prices and then sell them to final users at relatively high prices. That is, both theories predict that intermediaries charge bid-ask spreads. Also, both predict that intermediaries trade more frequently than final users, as long as the fraction of intermediaries in the market is not too large. That is, both theories predict that intermediaries have a larger trade volume than final users.

There is, however, one dimension along which the two theories make different predictions. To show this, Appendix C offers a simplified benchmark model of intermediation that distills the force we have studied thus far and formally contrasts it with an analogous environment where intermediaries have a better search technology. Here, we only sketch the key forces behind the argument.

In the theory of intermediation as rent extraction, more central intermediaries are those who can extract a larger fraction of the gains from trade (because, say, they are more likely to commit to their prices, they hire better traders, etc...). Then, when a final user—or more generally a given type of agent—sells the asset to a more central intermediary, he receives a lower price. When an agent buys the asset from a more central intermediary, he pays a higher price. Intuitively, when an agent trades with a more central intermediary, he captures a lower share of the gains from trade and, hence, ends up receiving a less favorable price.

Suppose instead that, in the spirit of RW, more central intermediaries are those who have a better search technology. Then, when an agent sells to a more central intermediary, he receives a higher price. When an agent buys from a more central intermediary, he pays a higher price.

Intuitively, when an agent sells the asset to a more central intermediary, the gains from trade are larger (as the intermediary can find a final buyer for the asset more quickly) and, hence, the agent receives a higher price. When an agent buys the asset from a more central intermediary, the gains from trade are smaller (as the outside option of the intermediary is better) and, hence, the agent pays a higher price. Other theories of intermediation as service provision would make similar predictions.

Thus, a benchmark model of intermediation predicts that, when it is driven by rent extraction, a given seller will sell the asset at a lower price to a more central intermediary than to a less central one. In contrast, when intermediation is instead driven by speed, the same model predicts that a given seller will sell the asset at a higher price to a more central intermediary than to a less central one. In either case, a given buyer will purchase the asset at a higher price from a more central intermediary than from a less central one.

5.2 Indonesian Interbank Market

We analyze the relationship between centrality of the counterparty and terms of trade using a novel dataset on the Indonesian interbank market for (Indonesian) Central Bank reserves. The dataset is well-suited for the analysis, as the object of trade is homogeneous (overnight loan), trade is decentralized and bilateral, the identity of buyer (borrower) and seller (lender) and the price (interest rate) are observed for the universe of transactions over an 11 year span. Moreover, the search for a counterparty is random and prices are negotiated bilaterally.

Let us start with some institutional details. The Indonesian interbank market for Central Bank reserves works in a way that is similar to the US federal funds market. Commercial banks in Indonesia have to meet reserve requirements on a daily basis and can use the market to borrow and lend and control their liquid positions. The loans are unsecured, mostly overnight (70%), and traded over the counter. Each day, banks calculate their liquidity needs and ask their traders to target this quantity at the best possible price. Banks have an incentive to meet the quantity targeted by the end of the trading day (5pm) because any excessive or insufficient liquidity is costly. Indeed, excessive or insufficient liquidity is adjusted by lending or borrowing with the Central Bank, which offers less attractive rates than the market does (i.e., lower interest rate for lending, higher interest rate for borrowing).

Banks typically trade in the interbank market through platforms managed by brokers licensed by the Central Bank.[10] Specifically, a bank informs a broker through a Bloomberg or Reuters chat of its bid or ask rate and its desired volume. The broker then shares the bid with all its clients without revealing the identity of the bidder or the desired volume. A potential counterparty may take the bid, or it may ask the broker to inform the bidder of a counteroffer (again

[10] There are nine licensed brokers, five of which account for over 90% of the trading volume.

Table 1: Summary Statistics

Year	Number of Banks			Transaction Volume		Number of
	Operating	Entering	Exiting	in millions USD	% Overnight	Transactions
2006	126	0	3	222,891	71	64,376
2007	123	0	1	311,402	77	71,550
2008	124	2	12	207,566	74	52,518
2009	113	1	4	195,783	77	45,559
2010	109	0	7	243,723	73	45,195
2011	102	0	1	292,960	71	44,726
2012	101	0	0	236,426	65	32,697
2013	103	2	1	246,647	62	38,519
2014	104	2	2	222,058	68	34,419
2015	104	2	2	208,201	64	36,756
2016	102	0	4	213,786	68	35,650
2017	98	0	3	224,989	71	37,163

Notes: Annual volumes and frequencies. All the interbank loans are denominated in local currency. We convert the annual volume into U.S. dollars using the annual average exchange rate reported in the IMF's International Financial Statistics.

anonymously and without details about volume). The bidder can then accept the counteroffer or negotiate again. Once the two parties agree on a rate, the broker reveals the identity of the banks involved in the trade, as well as the desired volume for each bank. The traded volume is the minimum between the volume desired by the borrower and the volume desired by the lender.[11]

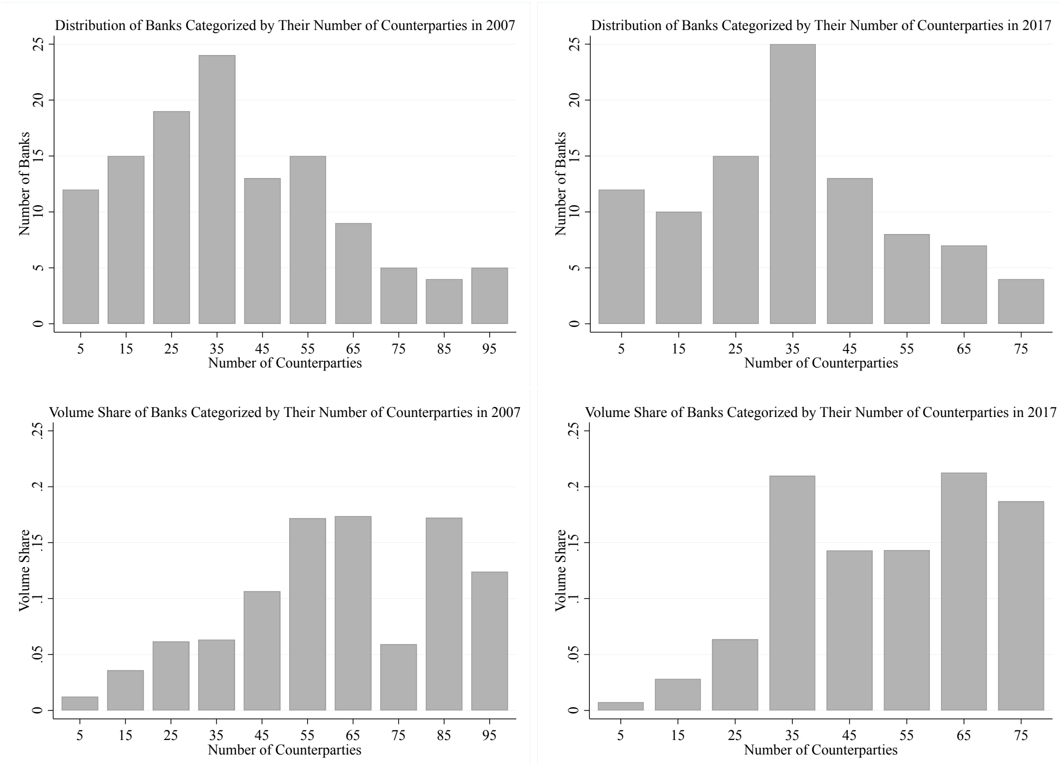
Our dataset covers the universe of trades in the Indonesian interbank market for the years 2006-2017. For each loan, the dataset includes information about the agreed-upon annualized nominal interest rate, the volume and maturity of the loan, a time stamp, the identity of the lending bank, and the identity of the borrowing bank.

Table 1 reports some summary statistics on the Indonesian interbank market over the years 2006-2017. The interbank market is large. On average, the trading volume in the market is close to 1 billion US dollars per business day, spread over approximately 135 bilateral loans. The interbank market is populated by a large and fairly stable number of banks. On average, the market is populated by more than 100 banks, with relatively low rates of entry and exit. The vast majority of loans are overnight. For this reason, we will only use overnight loans in the remainder of the analysis.

The top panels in Figure 4 contain histograms for the distribution of banks according to the number of distinct counterparties with which they trade in the years 2007 and 2017. Banks

[11] Banks can also choose to trade in the interbank market without the help of brokers. While we do not know the exact volume of trade that bypasses brokers, the traders with whom we talked told us that brokers are used about 95% of the time. Traders believe that brokers allow them to find better terms of trade and to meet their desired liquid position more quickly.

Figure 4: The Distribution of Banks by Number of Counterparties



Notes: The upper figures show the distribution of banks by their number of distinct counterparties for the respective year. The lower figures show the share of the annual transaction volume accounted for by each group.

are highly connected, with each bank trading with an average of 35 distinct counterparties in a given year. Yet, banks are very heterogeneous with respect to the number of their connections. Indeed, there is a 10% of banks that have between 1 and 10 counterparties, and a 5% of banks with more than 90 counterparties. The bottom panels in Figure 4 contain the distribution of banks' volume of trade according to the number of their counterparties. By comparing these panels with the top ones, one can see that banks with a small number of counterparties each have a relatively low trade volume, while banks with a large number of counterparties each have a relatively high trade volume.

5.3 Measuring Centrality

The first step of our empirical analysis is to rank banks by their centrality in the market. We consider four different measures of centrality. The first measure of centrality of bank i is its degree, which is defined as the number of different banks to which bank i lends in year t plus the number of different banks from which bank i borrows in year t. The second measure of centrality of bank i is its share of volume, which is defined as the sum of the volume of gross lending and gross borrowing of bank i in year t as a fraction of total volume of gross lending and borrowing in the market in year t. The third measure of centrality of bank i is its intermediation share. To compute it, we measure the minimum between the daily gross lending and gross borrowing of bank i and sum it across year t (bank i's intermediation). We then take the ratio to the sum of intermediation across all banks in the market in year t. The last measure of centrality of bank i is its betweenness. For each pair of nodes (banks) in a connected graph, there exists at least one path that minimizes the number of edges which constitute the path (shortest path). The betweenness of bank i is defined as the number of shortest paths that pass through i (Freeman, 1977).

The four measures of centrality capture the position of a bank in the market in different ways. The measures of centrality are highly correlated. In Table 4 in Appendix D, we report the raw correlation between the four measures, the Spearman's rank correlation of the banks' centrality, and the correlation between the banks' quartile of centrality. Yet, the four measures of centrality are not perfectly correlated. For this reason, we report our findings on the relationship between centrality and prices using each measure.

In Table 5 in Appendix D, we report the share of number of transactions between banks in different quartiles of the centrality distribution. The table shows that, according to all of our measures, more central banks are more likely trading partners for all types of banks (both peripheral and central). Yet, the table also shows that, according to all of our measures, a significant fraction of transactions takes place directly between peripheral banks.

Finally, in the empirical analysis, we measure centrality based on previous year trades. That is, what we call bank i's year t centrality is based entirely on trades in year $t-1$.[12]

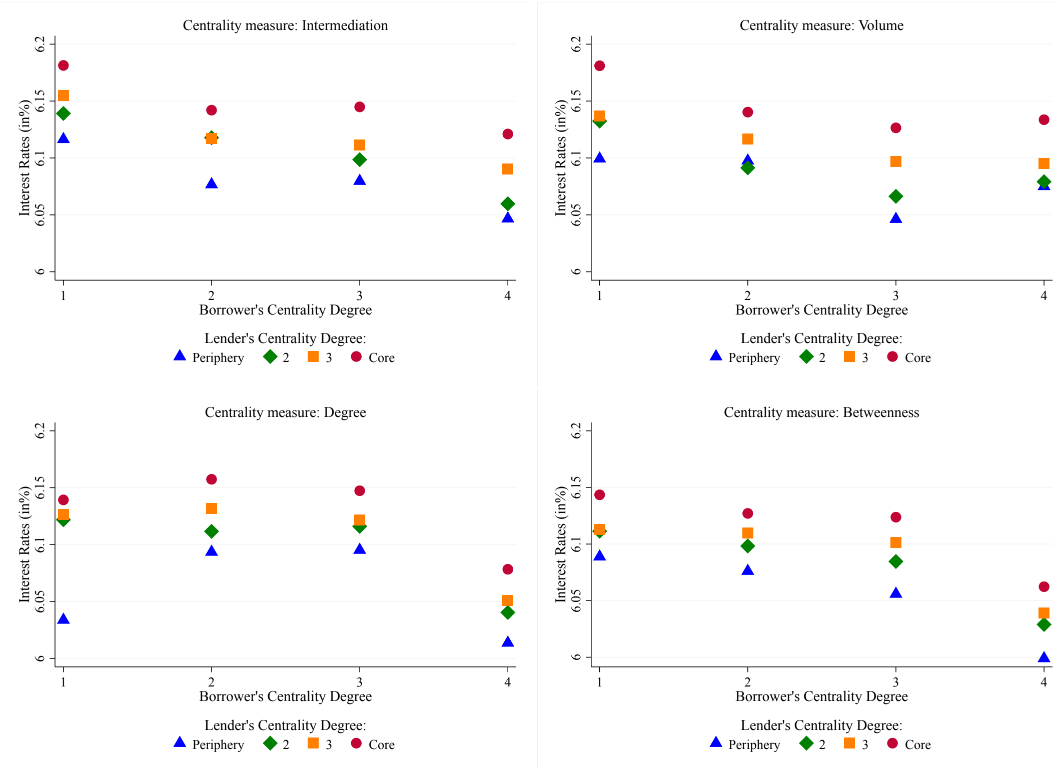
5.4 Centrality and Prices

The second step of our empirical analysis is to examine the relationship between the centrality of the two banks involved in a trade and the interest rate at which the trade is executed.

For each trading day d in year t, we construct the distribution of year-t centrality among the subset of banks that are actively borrowing or lending in day d. We assign each one of these banks to the centrality group $j = 1, 2, ..K$ if the bank falls in between the $(j-1)/K$-th and the j/K-th percentiles of the centrality distribution among banks active in day d. We group banks based on their position in the distribution of active banks in day d rather than in the distribution of all banks in year t as a way to control for the aggregate condition of the market. We then compute, for each day in the sample, the average nominal interest rate in trades between a borrower in group ℓ and a lender in group k. Finally, we take an unweighted average of these interest rates across all days for which we observe trades between banks in group k and banks

[12] We do so in order not to use any future information in the empirical analysis. Our results are robust to this choice because the centrality measures display a high degree of serial correlation.

Figure 5: Interest Rates across Centralities



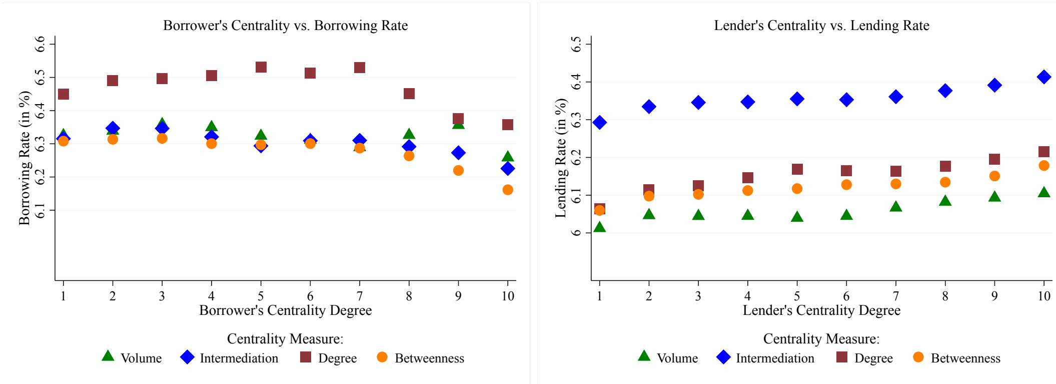
Notes: $K = 4$, see main text for construction of figure. Each panel uses a different centrality measure.

in group ℓ for all $(k,\ell) \in \{1,2,..K\}^2$.

Figure 5 plots the average nominal interest rates between a borrower in group ℓ and a lender in group k for $K = 4$. The bottom-right panel plots the average nominal interest rates computed using the betweenness measure of centrality. For any given the centrality group of the borrower, the average nominal interest rate is monotonically increasing in the centrality group of the lender. That is, a borrower (buyer) of any given centrality trades at a less favorable price with a more central lender (seller). Conversely, for a given centrality group of the lender, the average nominal interest rate is monotonically decreasing in the centrality of the borrower. That is, a lender (seller) of any given centrality trades at a less favorable price with a more central borrower (buyer). The same general pattern holds when we use the other measures of centrality (degree, volume share or intermediation share).

Figure 6 illustrates the average nominal interest rate for borrowers and lenders in group $k = 1,2,\ldots K$ for $K = 10$. As there are not many days with transactions for the 10^2 nominal interest rates for all possible combinations of borrowers' and lenders' groups, Figure 6 simply plots the nominal interest rate for borrowers in a given group averaged out across all counterparties (left panel), and the nominal interest rate for lenders in a given group averaged out across all counterparties (right panel). Figure 6 shows the same pattern as Figure 5. More central borrowers (buyers) tend to trade at lower interest rates (prices), while more central lenders

Figure 6: Interest Rates across Centralities



Notes: Identical to figure 5 but with ten centrality groups. Furthermore, here we pool across all lenders and only vary borrower centrality in the left plot and vice versa in the right plot.

(sellers) tend to trade at higher interest rates.

5.5 Regression Analysis

The last step of our empirical analysis is to make sure that the relationship between the centrality of lender and borrower involved in a trade and the nominal interest rate is not due to some correlation between the nominal interest rate and other characteristics of the trade, such as the calendar day, the time of the day, the volume of the trade, repeated interactions between lender and borrower etc... To account for such spurious correlation, we are going to run regressions of the nominal interest rate on the centrality of borrower and lender controlling for other features of the trade.

We start by running the following baseline regression

$$r_{i,j,\tau} = \alpha + \sum_{k=2}^{K} \beta_L^k \Psi_{i,t}^k + \sum_{\ell=2}^{K} \beta_B^\ell \Psi_{j,t}^\ell + \iota_{t,d} + \iota_h + \varepsilon_{i,j,\tau}. \tag{5.1}$$

The left-hand side variable $r_{i,j,\tau}$ denotes the annualized nominal interest rate for an overnight loan between lender i and borrower j at time stamp $\tau = \{t,d,h\}$, where t is the year, d is the day, and h is the hour at which the trade takes place. The right-hand side variable $\Psi_{i,t}^k$ denotes a dummy indicating whether the lender i belongs to the centrality group k, and $\Psi_{j,t}^\ell$ a dummy indicating whether the borrower j belongs to the centrality group ℓ. The variables $\iota_{t,d}$ and ι_h denote dummies for the calendar day and the hour at which the trade takes place.

We then run a version of (5.1) with additional controls. To control for the size of the loan, we include a third-order polynomial of the volume of the transaction between i and j. To control for the intensity of the trading relationship, we include the number of bilateral transactions between i and j, the number of consecutive years in which i and j have had at least one transaction, the share of i's annual lending to j, and the share of j's annual borrowing from i. Furthermore, we control for the total volume of lending by i and for the total volume of borrowing by j during the day of the transaction. We do so to alleviate concerns that banks might turn to more central counterparties on days in which they have high-buying or high-selling pressure. We also run a version of (5.1) in which we replace the borrower's dummy variable with an individual fixed-effect, and one in which we replace the lender's dummy variable with an individual fixed-effect.

Table 2 contains the regression results when we measure the centrality of a bank by its betweenness. For the baseline specification of (5.1), we find that the annualized nominal interest rate is 6 basis points higher in a transaction where the lender is from group 2 rather than from group 1 (the least central group); it is 7 basis points higher in a transaction where the lender is from group 3 rather than 1; and it is 10 basis points higher in a transaction where the lender is from group 4 (the most central group) rather than 1. Conversely, the annualized nominal interest rate is 2 basis points lower in a transaction where the borrower is from group 2 rather than 1; it is 3 basis points lower in a transaction where the borrower is from group 3 rather than 1; and it is 12 basis points lower in a transaction where the borrower is from group 4 rather than 1. Thus, even after controlling for calendar day and hour fixed effects, we find that the interest rate (price) monotonically increases with the centrality of the lender (seller) and monotonically decreases with the centrality of the borrower (buyer). The same is true when we add size and relationship controls (column 2), fixed-effects for the identity of the borrower (column 3) or for the identity of the lender (column 4). In Table 6, 7, and 8 in Appendix D, we show that the same findings hold when we use alternative measures of centrality. In Table 9, 10 11, and 12 in Appendix D, we show that the results are also robust when we regress the nominal interest rate on the centrality measure of borrower and lender, rather than on dummies for their centrality group.

Next, we run the following regression

$$r_{i,j,\tau} = \alpha + \sum_{k=1}^{K} \sum_{\ell=1}^{K} \beta_{k,\ell} \Psi_{i,j,t}^{k,\ell} + \iota_{t,d} + \iota_h + \varepsilon_{i,j,\tau}, \tag{5.2}$$

where $\Psi_{i,j,t}^{k,\ell}$ denotes a dummy indicating whether the lender i belongs to the centrality group k and borrower j belongs to the centrality group ℓ.[13] Compared with (5.1), the specification in (5.2) includes dummies for trades between the centrality group of the lender and the one of the borrower, rather than separately additive dummies for the centrality group of the lender and the borrower. For this reason, (5.2) is not affected by differences in the composition of the counterparties with whom a given type of lender or borrower trades.

Table 3 contains the regression results when we measure the centrality of a bank by its betweenness. Once again, we find that a lender in a given centrality group trades at a lower

[13] $i = 1, j = 1$ is the omitted category.

Table 2: Regression Results for Specification 5.1 with $K = 4$

VARIABLES	(1)	(2)	(3)	(4)
Group-2 Lender	0.06***	0.05***	0.02***	
	(0.00)	(0.00)	(0.00)	
Group-3 Lender	0.07***	0.06***	0.04***	
	(0.01)	(0.01)	(0.01)	
Group-4 Lender	0.10***	0.10***	0.07***	
	(0.01)	(0.01)	(0.01)	
Group-2 Borrower	-0.02**	-0.03***		-0.02***
	(0.01)	(0.01)		(0.01)
Group-3 Borrower	-0.03***	-0.05***		-0.03***
	(0.01)	(0.01)		(0.01)
Group-4 Borrower	-0.12***	-0.14***		-0.11***
	(0.01)	(0.01)		(0.01)
Lender's daily gross lending		-0.64***	-0.41***	-0.58***
		(0.08)	(0.07)	(0.11)
Lender's daily gross borrowing		0.63***	0.78***	0.53***
		(0.12)	(0.13)	(0.11)
Observations	359622	359622	359622	359622
Date FE	Yes	Yes	Yes	Yes
Hour FE	Yes	Yes	Yes	Yes
Size control	No	Yes	Yes	Yes
Relationship control	No	Yes	Yes	Yes
Borrower-year FE	No	No	Yes	No
Lender-year FE	No	No	No	Yes
Adjusted R^2	0.930	0.931	0.935	0.934

Notes: Column (1): Results for specification 5.1. Column (2): Additional size and relationship controls described in the main text. Columns (3) (and (4)): Borrower-year (Lender-year) fixed effects. Standard errors are clustered at the transaction-date level. Sample period: January 2006 to December 2017.

interest rate with a more central borrower and that a borrower in a given centrality group trades at a higher interest rate with a more central lender. This is true independently of the choice of control variables. As shown in Table 13, 14, and 15 in Appendix D, this is true if we use alternative measures of centrality.

As we explained at the beginning of this section and formally show in Appendix C, a simple benchmark model of intermediation is consistent with the fact that a given type of lender (seller) pays a lower nominal interest rate (price) when trading with a more central borrower (buyer) only when intermediation is driven by rent extraction. If it was instead driven by speed differences, as posited by the theory of intermediation as facilitating trade and other theories of intermediation as service provision, we should observe the opposite.

Our empirical findings simply discriminate between rent extraction and speed of trade as the exclusive drivers of intermediation. Presumably, in reality, more central intermediaries are both better negotiators and faster traders. What is clear from our findings, though, is that more central intermediaries must have more bargaining power as they end up purchasing assets at lower prices than less central ones. Clearly, it would be interesting to try and use both data on prices and trade volumes to recover the joint distribution of bargaining skills and velocity of trade across market participants.

6 Conclusions

In the first part of the paper, we advanced a novel theory of asset intermediation. In a population of traders who differ with respect to their bargaining skills, the equilibrium is such that agents with inferior skills act as final users and those with superior skills act as intermediaries. Intermediation is privately valuable because agents with superior skills can take positions from final users and unwind them at a better price than final users could. Intermediation, though, is socially useless as it does not improve the allocation of the asset among traders with different valuations for the asset. When agents can invest in bargaining skills, there are typically multiple equilibria created by a local strategic complementarity in the investment decisions. Equilibria differ with respect to the fraction of intermediaries in the market. Equilibria with more intermediaries have lower welfare and all equilibria with a positive fraction of intermediaries are inefficient, as all the resources invested in acquiring bargaining skills are a social waste. Surprisingly, when trading frictions become smaller, the return from acquiring bargaining skills increases and the fraction of intermediaries in the market rises. Even more surprisingly, welfare falls.

In the second part of the paper, we developed a simple empirical test to distinguish between our theory of intermediation as rent extraction and the standard theory of intermediation as

Table 3: Regression Results for Specification 5.2 with $K = 4$

VARIABLES	(1)	(2)
Group-1 Lender x Group-2 Borrower	-0.02**	-0.02***
	(0.01)	(0.01)
Group-1 Lender x Group-3 Borrower	-0.05***	-0.05***
	(0.01)	(0.01)
Group-1 Lender x Group-4 Borrower	-0.14***	-0.15***
	(0.01)	(0.01)
Group-2 Lender x Group-1 Borrower	0.05***	0.05***
	(0.01)	(0.01)
Group-2 Lender x Group-2 Borrower	0.03***	0.02**
	(0.01)	(0.01)
Group-2 Lender x Group-3 Borrower	0.01	-0.00
	(0.01)	(0.01)
Group-2 Lender x Group-4 Borrower	-0.07***	-0.10***
	(0.01)	(0.01)
Group-3 Lender x Group-1 Borrower	0.05***	0.05***
	(0.01)	(0.01)
Group-3 Lender x Group-2 Borrower	0.04***	0.03***
	(0.01)	(0.01)
Group-3 Lender x Group-3 Borrower	0.03**	0.02
	(0.01)	(0.01)
Group-3 Lender x Group-4 Borrower	-0.06***	-0.09***
	(0.01)	(0.01)
Group-4 Lender x Group-1 Borrower	0.08***	0.09***
	(0.01)	(0.01)
Group-4 Lender x Group-2 Borrower	0.06***	0.06***
	(0.01)	(0.01)
Group-4 Lender x Group-3 Borrower	0.06***	0.05***
	(0.01)	(0.01)
Group-4 Lender x Group-4 Borrower	-0.02***	-0.04***
	(0.01)	(0.01)
Lender's daily gross lending		-0.64***
		(0.08)
Lender's daily gross borrowing		0.63***
		(0.12)
Observations	359622	359622
Date FE	Yes	Yes
Hour FE	Yes	Yes
Size control	No	Yes
Relationship control	No	Yes
Adjusted R^2	0.930	0.931

Notes: Column (1): Results for specification 5.2. Column (2): Additional size and relationship controls described in the main text. Standard errors are clustered at the transaction-date level. Sample period: January 2006 to December 2017.

speed of trade. Our theory predicts that a particular seller gets a lower price when trading with a more central buyer. The standard theory predicts that a particular seller gets a higher price when trading with a more central buyer. We implemented the test using a novel dataset on the universe of transactions in the Indonesian interbank market for Central Bank reserves. In line with our theory, we found that lenders (sellers) of a given centrality trade at a lower interest rate (price) with borrowers (buyers) that are more central. These findings are not driven by volume nor by relationship lending.

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Appendix

A Uniqueness of Market Equilibrium

A stationary market equilibrium is symmetric if and only if $\mu_{i,L} = \nu_{i,H}$ for $i = \{S,T\}$. From the inflow-outflow conditions (3.15)-(3.16) and the fact that a potential buyer and a potential seller exchange the asset if and only if the gains from trade are positive, it follows that $\mu_{i,L} = \nu_{i,H}$ for $i = \{S,T\}$ if and only if agents of the same commitment type have the lowest and highest net valuations of the asset. Therefore, there are 8 possible patterns of trade that are consistent with the symmetry condition. These 8 possible patterns of trade are fully characterized by following chains of inequalities: (i) $D_{S,L} \leq D_{T,L} \leq D_{T,H} \leq D_{S,H}$; (ii) $D_{T,L} \leq D_{S,L} \leq D_{S,H} \leq D_{T,H}$; (iii) $D_{S,L} \leq D_{T,H} \leq D_{T,L} \leq D_{S,H}$; (iv) $D_{T,H} \leq D_{S,L} \leq D_{S,H} \leq D_{T,L}$; (v) $D_{S,H} \leq D_{T,L} \leq D_{T,H} \leq D_{S,L}$; (vi) $D_{S,H} \leq D_{T,H} \leq D_{T,L} \leq D_{S,L}$; (vii) $D_{T,L} \leq D_{S,H} \leq D_{S,L} \leq D_{T,H}$; (viii) $D_{T,H} \leq D_{S,H} \leq D_{S,L} \leq D_{T,L}$.

We first rule out the existence of a symmetric stationary equilibrium with $D_{S,H} \leq D_{S,L}$. This eliminates the equilibria (v)-(viii)..To this aim, note that in any equilibrium the lifetime utilities of an agent of type (S,L) who does and does not own the asset respectively satisfy

$$rV_{S,L} = u_L + \sigma\left(V_{S,H} - V_{S,L}\right) + \lambda_S \max\{D_{S,H} - D_{S,L}, 0\}/2. \tag{A.1}$$

$$rU_{S,L} = \sigma\left(U_{S,H} - U_{S,L}\right) + \hat{\lambda}_S \max\{D_{S,L} - D_{S,H}, 0\}/2. \tag{A.2}$$

The lifetime utilities of an agent of type (S,H) who does and does not own the asset respectively satisfy

$$rV_{S,H} = u_H + \sigma\left(V_{S,L} - V_{S,H}\right) + \hat{\lambda}_S \max\{D_{S,L} - D_{S,H}, 0\}/2. \tag{A.3}$$

$$rU_{S,H} = \sigma\left(U_{S,L} - U_{S,H}\right) + \lambda_S \max\{D_{S,H} - D_{S,L}, 0\}/2. \tag{A.4}$$

From (A.1)-(A.4), it follows that $D_{S,H} - D_{S,L}$ is given by

$$\begin{aligned}(r+2\sigma)\left(D_{S,H} - D_{S,L}\right) &= \Delta u - \lambda_S \max\{D_{S,H} - D_{S,L}, 0\} \\ &+ \hat{\lambda}_S \max\{D_{S,L} - D_{S,H}, 0\}.\end{aligned} \tag{A.5}$$

If $D_{S,H} \leq D_{S,L}$, (A.5) implies

$$D_{S,H} - D_{S,L} = \frac{\Delta u}{r + 2\sigma + \hat{\lambda}_S}. \tag{A.6}$$

The expression in (A.6) is clearly strictly positive. Therefore, if $D_{S,H} \leq D_{S,L}$, $D_{S,H} > D_{S,L}$ which is a contradiction. Therefore, in any market equilibrium $D_{S,H} > D_{S,L}$.

Next, we rule out the existence of a symmetric stationary equilibrium with $D_{T,H} \leq D_{T,L}$. This eliminates the equilibria (iii) and (iv). To this aim, note that in any equilibrium the lifetime utilities of an agent of type (T,L) who does and does not own the asset respectively satisfy

$$\begin{aligned} rV_{T,L} &= u_L + \sigma\left(V_{T,H} - V_{T,L}\right) + \lambda_S \max\{D_{S,H} - D_{T,L}, 0\} \\ &\quad + \hat{\lambda}_S \max\{D_{S,L} - D_{T,L}, 0\} + \lambda_T \max\{D_{T,H} - D_{T,L}, 0\}/2. \end{aligned} \tag{A.7}$$

and

$$\begin{aligned} rU_{T,L} &= \sigma\left(U_{T,H} - U_{T,L}\right) + \hat{\lambda}_S \max\{D_{T,L} - D_{S,H}, 0\} \\ &\quad + \lambda_S \max\{D_{T,L} - D_{S,L}, 0\} + \hat{\lambda}_T \max\{D_{T,L} - D_{T,H}, 0\}/2. \end{aligned} \tag{A.8}$$

Using (A.7)-(A.8) and the analogous expressions for an agent of type (T,H), we can show that $D_{T,H} - D_{T,L}$ is given by

$$\begin{aligned} & (r+2\sigma)\left(D_{T,H} - D_{T,L}\right) \\ = \; & \Delta u + \hat{\lambda}_T \max\{D_{T,L} - D_{T,H}, 0\} - \lambda_T \max\{D_{T,H} - D_{T,L}, 0\} \\ + \; & \lambda_S \max\{D_{S,H} - D_{T,H}, 0\} + \hat{\lambda}_S \max\{D_{S,L} - D_{T,H}, 0\} \\ - \; & \lambda_S \max\{D_{S,H} - D_{T,L}, 0\} - \hat{\lambda}_S \max\{D_{S,L} - D_{T,L}, 0\} \\ + \; & \lambda_S \max\{D_{T,L} - D_{S,L}, 0\} + \hat{\lambda}_S \max\{D_{T,L} - D_{S,H}, 0\} \\ - \; & \lambda_S \max\{D_{T,H} - D_{S,L}, 0\} - \hat{\lambda}_S \max\{D_{T,H} - D_{S,H}, 0\}. \end{aligned} \tag{A.9}$$

If $D_{TH} \leq D_{TL}$, we can rewrite (A.9) as

$$\begin{aligned} \left(r + 2\sigma + \hat{\lambda}_T\right)\left(D_{T,H} - D_{T,L}\right) &= \Delta u \\ &+ \lambda_S \left[\max\{D_{S,H} - D_{T,H}, 0\} - \max\{D_{S,H} - D_{T,L}, 0\}\right] \\ &+ \hat{\lambda}_S \left[\max\{D_{S,L} - D_{T,H}, 0\} - \max\{D_{S,L} - D_{T,L}, 0\}\right] \\ &+ \lambda_S \left[\max\{D_{T,L} - D_{S,L}, 0\} - \max\{D_{T,H} - D_{S,L}, 0\}\right] \\ &+ \hat{\lambda}_S \left[\max\{D_{T,L} - D_{S,H}, 0\} - \max\{D_{T,H} - D_{S,H}, 0\}\right]. \end{aligned} \tag{A.10}$$

Clearly, the second, third, fourth and fifth lines on the right-hand side of (A.10) are positive. The first line on the right-hand side of (A.10) is strictly positive. Therefore, if $D_{T,H} \leq D_{T,L}$, $D_{T,H} > D_{T,L}$ which is a contradiction. Therefore, in any market equilibrium $D_{T,H} > D_{T,L}$.

Finally, we rule out the existence of a symmetric stationary equilibrium with $D_{T,H} \leq D_{T,L}$. This eliminates the equilibrium (ii). To this aim, note that, using the expressions (A.1)-(A.4) and (A.7)-(A.8), we can write $D_{T,H} - D_{T,L}$ as

$$\begin{aligned} r\left(D_{T,L} - D_{S,L}\right) \quad &= \sigma\left(D_{T,H} - D_{T,L}\right) - \sigma\left(D_{S,H} - D_{S,L}\right) \\ &+ \lambda_T\left(D_{T,H} - D_{T,L}\right)/2 - \lambda_S\left(D_{S,H} - D_{S,L}\right)/2 \\ &+ \hat{\lambda}_S \max\{D_{S,L} - D_{T,L}, 0\} - \lambda_S \max\{D_{T,L} - D_{S,L}, 0\} \\ &+ \lambda_S \max\{D_{S,H} - D_{T,L}, 0\}. \end{aligned} \tag{A.11}$$

Note that the last line must be strictly positive, or else we would have $D_{S,L} < D_{S,H} \leq D_{T,L} < D_{T,H}$ which implies a non-symmetric distribution.[14] If $D_{T,L} \leq D_{S,L}$, $D_{S,H} \leq D_{T,H}$ and we can

[14]It is possible but tedious to show that this non-symmetric market equilibrium cannot exist either.

rewrite (A.11) as

$$
\begin{aligned}
& (r+\hat{\lambda}_S)\left(D_{T,L}-D_{S,L}\right) \\
= \; & \sigma\left(D_{T,H}-D_{T,L}\right)-\sigma\left(D_{S,H}-D_{S,L}\right) \\
+ \; & \lambda_T\left(D_{T,H}-D_{T,L}\right)/2-\lambda_S\left(D_{S,H}-D_{S,L}\right)/2+\lambda_S(D_{S,H}-D_{T,L}).
\end{aligned} \tag{A.12}
$$

In turn, (A.12) can be rewritten as

$$
\begin{aligned}
& (r+\hat{\lambda}_S)\left(D_{T,L}-D_{S,L}\right) \\
= \; & \sigma\left[\left(D_{T,H}-D_{T,L}\right)-\left(D_{S,H}-D_{S,L}\right)\right] \\
+ \; & \lambda_T\left(D_{T,H}-D_{T,L}\right)/2+\lambda_S\left(D_{S,H}-D_{S,L}\right)/2.
\end{aligned} \tag{A.13}
$$

Note that the right-hand side of (A.13) is strictly positive. Therefore, if $D_{T,L} \leq D_{S,L}$, $D_{T,L} > D_{S,L}$ which is a contradiction. Therefore, in any market equilibrium $D_{T,L} > D_{S,L}$.

B Inefficiency of Market Equilibrium

B.1 Transaction Cost

In the version of the model described in example 1 (transaction cost), we obtain the following expressions for the gains from trade:

$$D_{SH}-D_{SL}-c=\frac{\Delta u-2\sigma c}{r+2\sigma+\lambda_S}, \tag{B.1}$$

$$D_{TH}-D_{TL}-c=\frac{\Delta u-2\sigma c}{r+2\sigma+\lambda_T+2\lambda_S}, \tag{B.2}$$

$$D_{TL}-D_{SL}-c=D_{SH}-D_{TH}-c=\frac{1}{2}\frac{\Delta u-2\sigma c}{r+2\sigma+\lambda_S}\frac{\lambda_T+\lambda_S}{r+2\sigma+2\lambda_S+\lambda_T}. \tag{B.3}$$

It is immediate to verify that, for c small enough, the expressions in (B.1)-(B.3) are all strictly positive. Therefore, the equilibrium pattern of trade is the same as in Figure 1.

B.2 Richer Preferences

In the version of the model described in example 2 (richer preferences), we obtain the following expressions for the gains from trade:

$$D_{SH}-D_{SL}=\frac{\Delta u}{r+2\sigma+\lambda_S}, \tag{B.4}$$

$$D_{TH}-D_{TL}=\frac{\Delta u-\varepsilon}{r+2\sigma+\lambda_T+2\lambda_S}, \tag{B.5}$$

$$D_{TL}-D_{SL}=D_{SH}-D_{TH}=\frac{1}{2}\left[\frac{\Delta u\left(\lambda_T+\lambda_S\right)}{r+2\sigma+2\lambda_S}-\varepsilon\right]\frac{1}{r+2\sigma+2\lambda_S+\lambda_T}. \tag{B.6}$$

It is immediate to verify that, for ε small enough, the expressions in (B.4)-(B.6) are all strictly positive. Therefore, the equilibrium pattern of trade is the same as in Figure 1.

B.3 Heterogeneity in Contact Rates

In the version of the model described in example 3 (heterogeneity in contact rates), we obtain the following expressions for the gains from trade:

$$D_{SH} - D_{SL} = \frac{\Delta u}{r + 2\sigma + \lambda_S} > 0, \tag{B.7}$$

$$D_{TH} - D_{TL} = \frac{\Delta u}{r + 2\sigma + \omega(\lambda_T + 2\lambda_S)} > 0, \tag{B.8}$$

$$D_{TL} - D_{SL} = D_{SH} - D_{TH} = \frac{1}{2}\left[\frac{\Delta u \omega(\lambda_T + 2\lambda_S) - \lambda_s}{r + 2\sigma + 2\lambda_S}\right]\frac{1}{r + 2\sigma + \omega(2\lambda_S + \lambda_T)}. \tag{B.9}$$

It is immediate to verify that, for ω close enough to 1, the expressions in (B.7)-(B.9) are all strictly positive. Therefore, the equilibrium pattern of trade is the same as in Figure 1.

C Empirical Test

C.1 Intermediation as Speed of Trade

First, let us derive some implications for the relationship between prices and the speed of trade of the intermediaries. Consider an environment in which an intermediary meets final buyers and final sellers at the rate λ. Let V_S and U_S denote, respectively, the value of holding and not holding the asset for a final seller. Similarly, let V_B and U_B denote the value of holding and not holding the asset for a final buyer. Assume that $D_B \equiv V_B - U_B$ is greater than $D_S \equiv V_S - U_S$. Let V_I and U_I denote the value of holding and not holding the asset for an intermediary and let $D_I \equiv V_I - U_I$ For the sake of simplicity, assume that the intermediary gets a flow payoff of 0 from holding the asset.

The value V_I of holding the asset for an intermediary is such that

$$rV_I = \lambda\left[p_B + U_I - V_I\right], \tag{C.1}$$

where p_B is the price at which the intermediary sells the asset to a final buyer. The price p_B equally divides the gains from trade between the intermediary and the final buyer, i.e.

$$p_B = \frac{1}{2}(D_B + D_I). \tag{C.2}$$

The value U_I of not holding the asset for an intermediary is

$$rU_I = \lambda\left[V_I - U_I - p_S\right], \tag{C.3}$$

where p_S is the price at which the intermediary buys the asset from a final seller. The price p_S equally splits the gains from trade between the intermediary and the final seller, i.e.

$$p_S = \frac{1}{2}(D_I + D_S). \tag{C.4}$$

Substituting the prices into the value functions, we obtain:

$$rV_I = \frac{\lambda}{2}(D_B - D_I), \; rU_I = \frac{\lambda}{2}(D_I - D_S), \tag{C.5}$$

$$D_I = \frac{\lambda}{2(r+\lambda)}(D_B + D_S). \tag{C.6}$$

Replacing D_I into the price p_S, we get

$$p_S = \frac{1}{2}\left[\frac{1}{2}\frac{\lambda}{r+\lambda}D_B + \frac{1}{2}\frac{\lambda}{r+\lambda}D_S + D_S\right] \tag{C.7}$$

The derivative of p_S with respect to the speed of trade of the intermediary is

$$\frac{dp_S}{d\lambda} = \frac{1}{2}\left[\frac{1}{2}\frac{r}{(r+\lambda)^2}D_B + \frac{1}{2}\frac{r}{(r+\lambda)^2}D_S\right] > 0. \tag{C.8}$$

Therefore, a final seller trades the asset at a higher price from an intermediary that has a higher speed of trade λ. Since, intermediaries with a higher λ are more central in a version of the model with multiple types of intermediaries, it follows that a final seller trades the asset at a higher price from a more central intermediary.

Replacing D_I into the price p_B, we get

$$p_B = \frac{1}{2}\left[\frac{1}{2}\frac{\lambda}{r+\lambda}D_B + \frac{1}{2}\frac{\lambda}{r+\lambda}D_S + D_B\right] \tag{C.9}$$

The derivative of p_B with respect to the speed of the intermediary λ is

$$\frac{dp_B}{d\lambda} = \frac{1}{2}\left[\frac{1}{2}\frac{r}{(r+\lambda)^2}D_B + \frac{1}{2}\frac{r}{(r+\lambda)^2}D_S\right] > 0. \tag{C.10}$$

Therefore, a final buyer purchases the asset at a higher price from an intermediary that has a higher speed of trade and, hence, is more central.

C.2 Intermediation as Rent Extraction

Now, let us derive some implications for the relationship between prices and the rent extraction ability of intermediaries, as measured by the fraction $\gamma > 1/2$ of the gains from trade that they capture.

The value V_I of holding the asset for an intermediary is

$$rV_I = \lambda\left[p_B + U_I - V_I\right]. \tag{C.11}$$

The price p_B assigns to the intermediary a fraction $\gamma > 1/2$ of the gains from trade between the intermediary and the final buyer, i.e.

$$p_B = \gamma D_B + (1-\gamma)D_I, \tag{C.12}$$

The value U_I of not holding the asset for an intermediary is

$$rU_I = \lambda\left[V_I - U_I - p_S\right], \tag{C.13}$$

The price p_S assigns to the intermediary a fraction γ of the gains from trade between the intermediary and the final seller, i.e.

$$p_S = \gamma D_S + (1-\gamma)D_I. \tag{C.14}$$

Substituting the prices into the value functions, we obtain:

$$rV_I = \lambda\gamma[D_B - D_I],\ rU_I = \lambda\gamma[D_I - D_S], \tag{C.15}$$

$$D_I = \frac{\lambda\gamma}{r+2\lambda\gamma}\left[D_B + D_S\right]. \tag{C.16}$$

Replacing D_I into the price p_S at which the final seller trades the asset to the intermediary, we get

$$p_S = \gamma D_S + \frac{\lambda\gamma(1-\gamma)}{r+2\lambda\gamma}\left[D_B + D_S\right] \tag{C.17}$$

The derivative of p_S with respect to the bargaining power γ of the intermediary is

$$\begin{aligned} \frac{dp_S}{d\gamma} &= D_S + \frac{\lambda(1-2\gamma)(r+2\lambda\gamma) - 2\lambda^2\gamma(1-\gamma)}{(r+2\lambda\gamma)^2}\left[D_B + D_S\right] \\ &= D_S - \frac{r\lambda(2\gamma-1) + 2\lambda^2\gamma^2}{(r+2\lambda\gamma)^2}\left[D_B + D_S\right] \\ &\simeq D_S - \tfrac{1}{2}\left[D_B + D_S\right] < 0, \end{aligned} \tag{C.18}$$

where the third line is an approximation for $r \simeq 0$. Therefore, a final seller trades the asset at a lower price from an intermediary that has more bargaining power γ. Since, intermediaries with a higher γ are more central in a version of the model with multiple types of intermediaries, it follows that a final seller trades the asset at a lower price from a more central intermediary.

Replacing D_I into the price p_B at which the final buyer purchases the asset from an interme-

Table 4: Average Cross Sectional Correlation between Different Centrality Measures

Continuous	Betweenness	Intermediation	Volume	Degree
Betweenness	1			
Intermediation	.61	1		.
Volume	.58	.68	1	
Degree	.69	.55	.75	1

Spearman's rank correlation	Betweenness	Intermediation	Volume	Degree
Betweenness	1			
Intermediation	.66	1		.
Volume	.53	.82	1	
Degree	.80	.82	.79	1

By 4 group	Betweenness	Intermediation	Volume	Degree
Betweenness	1			
Intermediation	.61	1		.
Volume	.47	.79	1	
Degree	.74	.77	.74	1

Notes: The average cross correlations of the four different centrality measures used throughout the empirical part. The cross sectional correlation is computed every year and the table reports the simple time-series average of the correlations.

diary, we get

$$p_B = \gamma D_B + \frac{\lambda\gamma(1-\gamma)}{r+2\lambda\gamma}\left[D_B + D_S\right]. \tag{C.19}$$

The derivative of p_B with respect to the bargaining power of the intermediary is

$$\begin{aligned} \frac{dp_B}{d\gamma} &= D_B + \frac{\lambda(1-2\gamma)(r+2\lambda\gamma) - 2\lambda^2\gamma(1-\gamma)}{(r+2\lambda\gamma)^2}\left[D_B + D_S\right] \\ &\simeq D_B - \frac{1}{2}\left[D_B + D_S\right] > 0. \end{aligned} \tag{C.20}$$

Therefore, a final buyer purchases the asset at a higher price from an intermediary that has more bargaining power and, hence, is more central.

D Additional Summary Statistics and Reduced Form Results

Table 5: Transaction Distribution across Centralities

	Share of number of transactions with counterparties in				Share of transaction volume with counterparties in			
	Grp. 1	Grp. 2	Grp. 3	Grp. 4	Grp. 1	Grp. 2	Grp. 3	Grp. 4
Betweenness								
Most Periphery	3%	14%	24%	58%	3%	13%	24%	60%
Group 2	4%	13%	27%	56%	3%	12%	27%	58%
Group 3	6%	15%	26%	53%	5%	14%	25%	57%
Most Central	7%	16%	29%	49%	5%	14%	28%	53%
Intermediation								
Most Periphery	8%	20%	22%	50%	7%	17%	22%	55%
Group 2	7%	16%	28%	50%	5%	12%	27%	56%
Group 3	5%	12%	24%	59%	4%	9%	22%	65%
Most Central	6%	11%	27%	56%	4%	7%	24%	65%
Volume								
Most Periphery	22%	23%	21%	34%	18%	20%	22%	39%
Group 2	8%	14%	21%	56%	5%	11%	20%	64%
Group 3	3%	10%	23%	64%	2%	7%	21%	71%
Most Central	2%	10%	21%	67%	1%	5%	17%	77%
Degree								
Most Periphery	8%	15%	22%	54%	7%	14%	21%	58%
Group 2	4%	11%	24%	61%	3%	9%	22%	66%
Group 3	3%	13%	22%	62%	3%	10%	19%	68%
Most Central	4%	12%	24%	61%	2%	9%	21%	69%

Notes: For each year, banks are divided into four equal-sized groups based on their centrality. For each bank and each year, their annual transactions are divided into four groups based on the counterparties' centrality. Next, each bank's share of transactions with each group is computed. Next, in each year, the shares are averaged across banks within a group. Lastly, the shares in each group are averaged across years.

Table 6: Regression Results for Specification 5.1 with $K = 4$ (Intermediation)

VARIABLES	(1)	(2)	(3)	(4)
Group-2 Lender	0.04***	0.02***	0.01***	
	(0.00)	(0.00)	(0.00)	
Group-3 Lender	0.07***	0.05***	0.04***	
	(0.01)	(0.01)	(0.01)	
Group-4 Lender	0.10***	0.08***	0.07***	
	(0.01)	(0.01)	(0.01)	
Group-2 Borrower	-0.04***	-0.06***		-0.04***
	(0.01)	(0.01)		(0.01)
Group-3 Borrower	-0.05***	-0.08***		-0.07***
	(0.01)	(0.01)		(0.01)
Group-4 Borrower	-0.10***	-0.14***		-0.12***
	(0.01)	(0.01)		(0.01)
Lender's daily gross lending		-0.60***	-0.40***	-0.58***
		(0.08)	(0.07)	(0.11)
Lender's daily gross borrowing		0.70***	0.79***	0.58***
		(0.11)	(0.13)	(0.10)
Observations	359622	359622	359622	359622
Date FE	Yes	Yes	Yes	Yes
Hour FE	Yes	Yes	Yes	Yes
Size control	No	Yes	Yes	Yes
Relationship control	No	Yes	Yes	Yes
Borrower-year FE	No	No	Yes	No
Lender-year FE	No	No	No	Yes
Adjusted R^2	0.930	0.931	0.935	0.934

Notes: Column (1): Results for specification 5.1. Column (2): Additional size and relationship controls described in the main text. Columns (3) (and (4)): Borrower-year (Lender-year) fixed effects. Standard errors are clustered at the transaction-date level. Sample period: January 2006 to December 2017.

Table 7: Regression Results for Specification 5.1 with $K = 4$ (Volume)

VARIABLES	(1)	(2)	(3)	(4)
Group-2 Lender	0.02***	-0.00	0.02***	
	(0.00)	(0.00)	(0.00)	
Group-3 Lender	0.05***	0.04***	0.05***	
	(0.01)	(0.01)	(0.01)	
Group-4 Lender	0.07***	0.07***	0.08***	
	(0.01)	(0.01)	(0.01)	
Group-2 Borrower	-0.02***	-0.03***		-0.04***
	(0.01)	(0.01)		(0.01)
Group-3 Borrower	-0.05***	-0.08***		-0.09***
	(0.01)	(0.01)		(0.01)
Group-4 Borrower	-0.03***	-0.06***		-0.08***
	(0.01)	(0.01)		(0.01)
Lender's daily gross lending		-0.66***	-0.46***	-0.58***
		(0.09)	(0.08)	(0.11)
Lender's daily gross borrowing		0.57***	0.79***	0.55***
		(0.10)	(0.13)	(0.10)
Observations	359622	359622	359622	359622
Date FE	Yes	Yes	Yes	Yes
Hour FE	Yes	Yes	Yes	Yes
Size control	No	Yes	Yes	Yes
Relationship control	No	Yes	Yes	Yes
Borrower-year FE	No	No	Yes	No
Lender-year FE	No	No	No	Yes
Adjusted R^2	0.930	0.930	0.935	0.934

Notes: Column (1): Results for specification 5.1. Column (2): Additional size and relationship controls described in the main text. Columns (3) (and (4)): Borrower-year (Lender-year) fixed effects. Standard errors are clustered at the transaction-date level. Sample period: January 2006 to December 2017.

Table 8: Regression Results for Specification 5.1 with $K = 4$ (Degree)

VARIABLES	(1)	(2)	(3)	(4)
Group-2 Lender	0.08***	0.07***	0.03***	
	(0.01)	(0.00)	(0.00)	
Group-3 Lender	0.10***	0.09***	0.06***	
	(0.01)	(0.01)	(0.01)	
Group-4 Lender	0.12***	0.13***	0.09***	
	(0.01)	(0.01)	(0.01)	
Group-2 Borrower	0.03***	0.01**		-0.01
	(0.01)	(0.01)		(0.01)
Group-3 Borrower	0.03***	0.01*		-0.01
	(0.01)	(0.01)		(0.01)
Group-4 Borrower	-0.07***	-0.11***		-0.11***
	(0.01)	(0.01)		(0.01)
Lender's daily gross lending		-0.70***	-0.45***	-0.59***
		(0.08)	(0.08)	(0.11)
Lender's daily gross borrowing		0.63***	0.78***	0.56***
		(0.11)	(0.13)	(0.11)
Observations	359622	359622	359622	359622
Date FE	Yes	Yes	Yes	Yes
Hour FE	Yes	Yes	Yes	Yes
Size control	No	Yes	Yes	Yes
Relationship control	No	Yes	Yes	Yes
Borrower-year FE	No	No	Yes	No
Lender-year FE	No	No	No	Yes
Adjusted R^2	0.931	0.931	0.935	0.934

Notes: Column (1): Results for specification 5.1. Column (2): Additional size and relationship controls described in the main text. Columns (3) (and (4)): Borrower-year (Lender-year) fixed effects. Standard errors are clustered at the transaction-date level. Sample period: January 2006 to December 2017.

Table 9: Regression Results for Specification 5.1 with Continuous Centrality (Betweenness)

VARIABLES	(1)	(2)	(3)	(4)
Lender’s centrality	1.17***	1.15***	0.78***	
	(0.10)	(0.10)	(0.10)	
Borrower’s centrality	-2.32***	-2.68***		-2.55***
	(0.17)	(0.24)		(0.26)
Lender’s daily gross lending		-0.59***	-0.16**	-0.34***
		(0.08)	(0.08)	(0.12)
Lender’s daily gross borrowing		0.66***	0.91***	0.57***
		(0.12)	(0.14)	(0.12)
Observations	359622	359622	359622	359622
Date FE	Yes	Yes	Yes	Yes
Hour FE	Yes	Yes	Yes	Yes
Size control	No	Yes	Yes	Yes
Relationship control	No	Yes	Yes	Yes
Borrower-year FE	No	No	Yes	No
Lender-year FE	No	No	No	Yes
Adjusted R^2	0.930	0.931	0.934	0.932

Notes: Column (1): Results for specification 5.1. Column (2): Additional size and relationship controls described in the main text. Columns (3) (and (4)): Borrower-year (Lender-year) fixed effects. Standard errors are clustered at the transaction-date level. Sample period: January 2006 to December 2017.

Table 10: Regression Results for Specification 5.1 with Continuous Centrality (Intermediation)

VARIABLES	(1)	(2)	(3)	(4)
Lender's centrality	0.42***	0.27***	0.19***	
	(0.05)	(0.04)	(0.05)	
Borrower's centrality	-1.12***	-1.34***		-1.23***
	(0.09)	(0.11)		(0.11)
Lender's daily gross lending		-0.49***	-0.10	-0.33***
		(0.07)	(0.08)	(0.12)
Lender's daily gross borrowing		0.60***	0.91***	0.49***
		(0.11)	(0.14)	(0.11)
Observations	359622	359622	359622	359622
Date FE	Yes	Yes	Yes	Yes
Hour FE	Yes	Yes	Yes	Yes
Size control	No	Yes	Yes	Yes
Relationship control	No	Yes	Yes	Yes
Borrower-year FE	No	No	Yes	No
Lender-year FE	No	No	No	Yes
Adjusted R^2	0.930	0.931	0.934	0.932

Notes: Column (1): Results for specification 5.1. Column (2): Additional size and relationship controls described in the main text. Columns (3) (and (4)): Borrower-year (Lender-year) fixed effects. Standard errors are clustered at the transaction-date level. Sample period: January 2006 to December 2017.

Table 11: Regression Results for Specification 5.1 with Continuous Centrality (Volume)

VARIABLES	(1)	(2)	(3)	(4)
Lender's centrality	1.23***	1.36***	1.17***	
	(0.16)	(0.20)	(0.25)	
Borrower's centrality	-1.59***	-3.05***		-4.33***
	(0.22)	(0.23)		(0.28)
Lender's daily gross lending		-0.69***	-0.26**	-0.32***
		(0.09)	(0.10)	(0.11)
Lender's daily gross borrowing		0.73***	0.91***	0.76***
		(0.10)	(0.14)	(0.11)
Observations	359622	359622	359622	359622
Date FE	Yes	Yes	Yes	Yes
Hour FE	Yes	Yes	Yes	Yes
Size control	No	Yes	Yes	Yes
Relationship control	No	Yes	Yes	Yes
Borrower-year FE	No	No	Yes	No
Lender-year FE	No	No	No	Yes
Adjusted R^2	0.930	0.931	0.934	0.932

Notes: Column (1): Results for specification 5.1. Column (2): Additional size and relationship controls described in the main text. Columns (3) (and (4)): Borrower-year (Lender-year) fixed effects. Standard errors are clustered at the transaction-date level. Sample period: January 2006 to December 2017.

Table 12: Regression Results for Specification 5.1 with Continuous Centrality (Degree)

VARIABLES	(1)	(2)	(3)	(4)
Lender's centrality	0.33***	0.38***	0.19***	
	(0.02)	(0.03)	(0.03)	
Borrower's centrality	-0.26***	-0.38***		-0.49***
	(0.02)	(0.03)		(0.04)
Lender's daily gross lending		-0.78***	-0.23***	-0.36***
		(0.08)	(0.09)	(0.11)
Lender's daily gross borrowing		0.61***	0.90***	0.57***
		(0.11)	(0.14)	(0.12)
Observations	359622	359622	359622	359622
Date FE	Yes	Yes	Yes	Yes
Hour FE	Yes	Yes	Yes	Yes
Size control	No	Yes	Yes	Yes
Relationship control	No	Yes	Yes	Yes
Borrower-year FE	No	No	Yes	No
Lender-year FE	No	No	No	Yes
Adjusted R^2	0.930	0.931	0.934	0.932

Notes: Column (1): Results for specification 5.1. Column (2): Additional size and relationship controls described in the main text. Columns (3) (and (4)): Borrower-year (Lender-year) fixed effects. Standard errors are clustered at the transaction-date level. Sample period: January 2006 to December 2017.

Table 13: Regression Results for Specification 5.2 with $K = 4$ (Intermediation)

VARIABLES	(1)	(2)
Group-1 Lender x Group-2 Borrower	-0.06***	-0.07***
	(0.01)	(0.01)
Group-1 Lender x Group-3 Borrower	-0.06***	-0.09***
	(0.01)	(0.01)
Group-1 Lender x Group-4 Borrower	-0.11***	-0.14***
	(0.01)	(0.01)
Group-2 Lender x Group-1 Borrower	0.03***	0.02***
	(0.01)	(0.01)
Group-2 Lender x Group-2 Borrower	0.00	-0.02**
	(0.01)	(0.01)
Group-2 Lender x Group-3 Borrower	-0.03***	-0.07***
	(0.01)	(0.01)
Group-2 Lender x Group-4 Borrower	-0.08***	-0.13***
	(0.01)	(0.01)
Group-3 Lender x Group-1 Borrower	0.06***	0.05***
	(0.01)	(0.01)
Group-3 Lender x Group-2 Borrower	0.02**	-0.01
	(0.01)	(0.01)
Group-3 Lender x Group-3 Borrower	0.01	-0.03**
	(0.01)	(0.01)
Group-3 Lender x Group-4 Borrower	-0.03**	-0.09***
	(0.01)	(0.01)
Group-4 Lender x Group-1 Borrower	0.07***	0.07***
	(0.01)	(0.01)
Group-4 Lender x Group-2 Borrower	0.04***	0.02
	(0.01)	(0.01)
Group-4 Lender x Group-3 Borrower	0.05***	0.01
	(0.01)	(0.01)
Group-4 Lender x Group-4 Borrower	-0.00	-0.06***
	(0.01)	(0.01)
Lender's daily gross lending		-0.59***
		(0.08)
Lender's daily gross borrowing		0.70***
		(0.11)
Observations	359622	359622
Date FE	Yes	Yes
Hour FE	Yes	Yes
Size control	No	Yes
Relationship control	No	Yes
Adjusted R^2	0.930	0.931

Notes: Column (1): Results for specification 5.2. Column (2): Additional size and relationship controls described in the main text. Standard errors are clustered at the transaction-date level. Sample period: January 2006 to December 2017.

Table 14: Regression Results for Specification 5.2 with $K = 4$ (Volume)

VARIABLES	(1)	(2)
Group-1 Lender x Group-2 Borrower	-0.00	-0.01
	(0.01)	(0.01)
Group-1 Lender x Group-3 Borrower	-0.07***	-0.10***
	(0.01)	(0.01)
Group-1 Lender x Group-4 Borrower	-0.01	-0.03***
	(0.01)	(0.01)
Group-2 Lender x Group-1 Borrower	0.04***	0.02***
	(0.01)	(0.01)
Group-2 Lender x Group-2 Borrower	-0.01	-0.04***
	(0.01)	(0.01)
Group-2 Lender x Group-3 Borrower	-0.04***	-0.08***
	(0.01)	(0.01)
Group-2 Lender x Group-4 Borrower	-0.01	-0.05***
	(0.01)	(0.01)
Group-3 Lender x Group-1 Borrower	0.05***	0.04***
	(0.01)	(0.01)
Group-3 Lender x Group-2 Borrower	0.04***	0.01
	(0.01)	(0.01)
Group-3 Lender x Group-3 Borrower	0.01	-0.03***
	(0.01)	(0.01)
Group-3 Lender x Group-4 Borrower	0.02	-0.03**
	(0.01)	(0.01)
Group-4 Lender x Group-1 Borrower	0.07***	0.09***
	(0.01)	(0.01)
Group-4 Lender x Group-2 Borrower	0.05***	0.04***
	(0.01)	(0.01)
Group-4 Lender x Group-3 Borrower	0.03***	0.00
	(0.01)	(0.01)
Group-4 Lender x Group-4 Borrower	0.05***	0.01
	(0.01)	(0.01)
Lender's daily gross lending		-0.66***
		(0.09)
Lender's daily gross borrowing		0.57***
		(0.10)
Observations	359622	359622
Date FE	Yes	Yes
Hour FE	Yes	Yes
Size control	No	Yes
Relationship control	No	Yes
Adjusted R^2	0.930	0.930

Notes: Column (1): Results for specification 5.2. Column (2): Additional size and relationship controls described in the main text. Standard errors are clustered at the transaction-date level. Sample period: January 2006 to December 2017.

Table 15: Regression Results for Specification 5.2 with $K = 4$ (Degree)

VARIABLES	(1)	(2)
Group-1 Lender x Group-2 Borrower	0.08***	0.07***
	(0.01)	(0.01)
Group-1 Lender x Group-3 Borrower	0.10***	0.08***
	(0.01)	(0.01)
Group-1 Lender x Group-4 Borrower	-0.04***	-0.07***
	(0.01)	(0.01)
Group-2 Lender x Group-1 Borrower	0.15***	0.13***
	(0.01)	(0.01)
Group-2 Lender x Group-2 Borrower	0.13***	0.11***
	(0.01)	(0.01)
Group-2 Lender x Group-3 Borrower	0.15***	0.12***
	(0.01)	(0.01)
Group-2 Lender x Group-4 Borrower	0.04***	-0.00
	(0.01)	(0.01)
Group-3 Lender x Group-1 Borrower	0.16***	0.15***
	(0.01)	(0.01)
Group-3 Lender x Group-2 Borrower	0.16***	0.14***
	(0.01)	(0.01)
Group-3 Lender x Group-3 Borrower	0.16***	0.14***
	(0.01)	(0.01)
Group-3 Lender x Group-4 Borrower	0.07***	0.03***
	(0.01)	(0.01)
Group-4 Lender x Group-1 Borrower	0.16***	0.18***
	(0.01)	(0.01)
Group-4 Lender x Group-2 Borrower	0.19***	0.18***
	(0.02)	(0.02)
Group-4 Lender x Group-3 Borrower	0.18***	0.17***
	(0.01)	(0.01)
Group-4 Lender x Group-4 Borrower	0.09***	0.07***
	(0.01)	(0.01)
Lender's daily gross lending		-0.70***
		(0.08)
Lender's daily gross borrowing		0.62***
		(0.11)
Observations	359622	359622
Date FE	Yes	Yes
Hour FE	Yes	Yes
Size control	No	Yes
Relationship control	No	Yes
Adjusted R^2	0.931	0.931

Notes: Column (1): Results for specification 5.2. Column (2): Additional size and relationship controls described in the main text. Standard errors are clustered at the transaction-date level. Sample period: January 2006 to December 2017.