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FROM THE LAB

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Director's Message
Finn Kydland

This issue covers two anniversaries. One is the 5th-anniversary conference on Advances in Macro-Finance. When we started this series of annual conferences, we were not aware of any other conference even remotely like it. These days it's more common to see conferences combining these two areas, which we regard as very much interrelated. The conferences are organized in co-operation with Carnegie Mellon's Tepper School of Business. This last one took place in Pittsburgh. In the tradition of doing two in Pittsburgh, one in Santa Barbara, and so on, the next one, scheduled for middle of September 2015, will be held in Santa Barbara. Part of the format has been, to the extent possible, to pair authors to discussants with different backgrounds (macroeconomics and finance), with senior academics discussing the work of junior colleagues.

An important anniversary was that related to money as a medium of exchange. Twenty-five years ago, Nobu Kiyotaki and Randy Wright published a paper that introduced a new approach, based on search theory, into monetary economics. In this approach, agents in the model trade with each other, and not simply against their budget lines. This framework allows one to ask how they trade - using barter, commodity or fiat money, secured or unsecured credit, etc. Over the last twenty-five years much progress has been made in the area, applying and extending the original model on many dimensions. This conference provided an opportunity to look back at what has been done, and to look forward to where monetary economics is likely go. Organizers of the conference were Ricardo Lagos, NYU, and Peter Rupert, UCSB.

The macro-finance conference focused on research on the relationship between asset prices and macroeconomic fundamentals. Topics included, but were not limited to, production economies; exotic preferences; time variation in expected returns; learning; and the pricing of currencies, commodities and sovereign debt. The conference organizers were Brent Glover and Ariel Zetlin-Jones, both assistant professors at Carnegie Mellon University.

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On Money as a Medium of Exchange: KW at 25!

AUGUST 6-8, 2014

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Central Bank Purchases of Private Assets

Stephen D. Williamson

In this paper, Williamson characterizes the effect that government purchases of mortgage-backed securities might have on the incentives for households and banks to exchange mortgages. He allows both households and banks to fake the quality of their assets (their house in the case of the individuals, and mortgages in the case of the banks), and sees the extent to which these activities change when the government institutes a program to purchase mortgages. He first explores how behavior changes in response to conventional monetary policy, before moving to private asset purchases. He shows that while government activity may cause more agents in the economy to fake the quality of their collateral (houses or mortgages), these policies can still be welfare improving by increasing the quantity of collateral in the economy.

Williamson adapts the model of Lagos and Wright (2005) to address the change in behavior due to changes in monetary policy. Time is discrete, and each time period is divided into two sub-periods, a "centralized" market (CM), and a "decentralized" market (DM). In the economy, there are a set of buyers and sellers; the buyers purchase goods from sellers in the DM and often require either currency or credit for these purchases, and produce goods for the sellers in the CM. Buyers in this economy make deposits to banks in exchange for the option of withdrawing currency at the end of the CM or receiving a payout in the next period. In addition to deposits, these buyers have the option of mortgaging their homes as collateral. Buyers can choose to "fake" part of the value of their houses in order to receive more credit or currency to spend in the DM. This causes banks to require each household to take a "haircut" on their assets, which in this context means borrowing less than the full value of their collateral. At the end of the CM in each time period, buyers are told whether they are required to use currency for all exchanges in the DM and then are given the option of withdrawing money from their deposits and mortgages at the bank. Banks play the role of maximizing the expected utility of their depositors. In order to do this, they attempt to expand their balance sheets so that they can pay larger dividends. Like households, they have the option of inflating the value of their mortgage holdings by faking the quality of these assets, which may require them to take a haircut on the value of their holdings. The central bank has control over the nominal interest rate, and the purchase of mortgage-backed securities from banks when they are performing quantitative easing.

In equilibrium, both banks and households may fake the quality of their assets, depending upon whether their incentive constraints bind. In order for these constraints to matter, it must be the case that the quantity of collateral available in the economy is low enough to require agents to mortgage their houses to obtain the optimal quantity of consumption in the DM. In equilibrium, if either incentive constraint binds, there will be a spread between the real interest rate and the rate of return on mortgages. When monetary policy drives down the real interest rate, both households and banks will be more likely to fake the quality of their assets. This is because the price of houses will increase, so households can borrow more and banks can increase the size of their balance sheets. In addition, if the cost of faking for either the household or the bank is low, their respective incentive constraints will be more likely to bind. By lowering the interest rate, conventional monetary policy can serve to aggravate these incentive constraints and force households and banks to take a larger haircut in order to be ensure that they are not faking their mortgages. Quantitative easing, however, may either be neutral or beneficial, depending upon the state of the economy. By purchasing longer-term securities (mortgage-backed securities in this case), the central bank can increase the aggregate collateral in the economy and increase overall welfare for the case in which both incentive constraints bind. Of interest, these purchases actually increase the likelihood that households and banks fake (or take a larger haircut) the quality of their collateral. However, by increasing overall collateral, the central bank offsets this effect and increases welfare.

The audience seemed concerned about whether or not this actually reflected financial markets. Williamson agreed that there might be some concerns about the assumption and what kinds of things the banks can see. Audience members were also confused by the presence of three nominal assets, to which Williamson noted that they are only setting the interest rate and the rest is endogenous. On a more basic level, the audience didn't believe that anyone thought that these asset programs would induce anything other than incentive problems. ◆

Dynamic Indeterminacy and Welfare in Credit Economies

Zach Bethune, Tai-Wei Hu and Guillaume Rocheteau

In this paper, the authors explore and characterize the equilibria of a pure credit economy with random matching under incomplete information. They note that many current papers restrict their trading assets to credit under the assumption that record-keeping has become so good that banks can ignore limited commitment. They argue that these are important frictions and have implications for the equilibria of the economy. Their paper first completely characterizes the set of equilibria of pure credit economies under innocuous assumptions. Then, they characterize the constrained-efficient allocations of an economy that exhibits these features.

In the model, time is discrete, with each period subdivided into a decentralized and centralized market. In the decentralized market, buyers make take-it-or-leave-it offers to the sellers, who are the producers of non-storable goods valued by the buyers. These meetings in the DM are random: that is, buyers search for sellers and sellers search for buyers, and match at some exogenous rate. The CM is a standard Walrasian market. In order to facilitate trade in the DM, buyers require that sellers furnish credit that will be repaid in the CM. As an enforcement mechanism, sellers publicly record loan amounts in the DM and the repayment status in the CM, and make this information available to all other sellers. Each buyer makes a decision about what to offer, based upon his own history of trades, as well as whether to repay in the CM. The seller faces only one decision: whether or not to accept the terms of the trade. They restrict their analysis to

perfect Bayesian equilibria such that equilibria strategies do not depend on private histories, that all identical buyers adopt the same strategies, and that there is some bound on the amount of debt offered in equilibria.

They show that credit equilibria can arise if loans aren't so big that agents choose to deviate and enter autarky permanently. This is equivalent to having a sequence of debt limits small enough that buyers prefer to retain the ability to borrow. They show that a sufficient condition for a credit equilibrium is that the gain in utility from being able to exchange in the DM plus the capital gain associated with a change in the debt limit must be larger than the flow value of continuing to pay the debt. If this weren't the case, buyers would be incentivized to deviate. This definition allows both "too-tight" debt and "not-too-tight" debt while still retaining a credit equilibria, depending upon whether the incentive constraint binds. If the constraint does not bind, agents would prefer more debt to increase consumption in the DM, and would still be incentivized to repay. With this logic, they argue that there are a number of equilibria as long as the debt limit is low enough that agents continue to repay. They further show that there can be periodic equilibria of any length when the debt limit in other periods is low enough so as to not induce agents to deviate. They then relate these results to monetary economies and show that when there is monitoring the equilibria of a monetary economy are a strict subset of the credit economy. That is, all of the equilibria resulting from the monetary economy are feasible in the credit economy, while only a subset are true in reverse. Finally, they show that for economies in which the propensity to renege is low enough (i.e. agents aren't too impatient), the first-best is implementable by the planner. For the case in which they will renege under large debt limits, the best option is to set the debt limit at the "not-too-tight" level such that the incentive compatibility constraint just binds.

One audience member noted that he didn't think the debt limit should be taken exogenously—that instead it should be a market outcome. He argued that if there is an inefficiency, it is because the market is doing a bad job here. Rocheteau noted that what they are doing is subgame perfect, but that they are taking it as given. Another thought it was strange that lack of complete repayment could be caused by the actions of the creditor rather than the buyer. The presenter argued that this was sensible, since others would be able to see that the loan was too large and not the fault of the buyer. ◆

A Mechanism Design Approach to Financial Frictions

Nobuhiro Kiyotaki

In this paper, Kiyotaki shows how mechanism design by an intermediaries can lead to different environments under informational frictions. He first discusses a benchmark with public information about income and savings, and full commitment to credit contracts. He contrasts this with outcomes under private information over income, savings, and both together, as well as limited commitment and limited commitment in conjunction with the previous informational frictions. He demonstrates that the mechanism imposed by the financial intermediary can often cause the economy to exhibit consumption behavior similar to the permanent income hypothesis.

The basic environment can be described as a three period endowment economy. In the first period, agents agree to an insurance contract with the financial intermediary that involves sharing resources with other agents in the economy. In the second period, each agent receives an idiosyncratic income shock (high or low) and makes savings decisions, potentially making or receiving transfers from the financial intermediary. In the last period, all agents receive the same income, which is more than the low-income shock, but less than the high-income shock, and potentially a transfer from the intermediary, and then consume their total income plus savings. In the benchmark case, agent's income and savings is known, and they are able to fully commit to a contract with the intermediary in the first period. He then explores the environment that results when individual income is private information, but all else is as in the benchmark case. From there, he allows private information about both individual income and saving ("storage" in the paper). Next, he turns to limited commitment environments. First, he considers limited commitment to the contracts in the first period. Second, he looks at the outcome when full private information and limited commitment is present in the economy.

Under public information and full commitment, each agent smoothes consumption by using transfers from the intermediary and their own savings. Agents who receive a high income shock in the first period agree (and do) to transfer some of their resources to low income agents. Thus, each agent in the economy consumes the same in both periods, and the economy can be described as Arrow-Debreu. When agents are able to keep information about their level of income private, high-income agents are induced to lie about their level of income in the first period. Because savings is public knowledge, high income agents are restricted to saving like a low income agent in order to receive the subsidy in the first period. A "credit-like" environment emerges under the mechanism, as the intermediary finds it optimal to reduce incomes in the second period in order to prevent high income agents from pretending to be low-income. Under private information in both income and savings, the intermediary finds it optimal to disallow transfers of wealth across agents. This is because the high-type would always find it optimal to pretend to be the low-income type and receive at least one transfer. The mechanism provides a foundation for a "permanent income theory of consumption," by showing that each type smoothes. When limited commitment is included, agents are only required to return a fixed fraction of their income in the case in which they are the high-income type in the first period. The intermediary transfers the enforceable resources from the high type to the low-type, resulting in another permanent income environment for the high-type. All "pledgeable" wealth is allocated to the low-income agents. Finally, when both limited commitment and private information are included, the environment becomes remarkable similar to the environment with just private information. The intermediary cannot cross-subsidize agents, as the high-income agent will always find it optimal to disguise themselves as the low-type. The result is that high-income agents smooth their

consumption by saving, while the low-income agent borrows from their future income in order to consume more in the current period. This results in what Kiyotaki describes as "the permanent income theory of consumption with borrowing constraints."

One audience member argued that he thought the mechanism in the private information cases was simply punishing the poor in order to keep the rich in line. Kiyotaki noted that this interpretation wasn't entirely true, since the poor agents were still better off with partial insurance than no insurance at all even though the actions of the rich agent were negatively impacting them. Another took issue with the contract formulation, saying that the pricing was almost certainly non-linear, but had been restricted to be linear. ◆

Monetary Policy with Asset-Backed Money

David Andolfatto, Aleksander Berentsen and Christopher Waller

In this paper, Waller and his co-authors develop a model in which asset-backed money is used as a medium of exchange. In previous models, a real asset could be used as a medium of exchange, provided that its fundamental value was sufficiently high. When this wasn't the case, fiat money could be introduced in order to alleviate the resulting liquidity premium and move the economy closer to the first-best allocation. In other words, because it would be challenging to find a buyer for a real asset with low fundamental value, money would be welfare improving. The authors show, however, that a carefully designed dividend policy on the real asset makes it possible to alleviate these liquidity frictions and remove the need for fiat money to achieve the first best. Under some general restrictions, an intermediary that sells claims on dividends produced by capital can in many situations achieve the first best outcome without the need for fiat money. Of interest, they find that the optimal policy requires an analog to inflation, which is difficult to find in standard monetary models.

Their basic model follows Aruoba and Wright (2003), except that they allow for a policy rule such that fiat money is no longer necessary. There are two markets: a decentralized market that the authors denote as the "AM" market, and a centralized market called the "PM" market. Agents sequentially move from one market to the other, consuming a distinct non-storable good in each. In the AM market, agents are randomly assigned to one of three states: consumption, production or idling. Each producer creates a good that is exchanged with a consumer. Disutility from production creates an optimal level of quantity exchanged in this market. In the PM market, agents are given the option to purchase a claim to dividends produced by an intermediary. This intermediary owns all of the capital in the economy, sells claims, and has the option to charge a fee for the withdrawal of dividends by consumers. Agents can work for this intermediate firm and receive a wage, and then use money or wages to pay for PM consumption in a centralized market. In the AM market, consumers can pay for the non-storable good by trading claims to these dividends. Producers accept these claims and then return to the PM market to consume the PM good either by working or paying with these claims.

Because agents have quasilinear preferences, they will choose to enter the "AM" market with the same money holdings. As in previous papers, they show that if the fundamental value of money is high enough (which is equivalent to a large enough capital stock in this economy), a first best allocation is possible without intervention. What this means is that in the AM market, the quantity of goods exchanged are efficient and in the PM market, the level of capital is also efficient. If, however, the value is not high enough then producers in the AM market will be unwilling to sell the efficient amount of the AM good, because the dividend they will receive from these claims in the PM market will be small. This will result in the same suboptimal allocation described by previous papers when a real asset is used as a means of exchange. Instead of using fiat money, Waller and his co-authors allow the intermediary to adjust its dividend, inflation, and fee policies so that some economies can achieve first best. The intermediary implements a fee for withdrawing dividends and uses the proceeds to increase those same dividends. They show that under some conditions on optimal capital and preference parameters, paying such a fee will be voluntary, as the dividend will increase by enough to justify the fee being paid. In further contrast to previous work, they find that inflation of the asset-backed money can be optimal. If the value of money is low, then the agency must pay a high dividend in order to compensate AM producers for reaching the optimal production level; to do this, their optimal policy involves selling more claims during each period and distributing the proceeds among claimholders. Should this be true, inflation of the currency by the intermediary achieves the first best outcome, unlike previous papers in which a deflationary policy called the Friedman Rule was optimal.

The audience was very confused about how to think about the private firm that dispensed the dividends. They wanted to know whether or not it was appropriate to think about this as a central bank changing the rate of inflation. Waller said that you could think about the firm as a central bank, but that it was more general than that. In fact, he argued that this shows that a private firm could manage currency and achieve the first-best. Others wanted to know what distinguished the claim on the firm's production from fiat money, and Waller noted that there wasn't really a distinction. Another argued that the policy of the firm was just a Ponzi scheme. Waller pointed out that this wasn't quite correct, since there must be guaranteed future income. ◆

Search Theoretical Models of Money and Finance: An Integrated Approach

Alberto Trejos and Randall Wright

In their paper, Trejos and Wright show that two leading models of money and finance can be nested. The first model, known as the Shi-Trejos-Wright (STW), is a "second generation" model of monetary search that attempts to describe the ways in which individuals exchange money for goods. The second model, Duffie-Garleanu-Pederson (DGP), is a model of asset exchange in finance. Each, however, is simply a different way of modeling liquidity in a financial market. While neither model can be nested into the other, Trejos and Wright show that they are both special cases of a more general search formulation of financial markets. They argue that integrating the two approaches allows for the tools already

developed in one line of research to be applied to the other, and vice-versa.

Both models are in continuous time, wherein each agent can hold an indivisible asset. Each is a search model in which agents use assets as a source of liquidity. The asset is in fixed supply and in DGP yields a dividend of either high or low, which is unique to each agent. Agents also face the possibility of changing this dividend status over time. Agents in DGP obtain utility by trading with an agent of the opposite type: when a "low" type agent has an asset, they sell it to the high type. In STW, this asset yields a fixed dividend that agents receive each period. Instead, agents exchange the asset for production of a specialized good. When agents meet in this market, the bargain over quantity exchanged (in the case of STW), and price (in the case of DGP). Thus, different valuation in DGP serves to facilitate trade, while the need for liquidity serves the same purpose in STW. In order to integrate both models into the same framework, they allow the dividend to vary and considers the changes in quantities exchanged. By just varying the dividend, they are able to replicate the results of both models in a more general way.

They also introduce both models in a standard general equilibrium framework. They change to discrete time and require agents to sequentially trade in an OTC market and a competitive market. In the Walrasian Market, agents make decisions about how much to consume and how much of the asset to carry into the decentralized OTC market. They also receive dividend payments from holding the asset in the Walrasian Market. In the OTC market, some agents match randomly by searching to agents of the opposite type (buyer to seller, etc.). Initially, they restrict payoffs to be constant across types, as in STW, but they show that by allowing the payoff types to differ and be assigned at the beginning of the OTC market, this emulates DGP.

First considering the STW model, they show that when money is allowed a dividend (positive or negative), under some conditions the money will circulate. If the dividend is too negative, individuals are unwilling to take it in exchange for goods; if it is too positive, buyers are unwilling to use it to purchase goods. Turning to the DGP model, they extend it to include concave utility, which causes the model to exhibit multiple equilibria. They show that in the case of linear utility, the model can only exhibit one equilibrium. This nonlinearity also results in different trading patterns for agents, namely that some with high valuation of assets might trade their assets to agents with a low valuation (which would never occur in standard DGP), based upon their trading position. In the integrated model, as the high dividend falls, the high and low dividend individuals start trading and the model replicates DGP; as the high dividend approaches the low dividend, all agents start trading when they differ in their asset positions and it begins to replicate STW.

One audience member expected that when liquidity was endogenous it would become more valuable when liquidity decreased. Trejos said that he expected a similar result as well, but that the model didn't exhibit such an equilibrium. Another wanted to know if the model could exhibit an equilibrium in which agents would hold assets even if they were bad because they expected higher prices in the future. Trejos said that a similar equilibrium does exist in the case in which many agents are trading. ◆

Money and Credit Redux

Randall Wright, Chao Gu and Fabrizio Mattesini

In this paper, Wright and his co-authors characterize the conditions under which both credit and money can exist in New Monetarist models. For a broad range of mechanisms, they show that in monetary economies, for both credit and money to exist, it must be that credit crowds out money one-for-one. They extend their initial analysis to economies with endogenous debt and inflation policies, and show that these results still hold. From there, they show that even under extensions that might break their results, they still hold except for very extreme cases. They argue that these results imply that all monetary models with money and credit should check to see if both are essential in their models.

They employ the Lagos and Wright (2005) framework that allows for a degenerate distribution of money holdings. This makes it possible to do analysis without conditioning on the entire distribution of money holdings. Like Lagos and Wright, their model has a decentralized market (DM), and a centralized market (CM). Each agent is assigned permanently to be either a buyer or a seller, and plays their assigned roles while matching randomly in the DM. When a buyer and a seller match, sellers offer buyers a quantity of the DM good that they can buy for a price that they can pay with using either money or credit (debt). All participants can observe the liquidity position of the buyer and a price-quantity pair is offered by the general trading mechanism. In the CM, buyers work for a general consumption good and to repay any debts incurred during the DM. In addition, buyers can choose to carry money to the DM. Sellers in this period exchange their money for consumption. They then consider these mechanisms under limited commitment, stochastic monitoring, and general terms of trade.

Given a monetary policy and exogenous debt limit in the economy, agents will choose how much money to carry to the DM and determine the quantity exchanged between buyers and sellers. For low enough liquidity levels, the quantity exchanged will decrease as the interest increases. This is because inflation operates as an implicit tax on money holders, making agents less willing to take money in the DM. When debt limits are high enough, agents will consume the optimal amount in the DM. Because of the presence of a changing money supply, agents always prefer to purchase goods in the DM with credit, and because of this credit crowds out money one-for-one when debt limits are increased in the exogenous policy and debt regime. In other words, credit is neutral and strictly preferred to money unless the Friedman Rule, a particular form of deflation that equates the rate of return across assets. Thus, a monetary equilibrium can only exist for the situation in which quantity exchanged in the DM is less than the optimum; otherwise, it must be the case that the debt limit is high enough to support all agents carrying no money to the DM. Next, they turn to endogenizing the debt limit and the inflation policy. To do this, they allow agents to attempt not to pay their debt and tax obligations. Since a tax rebate is linked to inflationary monetary policy (the rebate is funded by inflating the money supply), and vice versa, the required interest rate is determined by the extent to which agents can shirk on their debt

obligations. The main result still holds under this specification, that credit is inessential, and changes in credit are neutral. They then turn to types of heterogeneity that may break the neutrality result. In particular, they show that when shocks are introduced ex ante in order to make the quantity exchanged in the DM random, both credit and money are essential. This proxies the situation in which agents may make small purchases with money in the DM, but large purchases with credit. They also show that when credit monitoring is random and varies by agent, then both credit and money are again essential.

One audience member noted that the paper basically said that money and credit played the same role, but that this doesn't appear to be exactly the case in reality. Wright said that they didn't want to make one better than the other by making them used for different purchases. Another argued that it's unreasonable to assume that individuals can observe money holdings in bilateral meetings. Wright agreed, but said that he thought the results were without loss of generality. ◆

Short-Run Dynamics in a Search-Theoretic Model of Monetary Exchange

Jonathan Chiu and Miguel Molico

Since the seminal work of Kiyotaki and Wright (1989), a large amount of research has been devoted to develop a series of micro-founded monetary models using a random-matching framework. By explicitly modeling the role for money as a medium of exchange, the literature has successfully addressed many theoretical questions related to monetary policy. However, due to technical difficulties, the literature mostly focused on the long-run steady state analysis, leaving the short-run dynamics and implications not fully explored and understood. The paper by Chiu and Molico contributed to the search-theoretical literature by analyzing the short-run dynamics of a random-matching model of money, in which agents are subject to both idiosyncratic liquidity shocks and aggregate monetary shocks. It shows that monetary policy has redistributive effects and persistent effects on output and prices: aggregate shocks will propagate and diffuse gradually as the money distribution adjusts over time.

Miguel started the presentation by briefly introducing the model environment, which is built on his 2006 paper. A continuum of infinitely lived agents specialize in consumption and production of goods, and engage in decentralized trading in the form of random pairwise matching. Agents are faced with idiosyncratic trading risks, as well as aggregate monetary shocks in money growth rate. They are unable to insure against idiosyncratic risks due to market frictions that generate the role of money, which is assumed to be perfectly divisible, and costlessly storable object that cannot be produced or consumed by any individual agent. For the individual agent, the relevant state variables is his holdings of money and the aggregate states, including both the aggregate shock and the law of motion of the distribution of money holdings. Taking the law of motion of the distribution of money holdings as given, individuals optimize lifetime utility. And the law of motion is endogenously determined in the recursive equilibrium.

Then, Miguel specified the numerical algorithm to characterize the equilibrium, which is the main focus of the presentation. Because the state vector includes the entire distribution of money holding, which is an infinite-dimensional object, solving the heterogeneous model with a continuum of agents constitutes a challenging technical problem. Therefore, the paper took the Krusell and Smith (1998) strategy of summarizing the cross-section distribution by a small number of moments in order to make the dimension of the state space more tractable. Moreover, since the agents in the model have to form an expectation of the potential gains from trade in order to solve their problem, the model needs to compute the expected gain from trade given the random matching, which increases the number of moments that the model keeps track of. Therefore, the authors' solution is to first adopt the parameterization of the cross-section distribution from Algan et al (2007) and then add the "reference moments" according to Reiter (2002). In this way, they obtain a better characterization of the cross-sectional distribution without increasing the number of state variables. Thereby, the algorithm goes by (1) computing the reference moments given value function and law of motion; (2) computing cross-sectional distribution to match the computed reference moments; (3) updating the value function; and (4) updating the law of motion. The algorithm iterates until convergence. At the end, Miguel went over numerical exercises about the short-term effects of monetary policies, including an unanticipated inflation shock as well as a change in the long-run inflation target. Both show persistent effects on output, prices and welfare economy.

During the presentation, a participant asked whether the equilibrium is stationary. Miguel responded that they don't focus on the stationary equilibrium but on a transitional dynamics across states in this paper. At the numerical algorithm part of presentation, Prof. Kiyotaki inquired about the reference moments. In particular, he asked which moments are used as reference moments, mean, variance or some higher order moments. Miguel made it clear that for the example in the paper, mean is fixed, variance is used as state variable, and 3rd and 5th-order moments of the distribution are used as reference moments. Then, Prof. Kiyotaki made a suggestion that they could try the quantile statistics of the distribution as reference moments instead of some higher-order moments. ◆

A Search-Theoretic Model of the Term Premium

Athanasios Geromichalos, Lucas Herrenbrueck and Kevin Salyer

Motivated by empirical evidence of positive term premia of bond yields and failure of expectation hypothesis of the term structure, the authors extend the modern monetary theory model based on Lagos and Wright (2005). It is conceptually related to Lagos (2010). Rather than identifying the term premium as a risk premium and employing consumption-based CAPM in analysis, the paper quantifies the term premium from the view of liquidity by introducing assets with different maturities and over-the-counter (OTC) market to characterize search and bargaining. The main results predict an upward sloping yield curve, in the sense that long term assets need to

compensate more for illiquidity. This matches the empirical observations in bond markets.

In the story of the paper, there are 3 ways to store wealth: money, three-month bond, and six-month bond. First two ways are great for liquidity and the last two are good for storage of values. The framework is a discrete time infinite horizon model; periods are divided into three: secondary asset market, decentralized goods market, and centralized market. A unique feature of the model is the introduction of the OTC market to trade assets with different maturities to meet different needs of liquidity. After consumption shocks, consumers learn future consumption plan and go to OTC market for liquidity. Those consumers who will consume in decentralized market will sell illiquid assets if they don't have enough to rebalance their liquidity, while those who won't consume are the providers of liquidity. This formalizes the suggestion of Duffie, Garleanu and Pedersen (2005). In the presentation, Geromichalos illustrates the case with assets with two maturities, he also mentions that general cases will share similar spirits.

After establishing the optimal assets holding choices of agents in the model and define the steady-state symmetric equilibrium, the author then characterizes propositions of the equilibrium. The key parameter is the supply of short term assets. There two cases to explore. First, supply of short term assets is plentiful, short term assets alone are enough to satisfy liquidity needs of the economy; there is no role for money an OTC market. Second, if supply of short term assets is insufficient, money will play a role. Equilibrium real balance will be suboptimal. Long term assets price will include two types of liquidity premia: as future's short term assets, and as a way to avoid carrying cost of liquid assets.

The paper also concludes that yield curve is upward sloping and the source is that higher yield from long term assets comes from relative lack of liquidity. Another result discusses the effect of secondary market liquidity on assets returns; yield curve is steeper for assets that trade in less liquid secondary markets. The authors also compare on-the-run and off-the-run prices; cheaper price of old assets reflects demand of liquidity.

One conference participant is concerned about the micro-foundation of the model. It seems to him that some assets in certain market are not tangible; only currency rather than other asset claims is recognized in decentralized good market. The participant argues that people trading at OTC market are different from those trading bonds at decentralized good market. The participant then raise the question why the decentralized good market cannot trades claims of entries in the spreadsheet. Maybe it is in the model as if short term assets are also traded in decentralized good market. The author emphasizes that allowing trades of short term assets in decentralized good market will have different results and this is not allowed due to the model assumptions. The model assumes such friction to exist in the decentralized good market. He agrees that micro-foundation for asset trading in a market is crucial and modeling market structure should be clear. ◆

Rehypothecation

David Andolfatto, Fernando Martin and Shengxing Zhang

Hypothecation refers to the use of collateral by a borrower to secure a loan, while rehypothecation refers to the use of the same collateral by the lender to secure a different loan. By granting rehypothecation right, liquidity allocation can be more efficient. Motivated by the possible welfare improvement, the authors explore theoretical implications of a legal restriction that limits the practice of rehypothecation in a standard general equilibrium model, which has not be formalized in current literatures before. In their models, the authors try to analyze welfare effects by comparing economies with and without rehypothecation regulations.

In their story, the authors introduce workers with output and bankers with cash and assets. The environment setting includes three subperiods, morning, afternoon and evening, in the discrete time model. Afternoon is segmented into early and late. All agents realize a random shock to determine whether to go to early or late market and early bankers are paired off with late bankers in partnerships. Market segmentation assumes that early bankers needs only cash while late bankers needs both cash and assets to trade output with workers. Due to Illiquidity of assets in early afternoon, trade between different types of bankers is thus possible and maybe welfare-improving. Such medium of exchange becomes necessary when markets are lacking in commitment and trading histories, due to anonymity in the model.

As there are incentives for early bankers to trade assets for cash, a natural configuration of liquidity reallocation features more assets and less cash for late bankers, which looks like a repo where early bank borrows cash and lend assets. Equivalent interpretation of the amount of assets lent includes the amount of borrowed assets that the late banker can reuse, or the amount of rehypothecation. Motivated by SEC Rule 15c3-3 in jurisdiction, the paper includes a regulation parameter to reflect tightness of regulation on rehypothecation. When the authors characterize the stationary equilibrium, several cases are discussed based on whether regulation is allowed and whether regulation constraint is binding or not when markets are regulated.

For economies with prohibited repyothecation, the authors conclude that rehypothecation typically increases welfare due to increase in output in general. For economies with binding regulation, output in early afternoon will increase while output in late afternoon as well as output price will decrease, relative to the case with unbinding regulatory constraint. Through these predictions from the model, attention goes to the effect of tightness of regulation, inflation and welfare. Friedman rule is derived here as the optimal policy like most monetary models. What is interesting is the role of rehypothecation in economies with different inflation. When inflation is low, rehypothecation plays no role to improve welfare. When inflation is high, away from Friedman rule, liquidity provided only by cash is constrained. Rehypothecation as a way to allocate liquidity thus allows flow of assets in exchange for cash to support demand of loan. It is as if cash constraint is relaxed thus welfare can be improved.

One participant raise a question why there is no intertemporal trade between early and late afternoon market or why these two markets are segmented. The authors explain that in the economy described, bankers and workers who trade in either early or late afternoon are anonymous and lack of commitment. The early bankers' trade of assets for cash with late bankers, from an outsider's point of view, looks like a collateralized cash loan, even if they have trust with each other and demand for assets from cash lender may be just for rehypothecation.

Another question is about the assumption of bankers' partnership. One participant says the treatment seems non-standard and asks for the reason for this treatment. The authors say that maximizing joint welfare of the bankers is due to the embedded game of assigning liquidity in the model. Another participant comments that this setup can be interpreted as maximizing an ex ante trade contract, much close to a liquidity insurance model. ◆

Heterogeneity in Decentralized Asset Markets

Julien Hugonnier, Benjamin Lester and Pierre-Olivier Weill

Walrasian paradigm assumes that all trades occur instantaneously at a single price. However, instead of being traded in a Walrasian market, many assets along with many durable goods are traded in decentralized markets, where (1) investors have to search in order to find counterparty; (2) once they find a potential trading partner, they must attempt to determine the terms of trade bilaterally. A recent literature has emerged that uses search and bargaining models to capture these features of a decentralized market. However, in order to keep the models simple and tractable, nearly all existing papers only focused on the cases where investors switch between two valuation type. The two-type restriction comes at a cost that models are silent on heterogeneity across individual investors' trading experiences, such as the likelihood they are holding a sub-optimal portfolio and the time it takes them to find a suitable counterparty for trade etc. The paper by Hugonnier, Lester and Weill make their contribution to the literature by allowing for an arbitrary distribution of types and characterizing the unique equilibrium in closed form both in and out of steady state.

Ben started the presentation with a brief introduction of the economic environment. The model adopts the main building blocks of Duffie, Garleanu and Pedersen (2005). It is assumed that there is a continuum of agents in the economy and a fixed measure of indivisible share of an asset. Agents have heterogeneous valuations for this asset, which is assumed to be an independently identically distributed (i.i.d.)draw from an arbitrary distribution over time. And they are allowed to hold either zero or one share. Each agent is periodically and randomly matched with one another, and a transaction ensues if there are gains from trade, with prices being determined by Nash bargaining.

To continue, Ben presented the benchmark equilibrium outcome in a centralized and frictionless setting. Then, he returns to the model with search frictions and provides a closed-form characterization of the unique equilibrium, in and out of steady state, for an arbitrary distribution of valuations. Since the state variables of the model economy include two infinite-dimensional dynamic distributions of valuation types among agents who hold zero and one assets, Ben also presented a two-step derivation methodology to solve for equilibrium in a closed form. The first step is to derive agents' reservation value using Bellman equations taking the joint distribution of asset holdings as given. The second step is to derive the joint distribution of asset holdings taking the rule of trading as given. Then, a unique equilibrium is obtained by combining the two steps. The equilibrium showed that despite a random search model setting, the trading patterns are not random in that assets are always passed along quickly from those with low valuations and then exchanged more slowly as the owners' valuation increases. Agents with "closed-to-marginal" valuations tend to specialize in intermediation, buying from agents with lower valuation and selling to those with higher valuation, which leads to an endogenous "core-periphery" trading network. At the end, Ben showed as the search friction vanishes, the equilibrium converges to the Walrasian frictionless benchmark.

At the beginning part of model environment description, Randall asked whether the model can relax the assumption of the i.i.d. draw of agents' valuation type, and accommodate a more generalized case. Ben admitted that they haven't considered the more generalized case but it could be a direction to go. As the presentation flowed to the effect of search frictions on the equilibrium, several participants had questions about why speed of convergence matters as the search frictions vanish, i.e. the arrival rate of the trading opportunities goes to infinity. Ben defended that it is still interesting to see different speeds of convergence to the Walrasian frictionless benchmark though the units of time might not be clear in this case. ◆

Asset Pricing in a Monetary Model with Dealers

Fabrizio Mattesini and Ed Nosal

Cash is costly to hold due to zero returns. However, entrepreneurs need cash to finance investment. Underinvestment due to costly holding of cash is observed in real life. Motivated by this phenomenon, the authors formalize their ideas in the standard monetary model by Lagos and Wright (2005). The over-the counter market, along the lines of Duffie, Garleanu and Pederson (2005), is introduced in the paper. Their focus is concentrated on the interactions and relationships between real investments, assets prices and money. The model features a phenomenon that resembles cash-in-the-market pricing as an equilibrium outcome. In other words, increase in market liquidity increases asset prices. This further indicates that market liquidity plays a role in asset prices fluctuation apart from change in asset fundamentals. Another prediction of negative correlation between asset prices and inflations is a surprising result and is in contrast to Mundell-Tobin effect which is common in some models with money.

Three markets are opened in the authors' story of an infinite horizon model: financial market, decentralized real investment market, and competitive rebalancing market. There are also three types of agents: investors, producers, and dealers. Due

to preference shocks, investors will be divided into consumers and non-consumers from an ex post viewpoint. Consumers need consumption produced by producers. The dealers will intermediate consumers and non-consumers to allocate liquidity more efficiently in OTC market. Dealers' bargaining power in non-competitive market allows for different prices for bid and ask; analysis of change in price spreads is thus accommodated in the model. As is assumed in the model, agents cannot commit; money is thus needed as a medium of exchange. The concept of liquidity is clearly defined as the fraction of investors that turn out to be liquidity providers in financial market. The analysis is thus about how change in the fraction of liquidity providers will affect asset returns, spreads and so on so forth.

After characterizing Kalai bargaining and the steady state equilibrium, the authors then discuss how increase in liquidity will affect endogenous variables. They first shows that when the market is liquidity constrained, increase in liquidity results in increase in bid price of assets. In contrast, when the market is asset constrained or unconstrained, increase in liquidity will not affect bid price. The authors also emphasize that whether the market is constrained and whether the market is asset or liquidity constrained depend on the supply of endowment assets from the beginning of each period. This theoretical explanation supports their intuition that liquidity can be decisive to asset prices apart from asset fundamentals. Next, the authors predict a result about negative correlation between liquidity and bid-ask spread and positive correlation between changes in asset returns and bid-ask spreads. Last, the paper turn the relation between inflation and asset returns. The theory predicts that economy will have higher asset returns when there is higher inflation.

One participant discusses whether the order of the bargaining will affect the solutions. Since the bargaining game is assumed to be two-stage, what if the order of bargaining is reversed? In the presented model, the bargaining game first matches dealers with customers and then matches dealers with liquidity providers. The authors say the solutions will be exactly the same, since the equations derived will be exactly the same. Nosal reasons that when the case of reversed order is considered, liquidity providers will still want to provide as much cash as they could for assets.

Another participant comments at the end that we need to think about the examples of welfare cost of liquidity. Investors may not need ex ante investment in cash; they only need to carry interest bearing assets to the goods market and convert them into cash whenever needed. Presumably, this will reduce cash holding and carry some assets to the goods market, which will reduce the welfare cost due to cash holding. The authors agree with this point. ◆

Sorting in the Interbank Money Market

Morten Bech and Cyril Monnet

In the interbank money market, several stylized facts are observed. According to Bech and Monnet (2013), in neutral liquidity conditions, overnight rate tends to hover around the mid-point of the corridor. When liquidity surplus increases, overnight rate will be driven down to the floor and its volatility will decrease. They also observe negative correlation between aggregate market volume and excess reserves and positive correlation between overnight rate and counterparty risk.

Based on these facts, the authors try to formalize a model to study the interbank market and monetary policy implementation. However, current literature doesn't make good predictions that match these facts. Motivated by the model of banks' reserve management in Poole (1968) and Afonso and Lagos (2012)'s study about intraday dynamics of fed fund with random search, the goal of the paper is to combine several aspects, auctions, interbank market and facilities, into the money market. By comparing different trading structures, the authors conclude that sorting with random matching can broadly replicate the stylized facts best.

Specifically, the model adds two important ingredients in Afonso-Lagos model. First is to assume a liquidity shock to banks before interbank market opens. Second, banks trade in OTC market and bargain over the rates. Three matching mechanisms are compared in trade to see different level of money market efficiency: random matching, random matching with directed search, and perfect matching. The discovery of the best trading structure that matches the stylized facts shows what the best models of the interbank market looks like; banks should have the choice to borrow or lend and then pick a borrow or lender at random. It seems to be some leeway to improve the functioning of the money market.

The paper also contributes to identify the effect of corridor size on money market volume. They predict that higher market volume increases with the corridor size. After introducing risky banks that cannot commit to pay back private loans, the authors shows that trading volume will decrease with counterparty risk, the fraction of risky banks. Counterparty risks may also increase indexed average, because distribution matters in the story. Moreover, through characterizing the willingness-to-pay for reserves, they provide a theory for the bid shading relative to the bid in Poole's workhorse model; the reason is that directed search trading structure (sorting) offers relatively more insurance against liquidity shock, leading to more aggressive bidding behaviors. That's why in the model, bid will go undervalued relative to Poole (1968) when there is excess reserves.

One participant raises a question why banks prefer sorting if they can choose different ways of matching. The authors respond that they do not consider choices of different trading structures. Their purpose is to compare levels of efficiency in different mechanisms and figure out sorting the best mechanism.

A group of participants also discuss with the authors the time series of corridor system employed by ECB. One asks that what is

the determinants of ceiling and floor of the corridors, deposit rate and lending rate, and what is the different between the corridors and overnight rate. The authors explain that the ceiling and floors are policy decided, while the overnight rate is the actual price in the interbank market which will always fluctuate within the corridors. The floor and the ceiling are outside option for market participants. Another participant comments that policy announcement may be ineffective and not credible to decide the corridor because markets are working; simple example is to set the floor and ceiling to be negative and positive infinity. One participant also finds it interesting that the overnight rate plummeted rather than shoot up during 2008 financial crisis; the intuition is that banks would hoard reserves and rates would spike up. There are still many questions waiting to be solved. ◆

Non Neutrality of Money in Dispersion: Hume Revisited

Gu Jin and Tao Zhu

In the classical essay *Of Money*, Hume (1752) discussed his view on short-run non-neutrality of money when new money is injected. He said: "…When any quantity of money is imported into a nation, it is … at first … confined to the coffers of a few persons.", "then the money is dispersed into many hands … some time is required before the money circulates through the whole state.", "… it is only … between the acquisition of money and rise of prices, that the increasing quantity of gold and silver is favorable to industry."

Jin and Zhu's paper interprets Hume's idea from a distributional perspective; they reason that non-neutrality of money comes from frictional transition of money dispersion, and change of money distribution in dispersion is due to unproportional money injection. With the help of the standard matching model with multiple money holdings, shown in Shi (1995) and Trejos and Wright (1995), the authors first define and prove the existence of steady state equilibrium. Rather than focusing on the long run analysis in Molico (2006), Jin and Zhu concentrate on the short run transitions. By means of numerical approach, they can explicitly show the response of aggregate output over time as well as distribution at steady state. Another interesting finding is about evolution of distribution of money before dispersing back to pre-injection shape (neutrality); under certain type of one-shot injection, sluggish price adjustment, persistent output response and positive relation between inflation and output can be witnessed.

In order to study the evolution of distribution of money holdings, the authors characterize law of motion of the value function and the distribution of money holdings, indexed by time. In their story, there are buyers and sellers who have indivisible units of money and are randomly matched at each date. Buyers make a TIOLI offer to maximize expected utility by choosing output level and lotteries on monetary transfers. The introduction of lotteries follows Berentsen, Molico and Wright (2002) to mitigate the limitation of indivisible money and to introduce additional pairwise divisibility.

The authors first have a look at the pairwise output choices in matching at the steady state. Then they focus on the short-run effect of one-shot money injection. Three different injection schemes are compared in the paper: lump-sum injection, injections with disutility cost to receive and injections with monetary cost to receive. The last scheme that leads to the spreading-out of distribution is discussed. To be specific, the paper uses the probability of winning the 2-units money lottery to measure monetary cost; higher probability means lower cost. When the probability varies, the distribution changes accordingly. The impulse response to injection confirms the authors' intuition. Lower monetary cost will increases output which is persistent and even hump-shaped for some parameters over time. Prices are sluggishly adjusted and a surprising short-run negatively-sloped Phillips curve is observed. The authors finally briefly discuss the case of every-period injection. They conclude that for low money growth, an increase in lottery-winning probability tends to increase aggregate output, while for high enough money growth rate, further raising the probability will deteriorate output level.

The participants discuss the necessity of the assumption proportional reduction of money in the model. One participant comments that the assumption constructs long-run neutrality in order to trace whether there is short run neutrality. The authors agree with the point. They say that it is, by construction, a way of normalization so that the aggregate money stock can return to the pre-injection level. The assumption is thus for consistency purposes. Another participant comments that the outflow of money is proportional while the inflow depends on different injection schemes. This practice makes results under different injection schemes comparable and meaningful. ◆

Advances in Macro-Finance V

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Misspecified Recovery

Jaroslav Borovicka, Lars Peter Hansen and Jose A. Schienkman

Many asset pricing papers make the assumption that economic agents have different discount rates over future states of the world, in addition to there being different underlying probabilities that determine prices. The authors show that under common conditions, it is not possible to separately identify stochastic discounting from probability distributions by using asset prices without additional assumptions. In common economic models, the probability distributions correspond to the investor's belief about future asset prices in the economy, while the stochastic discounting component is a preference parameter. They demonstrate that a previous identification result only holds under specialized conditions, namely that the martingale process of the probability measure must be assumed constant. This is important because several common economic models of asset pricing imply non-trivial (non-constant) martingale components. They employ Perron-Frobenius theory to recover the transition probabilities (the probability distribution) and show what assumptions are needed for these measures to reflect the probability distribution alone rather than components of the stochastic discount rate as well.

The authors consider two alternative restrictions on the stochastic discount factors. For the first, they assign it to exhibit "risk-neutral pricing," meaning that the stochastic discount factor is the mean of the prices. The second parametrization is setting the discount factor to exhibit "long-term pricing," involving a constant multiplied by a ratio of positive numbers, the denominator of which corresponds to the state in the current period while the numerator corresponds to a state in the next period. For the risk-neutral case, allowing the stochastic discount factor to be independent of the state tomorrow makes it possible to back out the probabilities based upon prices tomorrow. This is because the only thing that affects prices between periods is the differential probabilities of the future state occurring. They note, however, that this still includes the subjective discount factor of the risk-neutral investor and thus does not identify the probability distribution. For the long-term pricing case, application of Perron-Frobenius theory allows the transition matrix to be constructed, and from that a pricing kernel, by solving for the eigenvalues of the price vector. They show that under some constructions, this allows the transition probabilities to coincide.

Next, they explore whether common economic settings satisfy the above restrictions. Using a standard consumption-based asset pricing model, they derive a Euler Equation and show that the stochastic discount factor has a martingale component except in instances when consumption has a deterministic trend. In the second example, they employ specialized Epstein-Zin preferences, which allow the intertemporal elasticity of substitution to be independent of risk aversion. Under these conditions, the recovered transition matrix is shown to be distorted over time by risk-adjustment. They generalize these results to the set of models that exhibit Markov processes over a finite set of states. In general, identification relies on restrictions to the stochastic discount factor process or to the probability distribution.

The discussant, Mikhail Chernov, argued that while the paper was correct in noting that the environments in which identification holds are in fact specialized, they are nonetheless interesting for empirical analysis. He argues that the information recovered under these potentially incorrect specifications is not necessarily vastly different from the underlying probability distributions and thus could still provide valuable insights. He also proposed alternate identification assumptions that might be worth considering. Borovicka responded that any situation in which distortion wouldn't be large would be considered an extreme case, and also noted that he thought the alternate identification assumptions would still require a martingale component. ◆

Dynamic Dispersed Information and the Credit Spread Puzzle

Elias Albagli, Christian Hellwig and Aleh Tsyvinski

The credit spread puzzle refers to the difference between the price of investment-grade bonds and the expected payout of those bonds observed in the market. Recent work has shown that the difference is difficult to square with models of no-arbitrage pricing. In addition, the data shows that the puzzle is particularly severe for investment grade bonds, and for bonds with short maturities. The tractable model proposed in this paper sets out a solution that addresses these asymmetries, and in the process demonstrates another well-known outcome, which is that the spread tends to be increasing in the level of disagreement about forecasted outcomes among investors.

In the static version of the model, there is only one asset, defined by a probability of default. Risk-neutral investors receive a private signal about the quality of the asset, and decide how much of the asset to purchase. Importantly, their demand is bounded, either explicitly by position limits or fund availability, or by an implied risk aversion. In addition, a group of noise traders masks the aggregation of information by demanding some exogenous fraction of the asset. The equilibrium price and demand functions satisfy a rational expectations equilibrium where informed traders demand optimally and use Bayesian updating, and the market clears.

In equilibrium, the demand function of traders is defined by a threshold above which they demand the maximum allowable amount of the asset, and below which they demand the minimum, including a short position in a more general framework. Therefore, the price is informationally equivalent to the expected return of the marginal trader. However, this value differs from the expected bond payoff, which defines the spread. The intuition is that the price responds more to changes in demand than the fundamental value of the asset. An exogenous increase in demand raises the price through both a market clearing effect (wherein some measure of traders must be convinced to sell, therefore increasing the price) and through a learning effect, (wherein the higher price signals a higher expected payout, driving the price higher). Importantly, the fundamental value of the asset is unaffected by the market clearing channel, so the price is more volatile than the expected payout.

The paper also goes on to show that higher quality bonds are affected more strongly by these shocks, and therefore carry larger premiums, and that increasing informational frictions also increases the spread premium. Furthermore, generalizing to a dynamic version of the model with persistent likelihood of default generates the final important asymmetry in maturity, where spreads decrease with the maturity of bonds. A brief calibration exercise demonstrated the magnitude of these effects, and showed that, depending the maturity and quality of bond, the model can explain 30-40% of the difference between standard structural models of the bond and realized prices.

The discussant, Todd Walker, was impressed with the tractability of a model that has the potential to be taken directly to the data. However, he criticized the paper for failing to take into account recent work that has greatly improved understanding of the puzzle by incorporating macro factors such as liquidity. Walker encouraged the authors to focus the empirical portion of the paper on how their model explains the asymmetries still unexplained after the incorporation of these macro factors, rather than taking on the whole puzzle. In addition, he demonstrated how the model could be better connected to a more standard structural model, and encouraged the authors to do the same. Finally, Walker mentioned a possible extension of the dynamic model to include long-lived investors who must form higher-order beliefs. Albagli acknowledged the need to connect better to the literature with both theory and empirics, and thought that incorporating higher-order beliefs may be an interesting, if complicated, extension of the paper.

Further participant discussion centered on the ability of the model to handle extensions such as risk aversion and different assets, and the implications for firm financing. Future versions of the paper will include risk-averse agents to demonstrate the magnitude of the spread that comes from their mechanism versus risk premiums. The model has already been used to price options, with the mirror prediction that options will tend to be overpriced, and out-of-the-money options even more so. Finally, a participant mentioned that the paper may have important implications for corporate financing if a firm expects its assets will be mispriced, and that an empirical analysis could be undertaken to measure firms' response. ◆

Optimal Debt and Profitability in the Tradeoff Theory

Andrew Abel

What is the optimal debt level for a company? This is one of the most important and long-standing questions in corporate finance. The tradeoff theory of capital structure, dating back to the 1960s, obtains the optimal level of debt by equating marginal costs from default to marginal benefits from tax deductibility of interests. One of the direct implications of this simple and appealing concept is that more profitable firms will have higher leverage ratios, but this prediction finds little support in the data. In fact, several empirical studies show that leverage actually decreases when firms are more profitable. In recent years, models of capital structure have been trying to resolve this puzzle at the cost of an increased complexity.

In his paper, Abel mitigates these complexities by focusing on only one friction, endogenous borrowing constraints, and provides a simple closed-form solution to the optimal capital structure problem consistent with the empirical findings on capital structure. His continuous-time model features a firm that, in each instant, observes an exogenous realization of its profitability (EBIT) and chooses the amount of interest-bearing debt to issue in order to maximize its shareholder value. Key features of the model are that debt is issued and instantaneously repaid at par and that default occurs if the amount of debt to be repaid is higher than the firm's discounted expected cash flows.

The assumption of an infinitely short-duration debt—a major departure in Abel's paper from the previous literature—therefore makes the total value of the firm a natural upper bound to the firm's borrowing. The author shows that when EBIT falls below an endogenously-determined threshold, the value of the company is low and this borrowing constraint binds. In this case, optimal leverage is invariant to changes in EBIT. On the other hand, when

contemporaneous EBIT is above the threshold, the value of the company is increasing in EBIT and debt is independent of it, so that leverage is decreasing in profitability. In this region, the tradeoff theory of debt holds, and optimal debt is obtained by equating the marginal benefit from tax shields to the marginal cost of default.

In the second part of the paper, Abel considers the effect on capital structure of an increase in future, rather than contemporaneous, profitability by means of a rightward shift of the EBIT distribution. He shows that whenever the distribution is not too upward-sloping, increasing the expected value of the firm increases the cost of its default more than it increases the benefit from tax shields, so that the capital structure has to be adjusted to decrease the likelihood of default. Also, in this case an increase in profitability therefore decreases optimal leverage.

The discussant, Toni Whited, emphasized the novelty and elegance of Abel's model and pointed out that while the inverse relation between leverage and contemporaneous profitability can be obtained by already-existing models of structural corporate finance, the inverse relation between leverage and expected profitability cannot be obtained by these models if the firm faces endogenous borrowing constraints. Additionally, she provided a quick empirical test of the model's predictions in which she demonstrated that the leverage of firms constrained by low profitability is indeed not related to profitability. ◆

Agency Conflicts Around the World

Erwan Morellec, Boris Nikolov and Norman Schürhoff

Agency problems have strong theoretical implications for models of firm investment. However, studies measuring the magnitude of these problems have in large part relied on an indirect outcome of agency problems: the strength of regulations designed to limit them. This paper instead relies on manager preference as revealed through firm financing decisions in order to identify the strength of two important agency conflicts in a structural model.

In the paper's model, there are three types of agents associated with a given firm: majority shareholders, minority shareholders, and bondholders. Majority shareholders (or managers) make decisions for the firm, including investment, financing, and default decisions. Managers can also divert some of the firm's free cash flow as a private benefit. Therefore, as debt issuance limits unclaimed cash flows, managers issue less debt than in the first best. This practice—pitting majority shareholders with an incentive to divert cash against minority shareholders, who would rather invest the cash flow or issue debt—represents the first source of agency conflict identified in the paper. The magnitude of inefficiency depends on what fraction of cash flow the manager diverts.

The second source of agency conflict rests between shareholders (both majority and minority) and bondholders in the event of a default by the firm. If the firm chooses to default, they have the option of liquidation or renegotiation of the debt. Each carries a frictional cost, but renegotiation is less costly. When renegotiation generates a surplus, the shareholders and bondholders must determine how much of the surplus each group captures. The surplus is split according to Nash bargaining, with the shareholders' bargaining power determining the split. Therefore, as there is remaining surplus, shareholders default more often than in the first best. The magnitude of the inefficiency therefore depends on the shareholders' bargaining power parameter.

The combination of these two conflicts determines both a stationary and conditional time-series distribution of leverage for a firm, given the fraction of cash flow diverted by managers and the shareholders' bargaining power. The authors use data from a large panel of firms across 14 countries on firm leverage to identify these parameters at the firm level through Simulated Maximum Likelihood (SML) estimation. The resulting distributions allow them to analyze the magnitude of firm frictions, and the relevant levels of variation.

Analysis of variance shows that much of the variation in the magnitude of the two conflicts occurs within countries and within industries. In fact, cross-country factors explain only about three percent of the movement in both the manager advantage friction and the shareholder advantage friction. The authors are further able to show that traditional correlates of agency conflicts, such as civil law and creditor rights indices, are predictors of both frictions. This analysis is therefore consistent with previous analyses of agency conflicts. Significantly, however, it suggests that firm-level factors may be more important in addressing these conflicts.

The discussant, Murray Carlson, led an informative talk demonstrating the factors in the data that identified the magnitude of each friction. In two simple versions, he emphasized that the structural model in the paper predicts that firms that suffer from large managerial conflicts are on average under-leveraged, whereas firms that suffer from large shareholder conflicts are more often in equilibrium. These two factors, in combination with some related structural assumptions, define the equilibrium distribution of leverage at the firm level. Carlson also emphasized that the scope of the project was very ambitious. He recommended that the authors think carefully about how they define the minority shareholders in the model, and make adjustments so the surplus being split is more than "monopoly rents."

Discussion centered on the relevant level of analysis for these agency costs, with Nikolov again emphasizing that both intra-national and intra-industry variation in these frictions far outweighs any of the factors operating on those levels. In addition, several questions were asked about the correlation between the frictions, and the results indicated that firms experiencing a larger degree of manager advantage saw smaller frictions in the shareholder default decision. Further questions centered on the mechanics of fixed adjustment costs, with debate as to whether the cost should be in proportion to debt retired or to total debt. ◆

Investor Sophistication and Capital Income Inequality

Marcin Kacperczyk, Jaromir Nosal and Luminita Stevens

At a basic level, when inferring that the verification of the state of an asset is costly, one may conclude that those investors equipped with more financial means will have a better capacity to discern between high and low-yield assets. By investigating this premise, the authors formulate a theory of income inequality based around

differences in investor ability, specifically in regards to the investor's ability to verify information about the returns of financial assets. Their paper also considers heterogeneity in investor ability, as shown through their qualitative analysis of ability in terms of processing information: some investors are seen as "sophisticated," and others as "unsophisticated." Thus, the authors argue that this diametric contrast in investor ability creates frictions that ultimately cause sophisticated investors to earn higher returns on their wealth over time, serving to maintain their wealth and an income gap between investor types. Empirically, the authors document avoidance of risky assets by presumably less-informed investors, noting this decline increasing in intensity during the 2000s. Their model generates results consistent with what they observe in the data; in particular, they find that sophisticated investors choose to learn about more risky assets, while unsophisticated investors completely abandon risky assets as the economy expands. The authors find the same results hold along the trading frequency dimension, as sophisticated investors trade more intensely.

In the model, a continuum of investors make decisions about investments. These investors are heterogeneous in one key dimension: a fraction of them have a strictly higher capacity for comprehending information about the quality of a stock, and are thus termed the "sophisticated" investors. Typically during each time period, all investors must first solve an information problem involving learning about some or all of the asset payoffs. Then, all investors observe prices for these assets and choose their portfolio allocations. During this information stage, each investor receives a signal about each asset, and processes information about each of these assets contingent upon these signals. They learn about the payoffs of each of these assets up to a certain capacity, constrained by their investor type. Due to the fact that perfect information requires infinite capacity, each investor will face uncertainty about the payoffs. In equilibrium, all agents allocate their entire learning capacity to a single asset, which is in turn the subset of assets that are actively traded.

The authors conduct two experiments, one involving the aggregate holdings of assets, and one involving household portfolio construction. First, in the aggregate portfolio experiment, they set the capacity of unsophisticated investors to be 10% of the sophisticated investors. This is then used to analyze the relative performance of investor types over time in the United States, as well as predictions about trading frequency. Then, in the household portfolio experiment, they assess the effect this mechanism has on inequality. They link information capacities to their growth in financial wealth levels, and set the capacity ratio using the ratio of financial wealth of the top 10% to the bottom 50%. For income inequality, the aggregate portfolio experiment suggests that sophisticated investors experience 2.1 % larger average portfolio returns, while the household portfolio experiment suggests that the mechanism accounts for 98% of the growth in capital income inequality. The model also predicts increased flows of sophisticated investors to equity funds, while unsophisticated investors flow into less risky funds. The authors derive analytical predictions of their model; indeed, they are able to derive an analytical solution for the mass of investors actively trading each asset. In particular, agents will learn first about the most volatile asset, and then move sequentially to the next most risky asset if the information capacity is large enough in the economy. The authors find that as the capacity to interpret their private signals increases, the number of assets actively traded in the economy increases.

One conference participant, Stavros Panageas, noted during the discussion that this model functions as a "rational inattention" model, meaning that agents optimally decide not to focus on all the available assets. Panageas argued that the authors' methodology is not a standard approach to such a problem, and that the authors should consider adopting a "Grossman-Stiglitz" approach. Panageas also noted that the authors' assumptions are uncorrelated; if there were a correlation among assets, the portfolio choice might change. These factors make it challenging to map the model to the data. In response, Jaromir Nosal agreed with components of Panageas' critique, saying that the authors could certainly incorporate correlation, but it would involve additional restrictions on the model. He further noted that the model is still consistent with observations in the data. ◆

Financial Distress and Endogenous Uncertainty

François Gourio

What is the macroeconomic effect of having many firms close to default? The macroeconomic literature on financial frictions has extensively examined how financial distress amplifies fundamental shocks through investment, but has generally failed to replicate the large observed movements in aggregate quantities such as GDP and employment. On the other hand, while anecdotal evidence suggests that firms in financial distress experience deterioration in their relationships with customers, suppliers, and workers, little has been said about how these channels can amplify fundamental shocks.

In his paper, Gourio attempts to fill this gap. His discrete-time, dynamic general equilibrium model features a representative household and a continuum of heterogeneous firms producing intermediate goods. These goods are aggregated to produce a final good that can be either consumed by the household or re-purchased by the firms for production. In each period firms realize aggregate (TFP) and idiosyncratic productivity shocks and correspondingly choose how many units of the aggregate good to buy and how many workers to hire from the household. Once the decision is made, the firm realizes a random cost shock, and can then decide whether to continue operating or to default on its debt obligations. In this case, the firm is taken over by its creditors and immediately replaced by another one. A key ingredient of the model is that whenever a firm defaults its workers and suppliers then bear a cost, so that wages and input prices are endogenously determined as functions of idiosyncratic shocks - intuitively, riskier companies are charged higher prices to compensate for their higher risk of default.

This, in turn, has two affects, which Gourio illustrates in the numerical section of the paper. The first is an amplification of negative TFP shocks, driven by a reduction in aggregate labor supply (labor wedge) and by input misallocation toward bigger, safer firms (TFP wedge). The second is an increased volatility of both aggregate and cross-sectional output and employment for

low TFP realizations, driven by the higher sensitivity of aggregate quantities to the fundamental shock when more firms are close to default.

In the final empirical section of his paper, Gourio provides empirical tests of two predictions of the model. He demonstrates that those data firms close to default have sales and employment that are more sensitive to aggregate fluctuation, and that the number of firms close to default is procyclical.

The discussant, Joao Gomes, emphasized the novelty of the paper in modeling endogenous volatility while also highlighting three aspects of the study that, may require revision. First, in order to obtain a big enough amplification effect of TFP shocks, workers would have to lose the entirety of their wage in default. Second, firms might default on their employees and suppliers but still have sufficient cash flows to repay their debt. This then, raises the question of which claims should have higher seniority. Third, if debt is an endogenous choice variable, then risky companies will de-lever to avoid default, which might reduce the amplification effects of labor and TFP wedges. Additionally, another discussant also noted that employees hold claims to the firm's pension liabilities, thus making them more exposed to default. Gourio first replied that when using a quarterly calibration employees effectively lose only one fourth of their annual income in case of default. Gourio further explained that employees in the United States have slightly higher priority than debt holders in default, so that generally default cannot happen on workers before bondholders. Finally, he agreed with Gomes that incorporating endogenous debt would help both on imposing more structure on the seniority of the firm's liabilities as well as making the model closer to the current literature on default.

Following these comments, other discussants considered the possible extensions and testable implications of the paper. Is there a difference in sensitivity to macroeconomic fluctuations between firms operating in the product markets and firms operating in the intermediate goods market? What about the sensitivity of firms that go out of business, as opposed to those that are restructured? Do riskier companies actually pay a default premium to their employees and suppliers? Gourio welcomed their suggestions and put them on his agenda for future work. ◆

Taxing Atlas: Using Firm Data to Derive Optimal Income Tax Rates

Laurence Ales, Andrés Bellofatto and Jessie Wang

The top income earners (1%) have a high share of the United States national income (24% in 2001). This makes taxation of the top incomes very important and nuanced. However, the taxation of the top income earners is a very controversial topic within current public finance literature. While some literature suggests that top income earners should not be distorted, as they are the most productive agents, there are other which argue that the highest income level can have a positive and high marginal tax rate depending on the distribution of income. While this other literature is generally concerned with the supply side of the labor market, this paper endeavors to study taxation of the top labor incomes by focusing on the demand side of the labor market. The authors model top earners as managers by following certain data facts, such as the Rosen (1982) model, in which heterogeneously skilled managers can operate span-of-control technology. Additionally, the Rosen model demonstrates that a manager hires labor and combines his effective effort with that of the labor in order to produce firm output with a constant elasticity aggregator. This is an important aspect of the model due to the fact that wages become endogenous in contrast to the vastness of public finance literature. This model also helps the authors them to control the firm sizes. On the quantitative side, the authors calibrate their model with United States firm level data, finding that the optimal tax rates are similar with the United States tax code.

In the model, the wage of the manager is dependent upon the firm size, or the hired labor amount. Therefore, the firm size appears in the incentive constraint. In other words, managers do both hire the labor force in addition to controlling the informational rent via their hiring channel. Hence, the taxation of firm size is important. Subsidies on the higher skilled managers relax the incentive constraints.

The authors derive the optimal income taxation code similarly to other literature. They compare their model to E. Saez's 2001 paper on tax code, differing from Saez in regards to their definition of the elasticity term, which they define as a multiplicative of two terms. For the first term, they evaluate the ratio of elasticity of skill to the output against the elasticity of labor to the output. This ratio is equal to one for Saez's environment. However, the degree of substitutability across a manager's effective effort and his hired labor amount serves to make this term endogenous. Indeed, with perfect substitutability, it will be also be equal to one. This term raises the marginal taxes because the elasticity of effort is relatively low and additional taxes will not distort a manager's effort decision to a substantial degree.

The original elasticity term as seen in Saez's 2001 paper, was formerly defined as the inverse of compensated elasticity of labor supply with respect to wages. In this paper, the second term encompasses this while also including another component which measures the net of the elasticity of managerial skill and the elasticity of marginal productivity of effort. Again, this term would be equal to one if one were in Saez's (2001) set up. However, the endogeneity of wages makes this component vary across skill level. Similarly, if this term is indeed positive then it raises marginal taxes because effort increases marginal productivity of itself, thus the level of the distortionary by taxes is reduced.

After deriving the optimal tax code, the code is then arranged for the top skill managers. The arranged tax formula has two components, the first one being classically observed from J.A. Mirrlees' 1971 models. The second component, however, is new, and is positively related to the scale of operations, which appears in the total factor productivity term as the power as calculated by the skill level of the manager. As the scale of operations rise, the income distribution is dispersed which causes more thick tail for right, which then causes a decrease on the marginal taxes. As a result, the scale of operation has two controversial effects. Hence, the effects should be examined quantitatively.

The authors have chosen to use Compustat, an annually frequent firm level data, to calibrate the scale of operations coefficient and

resulting parameters. The Frisch elasticity of labor is likewise taken from the literature. The authors initially find that the top marginal tax rate should be between 20% and 50%. However, after some arrangement, they find that the top marginal tax rate should be closer to 32%, a figure similar to the United States tax code. This result differs from Mirrlees' and Saez's work, as the authors arrangement expects zero marginal rate while the work of Mirrlees and Saez finds it to be larger than 70%.

The discussant, Adriano Rampini, mentioned that the paper is the challenge of Diamond-Saez results, which have a high tax rate at the top. Rampini initially examined the classical static dynamic public finance results and mentioned that S. Rosen's 1982 framework provides more skewed income distribution than talent distribution, which lowers the tax rates at the top. He also emphasized that optimal income taxation can distort labor force in firm to provide incentives for managers.

A central critique of Rampini's of the paper is that the top 1% earners are not only managers, indeed lawyers and doctors are also included in that percentile. This sample may enhance results because calibration of the scale of the operation coefficient is sensitive to a/ the number of executives. Another point Rampini makes is that the model does not include capital. However if firm size, that is, the total labor force by a firm, is interpreted as the capital amount used by managers, there is a chance to talk about capital taxation, which is also in debate in the literature. According to Rampini, this paper has interesting quantitative model, by which applied policy questions can be answered with a careful calibration. ◆

Technological Specialization and Corporate Diversification

Fernando Anjos and Cesare Fracassi

In this paper, the authors are concerned with the way in which conglomerates allocate their resources in response to technological change. The main literature suggests that labor becomes more specific and is focused on narrower tasks as technology improves. This has the same implication on the conglomerates. Indeed, the technological diversity across division in an average conglomerate has fallen. Further, the data provides that the fraction of assets held by single-segment firms has risen from 1990s to 2010s. In this paper, the authors endeavor to explain the data theoretically and to testify the model with a calibration. In their model, conglomerates can optimally determine the resources across divisions. This creates synergies that depend on the level of technological specialization, and synergies in conglomerates that control the diversification activity. The model provides that the specialization of technology decreases technological diversity across divisions, and creates more focused conglomerates. Additionally, the ex post resource allocation decreases in conglomerates, which causes reduction in corporate diversification. The data facts above, with the inclusion of certain other facts, are further explained with a calibrated model.

The model links technological specialization and diversification of synergies within firm resource allocation. In this case, technology can be referred to by different concepts, such as technical capacities and managerial skills. Firms are modeled as business units and each unit has its own technological characteristics. Although market is competitive, a business unit has a comparative advantage when project requirements require a particular specialization. Facing with specialized projects decreases the value of diversification. However, if focused specialization is not required, then diversification adds value to diversification by ex post reallocation.

A business unit can be a single segment or a conglomerate, which consists of two segments. Each segment has its own characteristics, and the distance between two segments measures the technological diversification. If the two segments are close to each other, then the conglomerate has a specialization on only a small range of projects, which decreases the gain from the projects. However, if the distance is high then it is costly for the conglomerate to allocate the ex post resources.

The model is calibrated using the data on corporate diversification activity in the United States. The authors measure the distance of segments in a conglomerate based on input output flows. In this instance, the growth of technological specialization is used to generate an output growth. The authors then try to match some moments, such as single segment value, probability of a segment value, average excess value, and average diversification returns. With this calibration, they are able to match aggregate corporate diversification activity, or the ratio of assets allocated to single segment firms to the diversification discount. Moreover, the calibration explains the increase in the Tobin's Q of single segment firms and an increase in conglomerate excess value.

The authors also consider the cross sectional implications. The conglomerates bunch at the intermediate segment distance; the model's expectation is consistent with this fact. Additionally there is a positive relation between segment distance and conglomerate value. Yet, this is not matched because of the issue of adverse selection concerns between mergers.

The discussant, Vojislav Maksimovic, finds the model tractable, which is attained by assuming the firms are either single or a pair of segments. The model focuses more on the real side of the firm instead of on the dynamics that distinguish it from corporate finance literature. The main message of the paper is to explain how the firms are specialized in the steady state and how the valuation of a single firm and a conglomerate change is due to such specialization.

Maksimovic also questions the definition of a conglomerate. According to the current model, two mergers with different products can construct a conglomerate. However, if these two mergers are almost in the same line of a product, the conglomerate can produce a particular good and hence be a single segment firm. He also noted that there is no product market interaction in the model; the merger brings its own customers to the conglomerate.

Maksimovic analyzes the data set as well. The COMPUSTAT data does not restrict the firms about their reports as firms have freedom to choose their segments. He mentions that literature exists that criticizes the data set. B. Villalonga (2004) mentions that 80% of segment SIC codes assigned by COMPUSTAT are not in the segments of largest industry. Also D.C. Hyland (1997) states that changes in reporting practice only accounts for up to 25% of segment changes. As a result, Maksimovic thinks that the direct measurement of technological specialization might give better results. ◆

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