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FROM THE LAB

UC Santa Barbara | Laboratory for Aggregate Economics and Finance

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Pecuniary Externalities-The Back of the Invisible Hand

Presentation Summaries

Note: speakers are highlighted in author listings.

Third Annual Macroeconomics and Business CYCLE Conference

Presentation Summaries

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Associate Director's Message

Peter Rupert

Welcome to the new year! The inauguration of Donald Trump portends a raft of changes. While this issue covers some previous conferences and updates, future conferences will address some of the issues that are now at the forefront of policy. Health care, international trade, fiscal policy….to name just a few. That said, those of you reading this can begin to think about those, or other, issues that would be suitable for a conference, and let us know! Organizers come up with a focused topic and are responsible for putting together the papers for a two day conference. The conferences are typically held here at UCSB but we are also willing to co-sponsor at other sites around the globe. For example, we are co-sponsors of the Workshop of the Australasian Macroeconomic Society and also co-sponsor with Carnegie-Mellon Advances in Macro-Finance, rotating between Carnegie and UCSB.

Eric Young, Professor of Economics, and Zach Bethune, Assistant Professor of Economics, both at the University of Virginia organized Pecuniary Externalities—The Back of the Invisible Hand. It was a two day conference with eleven presentations aimed at understanding how small initial shocks, concentrated within a particular part of the economy, eventually spread through financial markets and prices, leading to widespread turmoil. In response to these and similar events in emerging market economies, researchers have analyzed models of "macro-prudential" policymaking, or policies aimed at preventing the onset of financial crises as opposed to those that act to mitigate the severity of crises once they begin. The goal of this conference is to bring together researchers studying the interaction of pecuniary externalities and policy; from those studying international capital flows and "sudden stops", in which foreign capital abruptly flees the domestic economy, to those studying domestic banking crises.

The third annual business CYCLE workshop was held at UCSB in May, organized by Carlos Garriga and Peter Rupert. It was four days and featured sixteen presentations. The mornings are reserved for the paper presentations and the afternoons for enjoying the beautiful Santa Barbara environs while cycling. Monday morning was devoted to labor markets; Tuesday to business cycles and macro economic performance; Wednesday focused on transmission mechanisms with emphasis on housing; Thursday had several papers on money, inflation and central bank policy. As always, the papers and the riding were intense and enjoyable!

Visitors to the "Lab" make it an exciting and productive location. We are lucky to have two regular visitors who have moved to Santa Barbara after retiring. Tom Cooley, former Dean at the Stern at NYU, splits time between pursuits at NYU and UCSB. Ray Riezman, is at the Lab on a regular basis now that he has moved full time to Santa Barbara. Ray was the C. Woody Thompson Research Professor of Economics at the University of Iowa. He brings to us much needed expertise in International Trade.

The Lab was also pleased to host a couple of former Ph.D. students from UCSB, Julian Neira 11/20-12/4/15 and Hrishikesh Singhania 6/4-7/4/16. Other visitors included Marek Kapicka 3/29-4/1/16, Hakki Yazici 3/30-4/1/16, Carlos Zarazaga 9/17-9/28/15, Jim Albrecht 5/30-6/4/16 and John Stachurski 7/4-7/28/16.

Pecuniary Externalities – The Back of the Invisible Hand

APRIL 22-23, 2016

CONFERENCE PARTICIPANTS

Juliane Begenau – Harvard University
Zachary Bethune – University of Virginia
Mick Devereux – University of British Columbia
Sebastian DiTella – Stanford University
Huberto Ennis – Richmond Federal Reserve Bank
Andrew Foerster – Kansas City Federal Reserve Bank
Kinda Hachem – University of Chicago
Anton Korinek – John Hopkins University
Finn Kydland – University of California Santa Barbara
Jennifer La'O – Columbia University
Jorge Miranda – University of Virginia
Chris Otrok – University of Missouri
Pablo Ottonello – University of Michigan
Yena Park – University of Rochester
Peter Rupert – University of California Santa Barbara
Stephanie Schmitt-Grohe – Columbia University
Eric Young – University of Virginia
Changhua Yu – Peking University

Participants and attendees shown at The Upham Hotel in Santa Barbara, California.

Multiple Equilibria in Open Economy Models with Collateral Constraints: Overborrowing Revisited

Stephanie Schmitt-Grohe and Martin Uribe

This paper shows that under plausible calibration, there exist equilibria with under-borrowing which stand in contrast to the over-borrowing result that is stressed in the related literature. It shows that under plausible calibrations, the presence of non-convexities can give rise to equilibria-exhibiting under-borrowing. Further, the authors discuss multiple equilibria generated by nonconvex collateral constraints. Specifically, they analytically establish the existence of multiple equilibria in infinite-horizon open-economy models in which tradable and non-tradable output serve as collateral. The amount of precautionary savings under pessimistic beliefs is so large that the economy ends up displaying less frequent financial crises than is optimal, from a Ramsey perspective. In an economy calibrated with parameters typically used in the emerging-market business cycle literature, and fed with shocks estimated on quarterly Argentina data, the authors find equilibria in which the unregulated economy borrows by 6 percentage points of GDP.

To establish the result, the authors first show a model of an open economy with collateral constraints. Under this formulation, the source of pecuniary externalities is the relative price of non-tradable goods, in terms of tradables. Under some parameter values, it is possible that the more indebted the economy becomes, the less leveraged it is. This possibility can give rise to multiple equilibria and self-fulfilling drops in the value of collateral. Furthermore, if the intra-temporal elasticity of substitution is less than unity, the equilibrium value of collateral is convex in the level of debt. This property may cause the emergence of two distinct values of debt levels for which the collateral constraints binds, as well as two disjoint intervals of debt levels for which the collateral constraints is slack. Intuition is such that when the public unexpectedly becomes pessimistic and aggregate demand contracts, households want to consume less, which brings down the value of collateral. The reduction is so large that it forces households to deleverage. The authors then analyze the magnitude by comparing the level of debt in the unregulated equilibria with that of Ramsey equilibrium with capital controls. The calibration exercise shows the possibility of multiple equilibria. The model predicts that the economy with collateral constraints borrows one fourth of that without collateral constraints. This shows that under maintained pessimistic expectations-coordination environment, households engage in a sub-optimally high level of precautionary savings which in turn is motivated by the fact that the economy is more fragile, as it is more prone financial crises caused by a binding collateral constraint.

One of the paper's discussants asked whether the equilibria is locally stable. Schmitt-Grohe responded that it needs to be embedded implicitly to generate multiplicity. Another discussant questioned the validity of some constraints, considering that when endowment increases, foreigners want to lend more money. Schmitt-Grohe responded that the justification partly comes from the literature and partly from the fact that debt depends on the value of stock or flow. ◆

Optimal Financial Regulation and the Concentration of Aggregate Risk

Sebastian Di Tella

This paper studies optimal financial regulation policy with a focus on the allocation of aggregate risk in a standard macroeconomic environment where financial frictions are derived from a moral hazard problem. In this environment, specialized agents - also known as experts - face a moral hazard problem in which they are able to secretly divert. Since they keep exposure to their idiosyncratic risk to provide incentives, they become less willing to hold capital when facing large financial losses, creating a financial amplification channel. In the model, the author allows agents to write complete, long-term contracts with full commitment. The author shows that experts' leverage is too high in equilibrium, and as a result they are exposed to too much idiosyncratic risk, for which they must be compensated. Also, the author finds that the allocation of aggregate risk will be inefficient if and only if aggregate shocks are correlated with the size of the externality. Under financial regulation, the author characterizes the best allocation that can be achieved by a social planner who faces the same contractual problem as the market. Then, the author shows how it can be implemented in a competitive equilibrium. The social planner prefers to reduce the price of capital, at the cost of less investment, in order to improve idiosyncratic risk sharing and reduce the cost of providing incentives to experts. The author shows that the optimal financial regulation policy admits a simple sufficient statistic representation. The sufficient statistic shows that the externality is related to inefficient idiosyncratic risk sharing, the leverage ratio for experts, the fraction of capital's idiosyncratic risk that cannot be insured away due to the moral hazard problem, and the semi-elasticity of the price of capital with respect to the growth rate.

The author solves the model numerically in two settings. In the first setting, the economy is hit only by Brownian TFP shocks, the social planner implements lower asset prices and investment than the unregulated competitive equilibrium in order to reduce the cost of providing incentives. Aggregate risk sharing, however, is efficient, because the size of the

externality is uncorrelated with TFP shocks. In the second setting, the economy is hit by uncertainty shocks that raise idiosyncratic risk. In this case, there is an excessive concentration of aggregate risk on experts' balance sheets. The social planner may allow experts' equilibrium leverage to go up after uncertainty shocks, but less so than in the unregulated competitive equilibrium. In summary, in the unregulated competitive equilibrium, asset prices and investment are too high and experts are too highly leveraged, financial losses are excessively concentrated on experts' balance sheets, and utility losses are excessively concentrated on households.

One of the discussant asked what is the difference between Ramsey planner and the planner in this paper. The author commented that the former is subject to ad hoc constraints while the latter is subject to endogenous constraints. Another discussant asked about how to think about capital reallocation. The author noted that in the unregulated economy with hidden action, since the agent can steal, there is a need for capital reallocation. Without regulation, there is externality on the equilibrium path. The author also noted that he chose the leverage ratio to be 10 in the numerical example because it matches the number in the 2008 financial crisis. He also noted that the problem is on the experts' side so that it does not matter whether households see aggregate shock and idiosyncratic shock or not. In the social planner's solution, he chose the parameter value so that social planner wants no stealing on the experts' side. ◆

Financial Frictions in Production Networks

Jennifer La'O and Saki Bigio

The authors attempt to assess the effect that financial frictions can have on the aggregate economy when linkages between sectors are taken into account. They describe the distortions that can take place when links in an input-output production network face different financial shocks, and the effect this can have on aggregate fluctuations based upon different network structures. They describe outcomes for a variety of network structures, and then calibrate the model to the input-output tables of the US economy, showing the impact these frictions had during the Great Recession. They demonstrate that these linkages increase the propagation of financial shocks far in excess of that predicted by previous models, which generally only provided a role for financial constraints on investment levels. They decompose the effect into two channels in the aggregate: an efficiency wedge and a labor wedge, where the first is a misallocation of labor across sectors and the second is a wedge between marginal product and wages.

The model links intermediate good production, capital, and labor to final good output through a chain of producers. Each of these links face pledgeability constraints, requiring that firms commit a fraction of revenue in order to finance both labor and intermediate good inputs. This means that while some links in the production chain will be able to produce the optimal level of output, some may not, creating distortions in prices and output at later links in the chain. The severity and effect of these distortions depend upon the structure of the chain. To better illustrate the intuition, they first analyze the model for two extreme cases of integration while considering only symmetric financial shocks: pure vertical and pure horizontal economies. In the purely vertical case, there is only a single intermediate goods producer at each stage of production, and only a single firm sells the final consumption good; in the horizontal case, there are no intermediate goods, and firms hire only labor, which they use to produce the consumption good. These two limit cases provide good intuition for the underlying mechanisms in the model. In the vertical case, the aggregate efficiency wedge – that is, the allocation of resources in the economy – is not affected by the introduction of financial frictions. The reason is that labor is only supplied to the first link in the chain, meaning that there cannot be a misallocation of labor. On the other hand, financial frictions increase the effective cost of labor, which forces the real wage to depress before the labor market can clear, increasing the size of the aggregate labor wedge. For the horizontal case, the real wage is unaffected, and thus the aggregate labor wedge is zero. This is because labor can allocate freely across constrained and unconstrained firms, forcing all workers to be paid their marginal product. However, this causes an efficiency wedge, as some firms are constrained and thus have a higher marginal productivity than unconstrained firms. The authors analytically characterize the equilibrium revenue and expenditures for firms, then derive the vector of sectoral prices, and finally show how this translates into GDP. Using these equations, they are able to express the efficiency loss in GDP and the labor wedge as a function of financial frictions for the case in which firms have constant returns to scale.

The authors use the input-output tables from the United States to calibrate the production network in the model from flows data at the industry level. They set preference parameters to common values in the literature, and match household expenditures on final goods. As in previous papers, they cannot identify the wedge parameter at the industry level without additional assumption about differences in technology across industries. To accommodate this, they assume that technologies are constant over the business cycle, and perform robustness tests. The primary empirical results rest on describing the effect during the Great Recession. They consider two calibrations for the wedge parameter, one being the case in which financial shocks will have the largest effect and one in which financial shocks will

have the smallest possible effect given the structure of the model. The authors then compare the model with the two calibrations to alternate input-output structures to assess the effect that the production structure has on aggregate fluctuations. For the most restrictive case (i.e., the case with the smallest effect of financial frictions), the model predicts a fall of 4% in GDP, caused by a 5% reduction in hours and a 1% reduction in GDP as a result of misallocation. In the least restrictive case (near constant returns to scale; largest effect of financial frictions), they find an output drop of 28%, with a 22% decline in hours and an 8% drop in GDP. Finally, they analyze the sectoral impact of shocks, finding that sectors with the largest consumption share play the largest role in affecting aggregate output, while manufacturing is the most sensitive to financial shocks. This translates into a liquidity multiplier of 1.8 to 6.3.

Members of the audience were very interested in the paper, but had trouble digesting the complexity of the model. One member was concerned about the lack of trade credit for firms, which could have eased the financial constraint. One found it challenging to believe that the input-output matrix should be held fixed for the duration of the business cycle. Overall, members of the audience were impressed by the capabilities of the model, and asked clarifying questions. ◆

A New Dilemma: Capital Controls and Monetary Policy in Sudden-stop Economies

Michael B. Devereux, Eric R. Young and Changhua Yu

Capital inflows stimulate growth in emerging economies, but the volatile nature of these inflows can lead to sudden stops when capital inflows abruptly stop. Economists have studied policies to try and stabilize capital inflows and offset sudden stops, but there exists a policy trilemma. Emerging economies hope to achieve three goals— to have open capital markets, stable exchange rates, and independent monetary policy— but only two of these three goals can be accomplished simultaneously. Policy makers must give up one goal to accomplish the other two. This paper reevaluates the prior literature about the policy trilemma. The authors ask whether monetary policy can be supplemented with capital controls to provide financial stability and avoid sudden stops and whether this monetary policy should be macro-prudential.

To answer this question, the authors use a small open economy model in which firms need to import intermediate goods to produce. The firms use imported intermediate goods, hire labor, and rent capital to produce a variety of final consumption goods. This final consumption good composite can be domestically consumed or exported. Firms are subject to collateral constraints that are occasionally binding. These constraints require that a fraction of imported inputs be financed in advance using the expected next period value of the domestic capital holdings as collateral. When these constraints bind, there is a sudden stop and the firm is prohibited from acquiring the optimal level of intermediate goods, which reduces domestic production and causes growth in these emerging economies to diminish.

To illustrate their model results, the authors use a simplified four-period version of their model. They show that when a sudden stop occurs, manipulating the terms of trade through monetary policy cannot offset nominal rigidities alone. The policy maker will have an incentive to generate inflation during a crisis to relax the collateral constraints. If policy makers are given a capital inflow tax as an additional policy tool, they will choose to subsidize foreign borrowing during the crisis. By subsidizing foreign borrowing, they further relax the collateral constraint and temporarily improve welfare. This will be optimal during a crisis, but when there is a lack of commitment, these capital controls reduce overall welfare relative to the competitive equilibrium. The planner will only subsidize capital inflows for a short period of time until the crisis is over and then will tax capital inflows. This demonstrates the main result of the paper, that capital controls should be kept out of the control of the central bank and not be used as a macro-prudential policy. Without time commitment, capital controls are beneficial to policy makers during a crisis but harmful to society overall.

The discussion on this paper focused on the form of capital constraint used in the paper. The authors assume that the ability to acquire intermediate good depends on the expectation of future price of capital. In other papers with similar collateral constraints (e.g., Mendoza, 2010), the current price of capital is used in the collateral constraint instead of expected future prices. The audience voiced questions regarding how much this matters and the authors replied that it matters greatly. They choose to include expected future price of capital in the constraint because it seemed more natural to assume the ability to acquire debt depends on the future price of this debt, since the debt would be repaid in future periods. ◆

Mendoza, Enrique G (2010) 'Sudden Stops, Financial Crises, and Leverage.' American Economic Review 100(5), 1941–1966.

Fire-Sale Externalities

Anton Korinek and Eduardo Davila

Following the Financial Crisis in 2008, there has been much interest in understanding whether financial crisis are associated with inefficiencies. This paper focuses on whether pecuniary externalities, or externalities associated with price movements, are sources for the inefficiencies that arise during financial crisis. Pecuniary externalities typically do not matter for Pareto efficiency, but Korinek and Davila show that in certain cases these externalities do generate Pareto inefficiencies.

Korinek and Davila develop a model to illustrate the inefficiencies caused by pecuniary externalities. Their model has three periods and two types of agents, borrowers and lenders. Agents receive endowments each period, value consumption, and can choose to invest in productive capital or arrow securities. There is uncertainty in the model, which is realized in period one. Their model also includes financial constraints and fire sales. Their financial constraints are restrictions on borrower's choices based on capital and arrow securities holdings.

Using this model, the authors find that there are two distinct types of pecuniary externalities, distributive externalities and collateral externalities. Distributive externalities arise because agents do not internalize that their actions change equilibrium prices. When financial constraints inhibit optimal risk-sharing and prohibit the equalization of marginal rates of substitution across agents, these distributive externalities can generate inefficiency. The sign and magnitude of the distributive externalities depend on the differences in the marginal rates of substitution between agents, the net trading positions on capital and arrow securities, and the sensitivity of equilibrium prices to changes in aggregates.

Collateral externalities arise when financial constraints depend on aggregate state variables, like market prices. For example, when capital serves as collateral that limits borrowing, fire sales that reduce the price of that capital can reduce the borrowing capacity of constrained agents. The sign and magnitude of collateral externalities depend on the shadow value on the financial constraint, the sensitivity of the financial constraint to the asset price, and the sensitivity of the equilibrium price of capital to changes in aggregates. Korinek and Davila derive optimal tax formulas based on several sufficient statistics that can correct the inefficiencies causes by these externalities.

There was much discussion trying to better understand the two types of pecuniary externalities. Conference participants noted that the distributive externalities arise in just about any general equilibrium model, regardless of the constraints. The presenter pointed out that these distributive externalities are always zero-sum, meaning the loss of lenders is the gain of borrowers, hence why they call them redistributive. But conference participants wondered whether this was only true with a complete markets structure. Anton Korinek noted that the dollar value of these redistributive values always add up to zero, regardless of whether it is a complete market structure or not. There was also some discussion how to correctly derive optimal taxes in this setting. Korinek and Davila solve for the constrained efficient allocations and then find taxes that can replicate that solution. Conference participants asked whether this was equivalent to providing the social planner with tax instruments and letting the planner set taxes to maximize total welfare. Anton Korinek responded that in their model those two methods are equivalent and generate the same corrective taxes. ◆

This paper is motivated by the recent push in banking reform

Regulation and Reputation

Kinda Hachem and Martin Kuncl

to eliminate expectations of a bailout in favor of a bail-in, in which creditors absorb a certain level of losses before the government regulator provides any form of assistance. The authors consider an environment in which the government regulator has the ability to force a bank's non-core capital, such as its hybrid debt instruments, to be written off or converted into core capital such as common stock before any bailout assistance is given. Hachem and Kunel explore if and how banks can commit regulatory arbitrage by offering implicit guarantees against these conversions and the actions the regulator can take against these attempts to undermine this bail-in process.

Past experiences with hybrid debt instruments suggest that banks do not take their conversion requirements as given, nor do regulators punish banks for failing to convert the appropriate instruments, despite ex-ante promises to punish accordingly. This suggests that regulators fear the negative signal the conversion sends to the overall banking system. A conference participant asked how exactly do these instruments get triggered, and the presenter explained that these instruments are generally debt with coupon payments that possess a threshold tied to the bank's level of core capital. If the bank's core capital falls below a certain ratio, the coupon payments seize. This trigger is pre-defined. The bail-in feature is the regulator's ability to step in and trigger that conversion, regardless of if the threshold has been reached or not.

The authors propose a model in which a continuum of homogenous banks operate in the presence of a regulator and in the absence of aggregate shocks. The presenter also extends the model to the heterogeneous case. Each bank raises a unit of funding to invest in a project from either standard debt or

hybrid debt. In the intermediate stage, this project can realize either a high or low return. If the project realizes a low return, there is an additional stage in which there is probability of the bank recovering and ultimately reaping a high return. For the investor, the return to standard debt is not contingent on the state. Hybrid debt is contingent on the state in the intermediate stage – if the project realizes a low return, the debt is written down. However, when initially issuing the hybrid debt, the bank can choose to offer a guarantee to the investor and not write down the debt completely, lowering the funding cost for the bank. Offers at the initial stage are unobserved by the regulator. However, realized guarantees at the intermediate stage are observed and penalized accordingly by the regulator. Further, it is not credible for the regulator to impose the penalty at the intermediate stage, for - in the model - this would impact the probability of recovery for the banking system. Therefore, the regulator only penalizes the payout of guarantees if the bank recovers in the third stage.

The probability of recovery is also dependent on some notion of overall net worth in the banking system. The regulator can provide bailout funds in order to increase the net worth of the aggregate system and increase the probability of recovery. The regulator chooses both the cap on standard debt and the amount of bailout funds at the initial stage of the game. The result in the homogenous case is fairly straightforward: the regulator can maintain an equilibrium in which no guarantees are given by issuing a small punishment in the recovery state of the third stage.

For the heterogeneous case, banks are of one of two types: good or bad. The type is private information. The good type has a higher probability of reaping a high return on the project in the intermediate stage. In order for a pooling equilibrium in which no guarantees nor bailout funds are given out, both types need to earn at least as much in a pooling equilibrium with no guarantees as in a separating equilibrium with guarantees. As long as the probability of success for the good banks is sufficiently greater than the probability of success for bad banks - and the number of bad banks overall is sufficiently high - this pooling equilibrium cannot exist. For the good type banks, the cost of the guarantee is the punishment from the regulator if the bank recovers. The benefit is that they can separate out of the pooling equilibrium from the bad types and avoid paying a higher return to investors. If the probability of recovery is low enough, the benefits outweigh the costs. Therefore, if the regulator wants to achieve an equilibrium with no guarantees, he has to use bailout funds to increase the probability of recovery. ◆

The Currency Composition of Sovereign Debt

Pablo Ottonello and Diego J. Perez

Choosing whether or not to issue debt denominated in local or foreign currency is an important decision for governments, especially for those of emerging economies. While issuing debt denominated in local currency can help shield a country from crises abroad and may provide consumption insurance if bad shocks are realized, it is also associated with a time inconsistency problem. This problem stems from incentives for the government, having already issued debt denominated in local currency, to engage in costly inflation to pay off the debt. As such, governments might be more inclined to denominate debt in foreign currency in order to avoid this "original sin." In this paper, the authors study the origins of this phenomenon with a model where the government lacks commitment and, as a result, chooses to issue more of its debt in foreign currency despite the positive hedging properties associated with locally denominated debt.

The authors begin by documenting two facts regarding the currency composition of sovereign debt in 18 emerging market economies. First, foreign currency makes up, on average, two-thirds of sovereign external debt. Second, the proportion of locally-to-foreign denominated debt is strongly pro-cyclical, such that the share of debt in local currency is higher in economic booms (a correlation between output and the share of locally denominated debt of 0.4). The authors then turn to reconcile these observations in theory, starting with a portfolio problem for a representative agent's decision to borrow in securities denominated in either local or foreign currency.

The portfolio problem features a risk averse (representative) agent with incomplete markets and uncertainty surrounding future real and nominal exchange rates and her income. The only savings and borrowing instruments available to the agent are one-period debt securities that pay 1 unit of currency (either local or foreign) in the following period with no risk of default. Under a power-utility functional form specification and assuming that income and the inverse of the nominal exchange rate are iid over time, the authors show analytically and numerically that locally denominated debt can be a good hedge for negative income shocks (if income and the inverse of the nominal exchange rate are intra-temporally positively correlated) or for positive income shocks (if that correlation is negative). This result, though intuitively appealing, stands in stark contrast to the observed results seen in the data. Here, more debt is denominated in the local currency and there is no cyclical component at all.

The authors propose that a lack of commitment by governments to engage in inflationary policies are one way to

resolve this disconnect. More formally, they construct a general equilibrium model with endogenously determined exchange rates where the government chooses its debt issuance and monetary policy (i.e. the inflation rate) without having to commit. The social planner in this environment is assumed to be benevolent, choosing consumption allocations, debt allocations, and the inflation rate to maximize the representative household's utility. Because there is an issue of commitment, the planner factors in the optimal monetary policy decisions of future planners when choosing how to allocate debt between the locally and foreign denominated securities. A calibration exercise results in a split of sovereign debt more in line with the data (3% in domestic currency and 24% in foreign currency) even with a low calibrated cost of inflation. In addition, the cyclical component of the debt composition is also (roughly) matched.

Next, the authors explore the situation where debt securities can be indexed to inflation. This would, on the surface, seem to solve the time inconsistency problem of monetary policy associated with a lack of commitment. However, they demonstrate that, as long as these policies have real impacts on economic activity, the same time inconsistency problem is present. The aforementioned model is extended in two important ways in this effort. In addition to the inflation-linked debt securities, the authors explicitly model production (endowments were used before) and assume some nominal wage rigidities (a minimum wage) so as to introduce the potential of unemployment (and so generate real effects from changes in inflation). With these ingredients, the planner can have incentives to engage in inflation because of the capacity to induce involuntary unemployment and enable depreciation of the real exchange rate, reducing the value of debt payments in terms of consumption.

A conference participant noted that the assumption of one-period securities might restrict the model along some dimensions. Allowing for different maturities on debt could enable the relaxation of certain assumptions and might enable an even better fit to the data. The presenter agreed, and explained that the simplification to only one-period securities, along with some other assumptions, are made for the purpose of facilitating this important first step toward research in this area. ◆

Financial Regulation in a Quantitative Model of the Modern Banking System

Juliane Begenau and Tim Landvoigt

Financial regulation is a particularly important topic for economists. In practice, there are often unintended consequences of such regulation. The authors explore this issue in the context of capital requirements for commercial banks. More specifically, they study the impact of these regulations on the popularity of shadow banking activities. These shadow banks are alternative financial intermediaries that provide similar services to commercial banks, but are not subject to the same regulatory oversight. In general, when capital requirements for commercial banks are added (or increased), shadow banks and their liquidity or credit services become relatively more attractive, resulting in an increase in unregulated banking activity. Because shadow banks internalize the costs of bankruptcy, however, the solution to this query is nuanced: there exists a capital requirement where shadow banks exist in equilibrium.

To study this issue, the authors construct a general equilibrium model with both regulated and unregulated banks. These intermediaries can be thought of as providing depository services to agents. The regulated commercial banks are subject to capital requirements but have deposit insurance that shields their customers in the event of a bankruptcy. Because of this, the price for these securities does not internalize the social cost of default. On the other hand, the unregulated shadow banks have no such requirement, but do not benefit from deposit insurance. Thus, unlike that of commercial banks, the price of the deposit securities offered to agents by the shadow bank internalizes the costs associated with default and will endogenously limit their leverage. Herein lies the primary mechanism, as capital requirements shift activity from safer (from the perspective of an agent) commercial banks to riskier shadow banks. This paper investigates this mechanism in both a two-period and infinite horizon environment.

The model works as follows: Households maximize discounted lifetime utility and can receive income from two stochastic sources. The first is directly endowed to them, while the second can only be accessed through a financial intermediary. These intermediaries, commercial and shadow banks, are exposed to idiosyncratic valuation shocks that will help to determine whether or not they declare bankruptcy. For shadow banks, this decision depends on the revenue it commands from issuing debt to households and the cost to fund this investment and the shock. In the event of a bankruptcy, creditors seize all assets and the equity is wiped out. The problem for commercial banks is similar, but there are key differences. To operate, commercial banks are required to pay a fee for each unit of issued debt,

in order to pay for the deposit insurance. Furthermore, there is a leverage constraint – a limit on the amount of debt the bank may issue – that is proportional to its chosen level of assets. Households who invest in commercial banks, unlike before, receive the full face value of the debt they purchase: the government's deposit insurance fund and lump sum taxes to reimburse depositors of bankrupt commercial banks.

The above model, in both its two-period and infinite horizon setups, is calibrated using quarterly data from the Flow of Funds, Compustat, NIPA, and other estimates from the relevant literature. The authors show that the asset accessible only through banks is pro-cyclical, which is intuitive. Similarly, household deposit rates are counter-cyclical, highlighting the fact that the marginal benefit of liquidity is higher in good times. The model also generates pro-cyclical leverage for commercial banks and market values that are counter-cyclical for the whole banking industry. The first result reflects the fact that the capital requirement constraint is relaxed in better states of the world. The second result stems from the endogenous borrowing constraint for shadow banks, limiting the extent to which shadow banks can "lever up" in good states. Thus, shadow banks will own a smaller share of the investment asset compared to commercial banks. With regard to the welfare implication of financial regulation, the authors are able to vary the capital requirement parameter to see when it is maximized. They find that the optimal amount is around 15%, and that both types of banks become safer (less prone to entering bankruptcy) than if there were no capital requirement. This effect, however, is not monotonic, and it is not optimal to make commercial banks perfectly safe (for depositors).

A conference participant asked if the way that a shadow bank is defined affects the optimal capital requirement calculation. The presenter explained that it would, and that there are a lot of competing definitions of what a shadow bank is, meaning that the figures given here are for their running definition. In particular, the authors define shadow banks as a composite of multiple types of financial institutions, such as money market mutual funds, finance companies, or security-brokers and dealers. Another participant raised a point about the implicit bounded rationality of households. That is, there are certain things that households don't (or can't) observe and that these things are fed into the prices. The presenter agreed, and explained that their results suggest that people, indeed, should be paying attention to these things. ◆

Estimating Macroeconomic Models of Financial Crisis: An Endogenous Regime Switching Approach

Chris Otrok

Macroeconomic models of financial crisis are highly non-linear, which makes them hard to solve and estimate. The fact that financial constraints bind occasionally amplifies regular business cycles and creates pecuniary externalities. Therefore, solving these models accurately and estimating its key parameters properly is crucial for the study of macro prudential policies or crisis management policies.

This paper provides a tractable method to solve and estimate macroeconomic models with occasionally binding borrowing constraints and several endogenous and exogenous state variables. The model is a small, open economy with a representative household-firm that makes consumption, investment, borrowing-lending, and production decisions. The firm needs to pay a fraction of working capital, labor and imported materials, before sales are realized, and does so by borrowing from international capital markets. The amount of bonds and working capital loan are restricted to be a fraction of total assets - in this case, the value capital stock. The economy is hit by exogenous shocks to interest rate, productivity, the price of imported intermediates, and to the fraction of assets that can be collateralized. The interest rate faced by the country is the risk-free interest rate plus a country risk premium component.

The solution method assumes the existence of two regimes: one in which the borrowing constraint in binding and another where the constraint is slack. The probability of regime switching is assumed to be logistic and depends on the leverage of the economy. When leverage is high, agents understand that it is more likely that - given the regime dependent distribution of exogenous shocks - the economy can enter into a crisis regime, as defined by an episode of binding constraint.

The model's equilibrium equations can be approximated using Taylor expansions around the two deterministic steady states. By using a second-order Taylor expansion, the model's solution incorporates risk, as households consider the likelihood of entering into financial crisis in its decision rules. One key parameter in this approach is the logistic coefficient that governs the positive relationship between leverage and the probability of the constraint to bind. When this coefficient goes to infinity, the borrowing constraint binds at a deterministic value of leverage.

The authors expose how sensitive the households' decisions are to the calibrated logistic coefficient. For low values, a negative productivity shock decreases leverage considerably, in what can be interpreted as precautionary deleveraging. When the coefficient is larger, agents have more certainty about when the

constraint binds, therefore do not incur as much deleveraging. The results are also very different to the case when the economy switches regime exogenously. Particularly, the endogenous regime-switching can amplify the business cycle due to the non-linear interaction between leverage and the probability of the financial crisis.

The authors estimate the key parameters of the model for Mexico using Bayesian methods. Unlike the prior literature, the regime switch and the regime-dependent parameters of shocks are estimated simultaneously. This is crucial because, in the model, agents understand that a crisis might occur. The authors are working on evaluating policies such as capital controls that would have avoided or mitigated the observed crisis in Mexico. ◆

Constrained Efficiency in a Human Capital Model

Yena Park

It is well known that labor income shocks and incomplete markets in a standard neoclassical growth model change individual's incentives to save. Further, precautionary savings lead to an over-accumulation of capital, compared to an environment with complete markets. However, the steady state capital stock in a competitive equilibrium can theoretically be higher or lower than the steady state capital stock of the constrained planner's problem. This is due to two opposing channels of pecuniary externalities. With the first channel, the insurance channel, the planner can mitigate the risk from labor income shocks by decreasing capital, implying a lower wage rate and a higher interest rate - thus decreasing the stochastic part of total income and increasing total welfare. With the second channel, the redistribution channel, the planner can increase total welfare by increasing capital - which in turn increases the wage rate and decreases the interest rate. With an increased wage the capital and consumption-poor benefit, therefore increasing total welfare. In a recent paper, Davila, Hong, Krusell and Rios-Rull (2012), DHKR hereafter, show that with a model calibrated to fit the observed wealth distribution, the redistribution channel dominates. This implies that the completive equilibrium generates an under-accumulation of capital compared to the constrained efficient solution.

This paper revisits these results by introducing human capital accumulation into the model. Including human capital accumulation generates an endogenous human capital dispersion and therefore an endogenous labor income dispersion. This generates another redistribution channel through which the constrained planner's solution differs from the competitive equilibrium - specifically, the redistribution of human capital across agents. For human capital-poor households the planner can improve welfare by decreasing the wage rate and increasing the interest rate, i.e. decreasing the capital stock. Since human capital-poor households also tend to be consumption-poor households, a decrease in the capital stock can improve welfare and works in a direction opposite that of the wealth redistribution channel. This paper shows that human capital inequality and the correlation between human capital and wealth are important components that determine how much the wealth redistribution channel can be mitigated through the inclusion of human capital accumulation. Using simulations, the author shows that a low correlation between human capital and wealth and a higher human capital inequality can overturn the conclusion of DHKR and lead to over-accumulation of capital in the competitive equilibrium compared to the constrained planner's solution.

The author also introduced risky human capital to further attempt to mitigate the effects of the wealth redistribution channel. The introduction of a multiplicative shock to human capital increases the mean and variance of labor income, and the insurance channel then becomes stronger. As before, increasing the strength of the insurance channel can overturn the DHKR result of under-accumulation, as the insurance channel acts against the wealth redistribution channel. The author calibrates an infinite horizon model with endogenous and risky human capital to match the earnings and wealth Gini coefficients and solves for the steady state capital-labor ratio. Including endogenous and risky human capital does not fully overturn the effect of the wealth redistribution channel, so the constrained efficient capital-labor ratio is about 3.6 times larger than the competitive equilibrium capital-labor ratio. However, the degree of under-accumulation is lower than that in the DHKR economy, in which the constrained efficient capital-labor ratio is about 8.5 times larger than the competitive equilibrium capital-labor ratio.

There was an initial discussion about what elements of the model were driving the redistribution of wealth channel to dominate over the insurance channel in the DHKR economy. The author responded by saying that what matters is the amount of wealth dispersion compared to the variance of labor shocks. A conference participant asked if over-accumulation in capital would imply an under-accumulation of labor and vice versa. Park answered that, theoretically, both variables could be over- or under-accumulated since all the channels affect both variables but the relevant statistic is the capital-labor ratio. Another conference participant asked if there were some restrictions on the fundamentals of the model that could show which channel will dominate. Park responded that this is not possible and, therefore, determining the value of the capital-labor ratio in the competitive equilibrium compared to the constrained efficient allocation is a quantitative question. ◆

Interventions in Markets with Adverse Selection: Implications for Discount Window Stigma

Huberto Ennis

The Central Bank discount window loans is an important governmental program that seeks to increase liquidity and enhance the efficiency of financial markets, especially in times of financial distress. However, this program can create stigma, such that banks that borrow from the authority are perceived as riskier. Given this stigma, banks would avoid borrowing from the discount window and would borrow from the market at even higher interest rates. Whether the discount window stigma exists or not is a relevant and important question, as such a stigma could compromise the effectiveness of the discount window policy.

This paper studies the mechanisms in which stigma can arise in equilibrium in a model of adverse selection and different configurations of the central bank discount window policy. The model economy has a set of risk-neutral investors, a continuum of banks, and a central bank. The only goal of the central bank is to fund investment projects as they have positive expected return. Banks are heterogeneous in the initial amount of asset as well as in the distribution of assets' returns. The quality of the bank's asset is private information. Banks hold some cash but still need to borrow money, either from the central banks or from investors, to undertake investment projects. Investors compete in the market of loans and can only observe the final cash flows of banks.

There are three time periods. At time 0, banks decide whether to take loans from the central bank or not, which is observed by investors. At time 1, banks that want to take a private loan meet an investor and propose a debt contract, specifying the size of loan and the interest rate. Investors only know the probability distribution of future banks' income, and know that the repayment probability is increasing in the bank's asset type. The central bank loans are junior, meaning that banks repay the discount window loans only if the private loans are paid fully.

The equilibrium without a discount window is such that only banks with assets below a threshold borrow from the market and invest. The high type banks do not borrow and do not invest. When the discount window is in place, there are multiple equilibriums. If the central bank offers loans that are enough to undertake the project, there are at least two equilibriums in which no bank borrows simultaneously from the discount window and from investors. In one equilibrium, low repayment probability banks (low asset types), borrow from the discount window and invest; medium asset types borrow from investors and invest; and high asset types do not borrow and do not invest. In this equilibrium each bank pays exactly the same interest rate, therefore there is no stigma.

There is one configuration of the central banks discount window that delivers elements of stigma in equilibrium. When the central bank offers small loans, such that banks that borrow from the authority also have to borrow from investors, it is the case that banks that borrow from the discount window are riskier and pay a higher interest rate in the market. On the other hand, banks that only borrow from investors pay an interest rate that is higher than the discount window rate. However, this is in an equilibrium where banks are indifferent between borrowing only from investors or from both sources. In addition, the selection effect that arises in equilibrium is the result of the central bank goal of increasing investment rather than an unintended result of a discount window policy.

To conclude, this paper discusses the elements of the model that would add more realism to the central bank discount window policy and potentially change the implications for stigma. These elements are: not restricting the amount of the discount window loan; setting a discount window interest rate with a penalty, require banks assets to collateralize the loan, and assume central bank loans are senior. ◆

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Participants and attendees shown at the Mosher Alumni House at the University of California Santa Barbara.

Technology, Skill, and the Wage Structure
Nancy L. Stokey

Stokey addresses the distribution of aggregate effects as a result of technological change. She notes two empirical regularities about inequality that have not been fully addressed. First, that there is growth in wages among the highest and lowest earnings but little in the middle (wage polarization). Second, that between-firm inequality is driving much of the increase in inequality. To address these regularities, Stokey builds a model in which technology shocks can have diffuse effects across even distant tasks. In the model, assortative matching guarantees that higher ability workers sort to higher technology firms. The employment effects caused by a technology shock depend upon the substitutability of goods. If goods are substitutable, other sectors shrink, with workers migrating to the newly more productive sector. Specifically, more productive workers move to the good that received the technology shock, while the effect is ambiguous for workers in the less productive sector. If goods are complements, these results are reversed, with employment contracting for less productive workers at the affected task, and ambiguous employment effects occurring at more productive firms. The model allows for rich analytical characterizations, which Stokey uses to better characterize the evolution of inequality over time.

In the single-sector model, a final good is produced using CRS technology that takes differentiated tasks (or goods) as inputs. Each task is characterized by its technology level, and by the distribution of worker human capital employed. That is, for each task, there are workers of different skill levels, though each is required to be within thresholds characterized by the technology level. Equilibrium is competitive; thus, workers and tasks are paid their marginal product given their human capital and technology. As technology changes, human capital thresholds shift, which changes the allocation of workers across firms. With this model, Stokey derives analytical results and shows that for some parametrizations, it's possible for wages in some firms to decrease as a result of technology change in other firms. Next, she alters the model by making final production CES over a set of differentiated inputs. These differentiated inputs are a weighted average of the tasks in the economy, with some degree of substitutability, and are thus similar to the production of the final good in the single-sector model. Here, changes in technology directly affect output of each "task," and impact aggregates through changes in output in different sectors. This model allows for richer dynamics of wage and employment for workers at different tasks in the economy. Stokey uses these two models to explore whether technology change "lifts all boats."

Stokey performs a number of numerical examples to explore the model's prediction for wage inequality. The parameter choices are standard from the literature, while she varies the degree of substitutability in the two models to assess the effects under various parameter sets. First, she assesses the effect of a technology change in the single-sector model. When there are no sectors and thus no price effects to dampen the change in demand as a result of changes in technology, Stokey shows that wages can decrease for workers not directly affected by the technology. Namely, she shows that for an improvement in technology near the middle of the technology distribution, wages decrease for workers in firms above or below this firm. When she, instead, considers the multi-sector economy, output prices for each sector adjust when a technology shock occurs. For hard-hit sectors, output declines and prices increase, whereas in the single-sector case, the price of the final good adjusts and workers reallocate. By allowing both prices of intermediate goods to adjust and workers to reallocate, wages increase for all workers when the same set of shocks are simulated, reversing the results from the single-sector model.

One member of the audience was confused about the structure of the labor market, wondering why workers of all skill types were equally substitutable, given their skills. Stokey noted that having high skill workers be complements would be a better story for discussing the upper tail of the wage distribution, which was not the exclusive point of her model. Another audience member noted that the change in the wage distribution under the single-sector case was just the inverse of the wage polarization story, with wages declining for the tails. Stokey noted that this was for a specific numerical example with one set of shocks. ◆

On the Welfare Implications of Automation
Maya Eden and **Paul Gaggl**

The falling price of computers and their increased importance in production over the past 20 years has raised many questions about the distributional and aggregate changes in income due to automation. Previous literature has looked at how the accumulation of Information and Communication Technologies (ICT) has impacted the distribution of income. First, the literature has looked at the effects of ICT on the distribution of income between capital and labor, and found a decrease in labor's share of output starting around 2000. This is evidence toward the theory that ICT is a substitute for labor. Second, the literature has investigated the effects of ICT on the distribution within capital and labor, specifically, the polarization of the labor market, which describes increases in wages at the tails of the income distribution, as well as a decline in wages in the middle. The current paper revisits these questions and quantifies the relative importance of both effects in a general equilibrium framework.

The authors decompose the trend in the labor share into routine and non-routine labor shares. The aggregate labor share was flat at about 65% from 1970 to 2000, after which it begins to steadily decrease. The decomposition reveals that the routine labor share decreased throughout the sample from 1968 to 2012 - while the non-routine labor share increased from 1968 through 2000, after which it leveled out. Therefore, the authors conclude that the entire decline in the aggregate labor share in the U.S. can be accounted for by routine occupations. Next, the authors decompose the trend in the capital share. To do so, they estimate the relative prices of ICT capital and non-ICT capital from 1950 to 2010. They find that the relative price of non-ICT capital stayed flat over this time period while the relative price of ICT capital experienced a strong decline. The authors also calculate the depreciation rates and find that the non-ICT capital depreciation rate remained constant at around 7% over the time period while the depreciation rate of ICT capital was flat at about 15% until 1980 - when it began a steady increase to about 20% in the early 2000. Using these estimated prices and depreciation rates the authors calculate ICT and non-ICT capital shares and find that, while the non-ICT capital share fluctuated around 34%, ICT capital share increased from about 0.5% in 1950 to about 4% in 2012. The authors argue that these trends indicate that ICT capital did not crowd out other forms of capital but instead crowded out routine labor.

Using the decomposition, the authors calibrate a nested CES production structure, where aggregate output is Cobb-Douglas with two inputs: capital and tasks. Tasks are either routine or non-routine and can be performed by either capital or labor. Using this calibrated technology, the authors embed it into a standard neo-classical growth model and run a counterfactual exercise in which the price of ICT capital is held fixed at its 1968 value and compare the counterfactual steady state to the current data. From this exercise, the authors conclude that the accumulation of ICT capital due to its strong price decline accounts for about half the decline in the labor share and increased total welfare by 3.6%. They show that there was both a redistribution of income between and within capital and labor, but argue that the effect of ICT on the redistribution within labor (i.e. the polarization of the labor market) was the larger effect.

During the presentation, a conference participant noted that the price of ICT capital began to fall pre-1950 and questioned whether comparing one steady state to another is a fair exercise. The author agreed, but responded that the data did not go back further so it is unclear when the price of ICT began its decline. Another participant asked about the classification of occupations into routine and non-routine types. The author responded that the classifications are based on the Dictionary of Occupational Titles, following the earlier literature. A discussion about whether or not wages influenced the classifications followed. The author added that they had also tried classifying occupations by their seasonality and got an almost identical categorization of occupations into routine and non-routine. ◆

Optimal Unemployment Insurance and Cyclical Fluctuations

Rui Li and **Noah Williams**

The authors study the design of optimal unemployment insurance in an environment with moral hazard and cyclical fluctuations. The author notes that the observed pattern of the current unemployment insurance program is arbitrary and subject to uncertainties in its implementation. Compared to Hopenhayn and Nicolini, which was one of the first papers to discuss optimal unemployment insurance, their model adds business cycle fluctuations by having the job-finding rate switch according to an exogenous Markov process. Under moral hazard, the optimal contract trades off insurance with incentives, and this relationship varies with the business cycle. In a recession, the required insurance is greater - as for a given amount of search effort a worker will be employed for a longer period of time. However, the incentive problem is also magnified, as a worker will get fewer job contracts and so generate less information. The optimal contract resolves this tension by including more search effort when it is more productive in boom, but with a greater reward in promised utility terms when the worker finds a job in a recession. In a special case with exponential utility and exponential cost function, the authors show that the contract can be implemented by allowing the worker to save and borrow, providing benefits which are constant in each aggregate state, providing a re-employment bonus and giving an additional bonus or charge when the aggregate state changes.

In a quantitative implementation exercise, the authors calibrate the model using a stylized version of the current system, which provides constant replacement rate of 47% for six months in a boom and nine months in a recession, following Hopenhayn and Nicolini. The authors show that the optimal unemployment insurance contract leads to a significant increase in job-finding rates, as well as a corresponding reduction in both the unemployment rate and the average duration of unemployment. In a recession, the optimal system reduces unemployment rates by roughly 2.5 percentage points and shortens the duration of unemployment by roughly 50%.

To gain insight on the impact of the reform of unemployment insurance in the most recent recession, the authors simulate a recession 70 weeks long and compare the performance of three systems: the benchmark current system with 39 weeks of benefits, the current system with benefits extended to 99 weeks, and their

optimal system. Under the benchmark system, unemployment rates increase by 1.4 percentage points as the economy goes from a boom to the long recession. The authors find that the extension of benefits has a very small impact, increasing unemployment rates by only an additional 0.1 percentage point. They also find that under their optimal system the unemployment rate increases by only 0.4 percentage points in the recession, and throughout the recession remains 2.7 percentage points lower than the current system.

The authors note that the simplicity of the model allows them to isolate the effects of insurance and incentives on job search as a determinant of unemployment. However, it also means that they are unable to address several important issues regarding the impact of unemployment insurance on job search and employment, such as mismatch between unemployed workers and job vacancies and labor force participation.

One of the participants asked why the optimal policy does not incorporate the feature that search effort increases when unemployment spell increases. Williams noted that in their model, the worker's consumption would decrease instead. Another discussant asked what drives the authors to believe that people search too little in boom and recession, or what evidences are in the data. Williams noted that the fact that the current unemployment rate remained high and the unemployment program is arbitrary in the recession are partly their motivations. ◆

Retirement Financing: An Optimal Reform Approach

Roozbeh Hosseini and Ali Shourideh

The U.S. government currently plays a large role in financing retirement consumption, with Social Security benefits comprising about 40 percent of all elderly income. These benefits currently make up about 30 percent of total federal expenditures, and the receipts of Social Security taxes are about 30 percent of all federal tax receipts. With a large cohort of individuals soon reaching retirement age, this demographic change poses a serious fiscal challenge, as outlays of Social Security will become larger than revenue collected from taxes. This paper proposes a new approach to retirement financing policy reform. The goal is to find optimal government tax and transfer policies that minimize the net present value of transfers to each generation while leaving the distribution of lifetime welfare across individuals unchanged. This strategy allows the authors to focus on policies that can improve efficiency without redistribution.

The authors present an overlapping generations model with constant population growth rate and fixed maximum age of individuals. In the model, individuals differ in their earnings ability - which is fixed throughout their lifetime – and in their mortality rates over time. A key assumption of the model is that higher-ability individuals have a lower mortality rate in each period. Individuals have utility over consumption, leisure and bequests, and all retire at the same exogenous age. There exits only a risk-free asset for individuals to save - no annuity or life insurance markets. Upon death, any holdings of the assets are transferred equally to all individuals that are alive in the form of bequests. The government collects taxes on labor earnings, consumption and corporate profits and makes transfers to individuals at both pre- and post-retirement ages.

The authors use a calibrated version of the model with the current tax/transfer and Social Security system of the US to show that the model matches well with the distributions of consumption, earnings, and bequests. Then using the lifetime welfare of the status-quo model, they solve for taxes on assets, bequests, and labor income that minimize the present value of outlays less receipts for the government, subject to individual incentive compatibility. That is, individuals optimize given their budget constraint, and individuals lifetime welfare must be greater than or equal to their status-quo welfare. The authors find that there should be a progressive subsidy on assets with the magnitude of the subsidy increasing with age. Overall, the optimal average marginal subsidy post retirement is 3.2%. They also find that there should be a regressive tax on bequests with taxes at the bottom of the wealth distribution for all ages equal to 100%. The average marginal tax rate on bequests is about 60%. Lastly, the authors find that the optimal labor income taxes remain almost unchanged from the current U.S. labor income taxes. In terms of transfers, the exercise shows that the aggregate amount of transfers to an individual should not change, but the timing of these transfers should. That is, per-retirement transfers should increase by 87% while social security benefits should decrease by 14%.

During the presentation, a conference participant asked why the authors decided to use a model without annuity markets when they do exist in the current system. Hosseini responded that these markets are relatively small and that they would be crowded out by the social security system. He added that the model, without these markets, matches the desired moments well. Another conference participant questioned the fixed retirement age of individuals and wondered if this choice was driving some of the results. Hosseini stated that the progressive subsidy result holds even if the retirement age of individuals was endogenous. Since the model does not deal with the forthcoming demographic changes, a question about how to incorporate such a shift into the current model was asked. Hosseini said that to answer the question of which policies are optimal with a demographic shift, the model would have to include transition dynamics. Following his response a participant commented that the costs of transition may be large and therefore, comparing one steady state to another may be misleading since it does not consider these costs. ◆

Identifying Ambiguity Shocks in Business Cycle Models

Anmol Bhandari, Jaroslav Borovicka and **Paul Ho**

Survey data on households' forecasts of future macroeconomic outcomes shows pessimistic biases as well as co-movement of these biases with business cycle frequencies. These systematic biases remain steady across 40 years of data. This paper extends the robust preference model of Hansen and Sargent (2001) to which agents' pessimism is motivated by concerns over model misspecification. Concerns over misspecification of an agent's "base" economic model lead agents to act on their belief of the "worst-case" scenario of the economy. The authors show that "ambiguity shocks," or time-variation in the agent's worst-case scenario beliefs, endogenously affect equilibrium dynamics, particularly labor market variables.

The authors use forecasts from the University of Michigan Surveys of Consumers and the Survey of Professional Forecasters on unemployment, inflation, and GDP growth. With these two sources they construct "belief wedges," which represent the bias of the household's forecast relative to the rational forecast. The presenter defended the authors' use of the SPF forecast as the rational forecast, citing it as "accurate enough" despite several conference participants pointing out its frequent inaccuracies. Another participant noted that these wedges might not be rooted in pessimistic bias – that is, the consumer might face a different basket of goods than the surveyor's basket and hence generate a different yet accurate forecast. The presenter, while noting that this may be the case, assured that the authors are focused on the co-movement of variables, and that their one-factor structure should eliminate any noise caused by this possibility.

The authors identify the ambiguity shocks from the survey data, assuming that the survey data is indicative of the consumer's "worst-case" belief. One participant asked if there is a narrative behind where these shocks come from. The presenter noted that for now they are treated as exogenous, but their framework is flexible enough to incorporate endogenous shocks, perhaps tied to movements in the unemployment rate.

The authors estimate a dynamic stochastic general equilibrium model with sticky prices and labor market frictions. The identified adverse ambiguity shocks have contractionary effects, especially in the labor market, where increased pessimism stemming from the shock decreases the number of new job matches by affecting both firm hiring decisions and search effort. One participant noted that there are policy implications: since households are fairly poor at forecasting, government agencies could do a better job of advertising their forecasts, which would be a relatively cheap way of reducing ambiguity. The presenter noted that optimal policy should include management of household expectations, however, past efforts by monetary authorities have shown little success in doing so. ◆

The Tail that Wags the Economy: Belief-Driven Business Cycles and Persistent Stagnation

Julian Kozlowski, **Laura Veldkamp** and Venky Venkateswaran

Why are some economic downturns more persistent than others? In the aftermath of the recent financial crises, this question seems more relevant than ever. Most macro modeling approaches generate these effects utilizing persistent shocks (e.g., assuming some Markov process). This approach, however straightforward, doesn't get us far in explaining why the recent downturn was so severe. This paper addresses this issue by looking at beliefs. The authors' explanation is a story of learning: agents, instead of simply inferring about what the state will be tomorrow, are uncovering more information as time continues and are updating their assessment of risk. In terms of the recent recession, the large and negative shock was seen as very unlikely and drastically affected how agents assess the probability of tail events. Smaller shocks, like the recession in 2001, are more numerous in the agent's information set, and so don't lead to long-lasting effects.

The main contribution of these authors is the belief formation mechanism. They put forth the realistic assumption that neither agents nor modelers truly know the distribution that shocks are drawn from. Instead, they will estimate the distribution, adding in data points as they arrive. For flexibility and generality, agents will non-parametrically estimate the distribution of iid shocks using a Gaussian kernel density procedure. The assumption of independence is interesting, considering the ultimate goal is to generate persistence, but assures that any that might be generated is due to this belief mechanism. Thus, if there is a large (rare) negative shock in a period, agents will add it to their data and estimate, which can have large effects on that distribution from a period-to-period basis. Smaller (more common) negative shocks won't change that estimated distribution much, and so won't have such long lasting effects (the effect will be permanent, but much smaller).

The mechanism highlighted above is nested within the Gourio (2013) model. A representative agent with recursive preferences lives forever in discrete time and maximizes her present discounted value of lifetime utility over consumption and leisure. This agent owns a unit measure of firms with Cobb-Douglas technology that use labor and capital as inputs. There are two types of iid shocks in this economy: an aggregate capital quality shock (the distribution of which is estimated by the agent) and an idiosyncratic firm shock that scales each firm's access to resources. A firm hires labor before shocks are realized and is exposed to default risk firms. Firms also have access to funding from a debt market where it may issue bonds and receive a price. The shocks and debt obligations feed into the decision of default for firms. In the event of a default, a fraction of the firms' assets are sold to a new firm at a discounted price.

In order to calibrate the model, the authors must first obtain measurements of the key variables, many of which must be backed out of other series. Most important to the novel contributions of this paper is the measurement of aggregate capital quality shocks. The authors utilize two series from the Flow of Funds: the values of post-war non-financial assets evaluated at historical cost and also at market value. They are able to recover this shock from these series with some correction adjustments for inflation and depreciation. What remains is the data series that is fed into the representative agent's non-parametric estimation of the distribution of shocks. The results of this estimation were then showed for two years, 2007 (before the crisis) and 2009 (after). After the crisis we can see a reasonably large "blip" in the tail of the distribution. To give numbers, while there is a mass approximately equal to 0 in the extreme left tail (below a value of 0.9 of the shock) before the crisis, after there is a mass of 2.5%.

How does this affect other key variables? After calibration, the authors show that the difference above leads to a 12% drop in output in consumption, a 7% drop in investment, and an 8% drop in employment. With regards to output, this matches the drop actually observed in the data. Moreover, this effect is persistent. Despite the independence of the shocks, the belief formation mechanism generates these drops long into the future (under simulations). For comparative purposes, when looking more closely before and after the 2001 recession, drop is observed but that drop is not nearly as persistent, reflecting the notion that the recent financial meltdown was so long lasting because it drastically altered how agents assessed tail risk. The authors also explain the nuances of the results. For instance, because debt is subject to the possibility of default, the effects of increases in tail risk (or, rather, the assessment of the likelihood of such events) are larger and more persistent when there is more debt in the economy.

A conference participant inquired about the choice to use post-war data. The presenter explained that this was mostly due to data availability. In the paper, however, they address the question more thoroughly. Not only do they extend their data to the great depression (utilizing a few tricks to infer the values of data before 1950), but they also consider the idea that past data, especially data from the distant past, might not be as pertinent as more recent data. That is, the general institutional structure in the 1930s might not be directly comparable to events occurring today. As such, we might expect agents to give observations from a long time ago less weight when estimating. As expected, adding in this feature (with the lengthened dataset) dampens the effect of the recent recession in simulations. ◆

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Asymmetric and State Dependent Dynamics in Credit and Labor Markets

Nicolas Petrosky-Nadeau, **Benjamin Tengelsen**, and Etienne Wasmer

The authors propose that the congestion property of matching markets limits booms and amplifies downturns. The authors first note that there is high contemporaneous business cycle correlation between unemployment rate and BAA-10Y treasury interest rate spread. There is also similar time series asymmetry in that they display similar skewness and kurtosis of deviations from trend. The authors also note that unemployment moves twice as much during a recession compared to normal times, but there is little response during expansions. They show that unemployment and measures of the spread have longer right tails, and that a significant portion of the variance is attributable to infrequent large deviations. They also show that the labor market response when the spread increases 1 percentage point is much larger if the labor market is slack, indicating state dependence.

In their model, workers in a representative household supply labor. Firms produce with labor. Financial institutions supply funds to firms. There are labor market and credit market with search friction. Firms add production capacity when they match with a creditor, receive funds when job is vacant to cover cost, and share revenues during production. Financial institutions search and manage credit market matches, provide funds when a job is vacant, and receive payment from jobs in production. Meetings in the financial market follow a CRS matching function. In the labor market, vacant positions search for the unemployed, funded by creditors, and unemployed workers search for vacant jobs. They show that the equilibrium credit market tightness is increasing search costs and decreasing in relatively more entry of creditors.

They estimate the model by a simulated method of moments. The model shows that there is asymmetry and state dependence in labor and credit market variables over the business cycle. The authors comment that they will add higher-order moments to estimation and endogenize job destruction and credit destruction in the future.

Several discussants commented that the fact that unemployment rate is bounded by zero will give rise to skewness. Tengelsen noted that a zero unemployment rate did not show up in the data. Another discussant pointed out that the fact that the shocks are log normal would also lead to skewness. One discussant asked how the findings of the paper reconcile with other different findings in RBC models. A presenting author acknowledged that the current version of the paper did not address these questions, and they will extend the work in the future. ◆

The Slow Job Recovery in a Macro Model of Search and Recruiting Intensity

Sylvain Leduc and Zheng Liu

The authors of this paper attempt to address some anomalous behavior of the labor market during the recovery from the Great Recession. They focus on the differences between observed job finding and filling rates, and what would have been expected from a standard model of the labor market. To account for these differences, they employ a canonical model of the labor market with frictions, and extend it to include firm and worker search intensity. They further allow for a sunk cost associated with posting a vacancy, which changes entry conditions of firms. Unlike the textbook model, this allows both margins to vary with the business cycle, which rectifies the inconsistency with the data.

The model is based on a monthly version of the Mortensen-Pissarides (DMP) framework in which firms post vacancies until a condition is met and then workers search for those jobs randomly, with both parties meeting at rates determined by the equilibrium quantities of unemployed workers and firms with vacancies. The authors alter this model to allow a sunk cost associated with posting a vacancy, which is drawn from an i.i.d. distribution. In the canonical DMP framework, firms only face a cost of keeping a vacancy open, rather than posting one initially. Here, firms must pay a cost to keep a vacancy posted (modeled as an "advertising cost"), and also pay a cost to initially post a vacancy that is not counted toward maintaining the posting. This is important because the cost paid by the firm for maintaining an open vacancy is now a choice variable, which allows it to change differentially across the business cycle. Thus, when the economy looks bleak, a firm can decide to stop trying to attract workers, while still keeping their vacancy posted. This is contrasted with the standard model, in which the number of vacancies would fall. Likewise, workers have the ability to choose their search effort in obtaining jobs, which allows cyclical fluctuations on the worker's side as well. The model is otherwise standard, allowing for aggregate shocks in the productivity of jobs over time, and including a bargaining mechanism that is consistent with Hall and Milgrom's solution to the Shimer Puzzle.

The authors calibrate the model using a mostly standard calibration for monthly labor market search models. For their baseline experiment, they calibrate the distribution of sunk costs to be uniform, which is a middle ground between no flexibility in posting and complete flexibility – as would be the case in standard models. They also set wage rigidity to be high, relative to the estimates from Hall and Milgrom (0.95), although this is still within their proscribed range. They employ Bayesian estimation, given model parameters to recover estimates of the distribution parameters. Having calibrated and estimated the parameters of the model, they explore the mechanism and then simulate the model by feeding in TFP shocks for the period in and around the Great Recession. Like the standard Mortensen-Pissarides model, a decline in TFP leads to a decline in hiring and vacancy postings. However, unlike the standard model, the value of an unfilled vacancy remains positive. This is because of the sunk cost paid to post a vacancy. Instead, firms respond by decreasing their recruiting intensity, since matches are less valuable than before, while workers respond by decreasing their search intensity, since the surplus of the match available for bargaining has decreased as well. Combined, these two effects serve to cause an outward shift in the Beveridge Curve, corresponding precisely to what we observe in the data. To assess the relative importance of these two factors in explaining fluctuations, they shut each off in turn (recruiting, and then search intensity), and compare aggregate outcomes. They find that when either intensity is held fixed in response to an aggregate shock (as would be the case in the standard model), the response is cut in half.

The audience was interested in the presentation, and had a few questions. First, there was confusion about the notion of vacancies being "costless" in the standard model. The first author explained that if one thought about the cost of maintaining a vacancy in the standard model as the cost of "advertising" that vacancy, the terminology was equivalent. Another member of the audience wanted to understand the effect in the model of differences in matching elasticity. The first author responded that they hadn't done that yet, but wanted to take a standard elasticity measure and show that these effects could take the model most of the way to explaining the phenomena. Finally, some audience members were concerned about heterogeneity in the labor market, and whether these results could be driven by compositional effects. The authors responded that while that could contribute, none of the results in the presentation were driven by compositional effects. ◆

Mortgage Debt, Consumption, and Illiquid Housing Markets in the Great Recession

Carlos Garriga and **Aaron Hedlund**

It is well-known that during the Great Recession there was a large decline in home prices and an ensuing foreclosure crisis. A lesser-known fact is that the time it took to sell a home more than doubled, representing a significant increase in housing market illiquidity. The Federal Reserve took action to aggressively intervene in financial markets to attempt to reduce the cost of borrowing and boost the economy, but it remains unclear whether these actions helped improve housing markets. This paper explores the effects of housing market illiquidity.

The authors construct a macroeconomic model with housing search frictions, endogenous credit constraints, and equilibrium default. In the model, the ability to sell a house varies endogenously. Sellers choose a list price for their home and, in equilibrium, this determines their sales probability. Because of the heterogeneity in the model, this leads to a computationally challenging problem. To make the model tractable, the authors introduce real estate brokers to act as intermediaries. Sellers and buyers individually match with homogenous brokers. As long as the broker makes a non-negative profit in expectation, the broker will accept the seller's list price and instantaneously match with a buyer. Thus, this frictional housing market can be summarized as a number of submarkets indexed by list prices, each with an endogenous match probability that defines housing market illiquidity. Submarkets with higher list prices have lower match probabilities.

Credit liquidity and housing liquidity are directly connected in equilibrium. As housing liquidity decreases, the cost of borrowing increases. This connection occurs because a reduction in housing liquidity increases mortgage default. A household that is financially distressed but has equity would choose to sell their home rather than go through default. However, with housing illiquidity, this financially distressed household might be forced into default prior to being able to sell the home. Thus, housing illiquidity increases default – which then gets priced into the mortgage.

The authors calibrate their model and then replicate the Great Recession. They decompose the shocks that occurred during the Great Recession to determine which has the largest quantitative effect. They find that increasing labor market risk, with households having a higher probability of negative income shocks, is the key driver of housing market declines. With this shock alone, their model generates a 12% decline in home prices and an eight-week increase in sales delays. Total factor productivity shocks did not have much of an effect, increasing sales delays by only one week and reducing home prices by only 2%.

The authors are able to quantify how much housing illiquidity amplified the housing market decline. For example, they find that it played an important role in foreclosure dynamics. If sales delays had not occurred, foreclosure rates would have only increased by about 1.25% rather than 4.5%. Even if they force home prices to decline as much without sales delays as they declined with sales delays, foreclosure rates would have only increased by 2.5%. Thus, the fact that there are search frictions in housing markets – and that homeowners cannot sell their homes immediately when they need to – has a big impact on foreclosures.

Conference participants discussed whether the mortgages seen in practice are the optimal contracts. With perfect information, we would expect to see mortgage contracts with renegotiation clauses that allow homeowners to avoid foreclosure when financially distressed. The first author commented that renegotiation is uncommon because of moral hazard. Since there is not perfect information, borrowers who are able to make payments might demand a renegotiation from the lender when aggregate conditions deteriorate. Because of this, rather than solving for some optimal mortgage contract, the model includes the standard mortgages seen empirically. There was also some discussion about the foresight that households have in the model. The model assumes that as soon as the Great Recession occurs, households can foresee all future conditions. Since the household's knowledge of future labor risk plays a big role in the home price declines, there was some discussion that this assumption may be too strong. However, the presenter commented that the household's anticipation of future income risk was not the only factor that led to home price declines, as financial conditions also played a large role in their model. Rather than suggesting household foresight played a large role, their central message is that the standard total factor productivity did not play a large role in home price declines. ◆

Consumption and House Prices in the Great Recession: Model Meets Evidence

Greg Kaplan, **Kurt Mitman** and Giovanni L. Violante

In the past fifteen years, there has been a boom and bust in both house prices and nondurable consumption. The authors ask a number of questions related to this boom-bust cycle. First, they seek to understand what drove the cycle in home prices. Then, they ask how much of the movement in consumption is driven by movements in house prices? The prior literature—specifically Mian, Rao, and Sufi (2012)— suggests that almost all of the movement in consumption is driven by movements in house prices.

To answer these questions, the authors develop an overlapping generations life-cycle model with uninsurable idiosyncratic earnings risk. Households value nondurable consumption and housing services and can acquire a risk-free asset. Households can rent or own houses and they can finance their home purchases using long-term mortgages and home-equity lines of credit (HELOCs). Mortgages are priced competitively with options to refinance and default.

There are a number of aggregate states that play an important role in this model. These include an aggregate productivity that affects the production of final goods, credit conditions that

change required collateral and mortgage origination costs, and household beliefs about future housing demand. Households can have three sets of beliefs about future housing demand: either they expect it to be low and have an unlikely transition to high, they expect it to be low and have a likely transition to high, or they expect it to be high. In equilibrium, house prices and rent prices are determined endogenously through construction and rental markets, respectively.

The authors parameterize the model to match cross-sectional and lifecycle micro data. Once they parameterize their model, they attempt to simulate the boom-bust cycle quantitatively to match movements in home prices, consumption, rent-price ratio, homeownership, leverage ratios, and foreclosure levels. With shocks to the aggregate states in their model, they are able to replicate movements in home prices and consumption. They find that beliefs about future housing demand is the key driver of the boom-bust cycle in home prices. They find that credit conditions played a lesser role on home prices but remain important for matching home ownership, leverage, and foreclosure rates. The authors also find that home prices do affect consumption – mostly through wealth effects. They can explain two-thirds of the movement in nondurable consumption through movements in home prices.

Conference participants asked several questions about the belief structure in the model. Specifically, there was discussion about whether it mattered that beliefs were about a demand-side preference parameter as opposed to the aggregate supply of land, credit conditions, or some other supply-side parameter. The second author stated that as long as the beliefs were about something that causes home prices to adjust, the same sort of boom-bust cycle could arise. There was also some discussion about whether or not beliefs about demand or supply side parameters are isomorphic. The second author replied that the same movement in home prices seen with their demand story could be generated with the expectation that there would be 35% fewer land permits in the future. In this sense, a supply-side story and a demand-side story could generate similar movements in home prices. ◆

The Mortgage Credit Channel of Macroeconomic Transmission

Daniel Lewis Greenwald

This paper investigates if, how, and when mortgage credit growth propagates and amplifies shocks to the macroeconomy, and evaluates the implications of these dynamics for monetary and macroprudential policy. The author develops a model that embeds these features in a New Keynesian dynamic stochastic general equilibrium environment. The framework centers on two key mechanisms. The first is loan-to-value ratio and payment-to-income ratio, and the second is borrower's decision to choose whether to prepay their existing loans and replace them with new loans. The author develops a tractable method to aggregate over the discrete prepayment decision and calibrate the model to match estimates from a workhorse prepayment model. The author shows that the endogenous response of prepayment to interest rates is of first-order importance for credit dynamics and transmission.

The author incorporates these features into the modeling framework and shows that the mortgage credit channel is a powerful transmission mechanism from interest rates through credit growth into house prices and aggregate demand. The author finds that the addition of payment-to-income ratio limits and endogenous prepayment greatly amplifies the effect of interest rate fluctuations on credit growth. A 1% decrease in the mortgage interest rate increases the amount she can borrow by up to 10%. The sensitivity is magnified by parallel movements at the extensive margin, since lower interest rates on new loans increase borrower incentives to prepay, encouraging issuance of new loans. The author also finds that the interaction between payment-to-loan ratio and loan-to-value ratio limits creates a novel channel through which interest rates influence house prices. The author marks this as the constraint switching effect. The author also finds that endogenous changes in prepayment rates can greatly amplify transmission into output. Quantatively, incorporating endogenous prepayment increases of impact of a 1% technology shock on output by nearly 50%.

The author applies these results to two topics with direct policy relevance. First, the author demonstrates that the mortgage credit channel strengthens the ability of monetary policy to stabilize inflation, requiring smaller movements in the policy rate to return to target after a shock. Second, the author uses the model to investigate the sources of the boom and bust and the implications for macroprudential policy. He finds that payment-to-income limits were greatly relaxed during the housing boom, resulting in a massive increase in the payment-to-income ratios on new loans that far outstripped the growth in loan-to-value ratios over the same period. The author notes that the paper's mortgage structure also has implications for redistribution, since prepayment changes the interest rate on existing debt. He demonstrates that these redistributions have minimal impact on aggregate variables in a fixed-rate environment, even though the total transfer of wealth can be large in present value. The author finds that the key determinant of the aggregate effect of redistribution is persistence. In the case of prepayment, the near-permanent change in interest flows alters the constrained borrower's current income, and the patient saver's permanent income approximately equal magnitudes, leading to offsetting

demand responses by borrowers and savers. He notes that this result indicates that recent mortgage market interventions that adjust only the rate and not the balance of a loan are therefore unlikely to generate large stimulus.

The paper's discussants asked how interest rate changes conditional on belief about housing price. They also wanted to know how income constraint will affect housing demand. They also asked how much consumption change took place when shock happens. One of the discussant commented that the author linearizes the model while the constraints might make the model non-linear. ◆

How Credit Constraints Impact the Job Finding Rates, Sorting and Aggregate Output

Kyle Herkenhoff, Gordon Phillips and Ethan Cohen-Cole

Unlike the effects of unemployment benefits on subsequent earnings, unemployment length, and job quality, we know little about how consumer credit (and access to it) affects these important outcomes. In an effort to alleviate this deficiency, this paper first documents some facts regarding the relationship between credit and these important job search variables. Then, the authors construct a structural model in order to estimate key parameters, as well as to simulate and test the quantitative implications of experiments to expand or contract credit in recessions. In these efforts, they are able to make novel contributions to policy. Their parameter estimates of the elasticity of the job finding rate with respect to credit informs the debate on optimal unemployment benefits insofar as it can be substituted with credit and that credit can provide an alternative policy tool.

Due to the relative novelty of this research, the authors begin with a measurement exercise. They merge a dataset of 5 million individual credit reports from TransUnion with employment records from the Longitudinal Employment and Household Dynamics dataset. The explanatory variable of interest is access to credit, which the authors capture using individual unused credit limits. The left-hand-side variables are the labor market outcomes noted earlier. An issue regarding endogeneity quickly surfaces, however, because there exist many unobservables that are related to both credit access and these labor market outcomes. Following Saiz (2010) and Mian and Sufi (2012), the authors instrument their measure of credit access with geographic constraints in order to recover exogenous variation in the unused credit limit, enabling them to produce the first estimates of the relationship between job finding rates and credit access. In particular, they find that an increase in credit access equal to 10% of prior earnings leads to an increase in the average non-employment spell of .3 to 1 weeks and also an increase in subsequent earnings of .5% to 1.5%.

How can these results be reconciled in theory? That is, what sorts of structural mechanisms can explain these empirical results? The authors construct a model that is rich enough to answer these questions. The model contains heterogeneous workers and firms, where workers direct their search for jobs. Workers are credit-constrained and earn human capital when working. Firms are also credit- constrained in that they must borrow in order to fulfill an initial capital investment and they are also subject to default should they fail to find an employee. Further, because the authors are interested in the quality of subsequent jobs that a non-employed person fills, they assume supermodularity in order to generate sorting of workers and firms with high human and physical capital, respectively.

A calibration exercise produces structural estimates of the elasticity of non-employment durations with respect to unused credit of 0.718, which translates to roughly 1 more week of non-employment when access to credit is expanded by 10%. In addition, they find that the elasticity of subsequent earnings with respect to credit access is approximately 0. The model is also used to conduct an experiment wherein borrowing limits are constricted during the Great Recession period. The resulting recovery is then compared to a counterfactual where limits are held constant. Under the tightened credit conditions, productivity and output depress by .25 and .1 percentage points. On the other hand, employment increases faster with tighter debt limits because agents are more inclined to take jobs sooner, as they are less capable of smoothing consumption by borrowing. Measures of sorting also improve, meaning that more high (low) human capital workers are paired with high (low) physical capital firms. This is due to the fact that restricted access to credit disproportionately urges low-human capital agents to accept low-physical capital jobs sooner (high-human capital agents have generally more savings and so can afford to search longer).

A conference participant raised a concern that the wage-sharing rule used by the authors, namely that output is split between workers and firms in a fixed proportion, is not optimal. While the assumption is made for tractability purposes, it raises some questions about the magnitudes of the estimates and the results of the simulated experiment. If agents and firms are optimally splitting output, how will the changes in credit access affect the structurally estimated elasticities or the recovery (output, productivity, etc.)? At the outset it's not entirely clear, though this research is a promising first step into these deeper questions about credit access and these outcomes. ◆

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Inequality and Policy Changes: The Case of a Decline on Inflation in Open Economies

Bernardino Adão and Maria Isabel Horta Correia

One of the most widespread and sustained economic policy regime changes in recent history is the decline in the average inflation rate across developed countries. This change is generally thought to be beneficial due to the increased efficiency of lower inflation rates. However, these benefits are likely to be accrued differently across the population. For instance, there is evidence that high-income households in the U.S. use currency for a smaller fraction of their transactions. Similarly, the proportion of households' wealth held in liquid assets decreases with income and wealth. Household heterogeneity in wealth levels and currency utilization patterns could spread the cost or benefits of inflation in ways that accentuate or attenuate income and wealth inequality.

The authors develop a monetary general equilibrium model with heterogeneous households to evaluate the relationship between inequality and an anticipated inflation decline. Their environment is populated by households that have different productivity levels and heterogeneous real wealth endowments, as well as a government that collects consumption taxes and sets inflationary policy. The government's role in this economy is to maintain a given level of governmental consumption. Since their objective implies constant revenue collection, their inflationary and tax policy choices have to be revenue neutral, so a decrease in inflation has to be compensated by higher consumption taxes and vice versa.

Households choose to spend their time on production, leisure, or creating credit. They use their income (money) or the credit they produced to pay for their consumption. Households create credit through a transaction production function, which can be constant returns to scale (the average cost of credit remains constant the more credit households use) or increasing returns to scale technology (the average cost of credit goes down as households use more credit). Costly credit introduces a tradeoff between the cost of avoiding the inflation tax through credit, the cost producing credit, and paying consumption taxes. Households can shelter their income from inflation by using credit, but that will cost them labor hours which translate into lower consumption levels. At the same time, they could use money and pay both the consumption and inflation tax, but this also reduces consumption. This tradeoff means that households use credit for some of their transactions to ameliorate the effects of inflation on their monetary assets and pay consumption taxes on the rest.

Heterogeneity in real wealth endowments across households implies differences in their valuation of money balances and labor costs. These differences introduce heterogeneity in the transaction patterns across households. Under increasing returns to scale transaction technology, wealthier households hold a lower share of money to consumption than poor households. For this reason, inflation has heterogeneous effects on the effective price of consumption across households, with poor households paying more inflation tax than wealthier households.

Within this framework, the authors show that a decline in inflation improves welfare equality. Since the government seeks a constant level of revenue collection, lowering inflation income has to be compensated by increasing consumption taxes. Since consumption taxes have a broader tax base and the inflation tax affects poor households disproportionately, reducing the inflation tax improves welfare inequality. In short, taxing money hurts the poor because they use money more than the wealthy, and switching to a broader tax base collects the same tax revenue more equitably – even when consumption taxes are regressive in the usual sense.

During the presentation, a conference participant asked about the nature of inflation in the model. The presenter responded that households fully anticipate inflation. Since the model is deterministic, inflation misallocates resources from the goods sector to the credit sector, and inflation, like a tax, distorts the relative price of leisure and the intratemporal marginal rate of substitution with consumption.

Another participant asked how changing the nominal interest rate affects inflation? The presenter explained that costly credit services are a deadweight loss. The government, therefore, is trying to balance the dead weight of credit services against the dead weight of consumption taxation.

At the end of the presentation, the discussion shifted to normative inflation policy. A conference attendant asked about the optimal rate of inflation and the welfare effect of a tax on money. The presenter explained that all agents are unambiguously better by lowering the inflation rate. Because increasing inflation affects everyone negatively, even if consumption taxes are not available, the government should not tax money. The presenter characterized this result as stronger than Friedman rule because they model heterogeneous households and the result is independent of the distribution of wealth across the population. ◆

A Demand Theory of the Price Level

Marcus Hagedorn

The author proposes a new theory that generates a globally determinate price level, with monetary and fiscal policies resembling those actually implemented in practice. The two key features of this model are, first, that fiscal policy is nominal and, second, the failure of the permanent income hypothesis. Monetary policy works through setting nominal interest rates, for example an interest rate peg, while fiscal policy sets sequences of nominal government spending, taxes, and government debt, satisfying the present value budget constraint at all times (in contrast to the Fiscal Theory of the Price Level). The price level is then determined such that demand equals supply in the goods market.

A uniquely determined price level is very important, as indeterminate price levels can lead to very different policy predictions. Cochrane (2015)'s policy analysis of new-Keynesian models during a liquidity trap illustrates the strong dependence of policy predictions on the researcher's choices when selecting a specific equilibrium. The researcher's specific decisions can lead to an arbitrarily large or negative fiscal multiplier. This problem arises because if the price level is indeterminate, the researcher must choose one equilibrium while a continuum of other choices exists simultaneously, which could lead to very different policy predictions.

To keep the model tractable, the author develops the simplest setup that results in the following empirical finding on individual consumption and precautionary saving behavior. A permanent income gain, such as a permanent tax rebate, increases household consumption by less than one-for-one, and thus increases savings too. The key simplifying assumption used by Hagedorn is that households are members of a family which provides insurance such that the distribution of asset holdings across agents is degenerate. These families live in an infinite horizon endowment economy without capital.

The theoretical analysis leads to the main result that the price level is globally uniquely determinate and that it depends on both monetary policy and fiscal policy. This paper illustrates the workings of the model, adding key features for meaningful numerical analysis: labor supply is endogenous, prices are sticky and only a small fraction of government spending is nominally fixed. The author then numerically computes impulse responses to monetary and fiscal policy shocks, as well as to technology and discount factor shocks. He finds that all impulse responses are in line with their empirical counterparts. An increase in nominal interest rates leads to an increase in saving and therefore lowers consumption demand - which implies a drop in prices. An increase in government spending stimulates aggregate demand, implying a rise in prices. An increase in technology raises supply and households' incentives to save, implying a drop in prices. Finally, an increase in the discount factor leads to an increase in savings because households are more patient, implying a drop in prices. This model leads to these results for both sticky prices and when prices are flexible. Specifically, price rigidities are not needed for monetary policy to have effects.

The author notes that the model utilized to conduct the quantitative exercises lacks some features that could be necessary to obtain precise estimates of the policy effects. Using the insights from this paper, future work will use a full quantitative macroeconomic that utilizes the Aiyagari (1994) incomplete market model with capital and elastic labor supply as a starting point. This method is able to overcome Cochrane's criticism of existing approaches to quantifying the fiscal multiplier when the zero lower bound is binding. ◆

Optimal Central Bank Policy in a Model of Regional Shocks and Private Information

Pamela Labadie

The author builds a theoretical banking model, such as in Diamond and Dybvig (1983). The model incorporates two types of frictions in the form of market and informational frictions. The banks are in regions that experience liquidity and productivity shocks, which create incentive for risk-sharing agreements in order to diversify idiosyncratic risk.

The only uncertainty comes from regional shocks. There are two kinds of private information - first is the liquidity shocks on the liability side of regional banks' balance sheet, which takes the form of randomness in the fraction of early and late consumers. The second is the distribution of the productivity shock, which is where the adverse selection comes in.

The model is a three-period model with a continuum of locations. There is a financial intermediary (a bank) and a continuum of households at each location or, equivalently, a representative household who has perfectly divisible consumption. Each region is initially identical. There is risk-free technology between period 0 and period 1, and a risky technology between periods 0 and 2 which cannot be interrupted at time 1 - so there are no bank runs in the model. Productivity shock is observable to everyone. Each region has its own risky technology, they are independently but not identically distributed, regions differ in terms of their probability of drawing low or high state. Endowments cannot be moved across regions.

When all realizations of shocks are publicly observable, the social planner's solution is that optimal investment function

has the property that low-return regions invest more in short-term, risk-free projects and high return regions invest more in risky projects. Since the social planner knows the realization of the shocks, it would be optimal for the social planner to take endowment of low return regions and move it over to high return regions. So, this paper assumes that it is not allowed.

This first best allocation can be implemented as a competitive equilibrium by setting up a contingent claims market both for the liquidity shock and for the productivity shock. Deposit insurance is equivalent to trade in contingent claims at time 0 before a region observed its realization of liquidity shock. Securitization is in the form of insurance against shocks to the asset side of the banks' balance sheet - productivity shocks. The bank sells the state contingent payoffs in return for a certain return. While interbank borrowing and lending smooth liquidity shocks conditional on realization, it is not a substitute for deposit insurance.

As for the productivity shock, regions differ in terms of their probability of drawing a good shock or a bad shock. The liquidity shock is like that of the standard Diamond-Dybvig model, which determines whether a household is patient or impatient (an early or late consumer). An important assumption is that the relative risk aversion is greater than or equal to 1, which is needed in order to create a demand for liquidity insurance. The private information is across regions, so in a given region, everyone knows the realization of the shocks.

This paper looks at the impact of shocks by first shutting down one private information, and then the other one. However, in both cases, the private trading assumption is maintained. In the first scenario, when the liquidity shock is private information, there is private trading and no productivity shock, and the opportunity to borrow and lend changes the incentive compatibility constraint. This results in higher investment in risky projects relative to the first best allocation. Moreover, the equilibrium interest rate in the interbank credit market is lower than the first best interest rate, which spills over to portfolio decision and creates an incentive to over-invest in the risky asset. The reason is that agents can count on borrowing to smooth the liquidity shock instead of investing risk free short-term asset which is a pecuniary externality. Bhattacharya and Gale (1987) call this a free rider problem.

One of the participants asked about the real world equivalent of trading privately after the social planner. The author replied that private trading is a natural assumption towards realism since you don't see the markets like those in the incentive-efficient allocation in which you have all the restrictions of activities, so that you have to consume the bundle that is allocated. The social planner cannot prevent the elimination of arbitrage profit opportunities, which is a cornerstone of finance. It is natural assumption to eliminate arbitrage profit opportunities even when there is private information.

When there is private trading and private information, there is a central bank policy that will improve welfare - which is private trading constrained efficient allocation. The policy is to make a liquidity floor that will create a wedge between marginal rate of transformation and marginal rate of substitution between periods 1 and 2. The portfolio implies a lambda that is higher than the interbank interest rate. By lowering the interest rate in interbank market, the impact of a liquidity shock is dampened, because the rate of consumption in the first and second period are driven closer. Essentially, it is making it easier for a region to smooth the liquidity shock, which is the intuition why one would want to drive a wedge. The problem is standard except that the incentive compatibility constraint changes.

The paper then turns off the liquidity shock, so the model has the uncertainty as a productivity shock, which creates a need for insurance, and the regions' type is private information. That insurance is through securitization as a way of diversifying idiosyncratic risk. In a first best solution, there is a contingent claims market in which prices vary with the type. Here, because of private trading assumption and the elimination of arbitrage profit opportunities, you cannot separate markets by type. Hence, the contingent claims prices are going to be equalized across regions. The result is that - since all regions have the same endowment, even though they have different risk of drawing high or low productivity shock - they are going to end up making the same decision in terms of how much to invest in risk-free and risky asset because they face the same prices. Unlike the optimal distribution of the portfolio that varies with type in the first best solution, the distribution in this case is degenerate, such that all regions will invest the same amount in risk-free and risky projects. However, the consumption in period 2 will vary with the productivity shock. This means that the regions will under- or over-insure against the low productivity shock. So the securitization does not eliminate the idiosyncratic risk because of private information. Lower return regions are going to act like high return region, and there will be misallocation in terms of the investment. The securitization will result in low return regions overinvesting in risk-free assets and high return regions investing in risky assets.

The final step is to look at having both types of private information. The result in this case is that the optimal policy of central banks will be a convex combination of previous cases. Central banks will choose prices in the securitization process so that lower interest rates in interbank trading market will help regions smooth the liquidity shock. The optimal policy is to create a wedge between prices and the interest rate to correct for this pecuniary externality.

In sum, the key difference is when there is adverse selection problem with private trading, the risky investment will have a degenerate distribution. Then, the private trading constraint efficient allocation is that the social planner or the central bank would like to impose a liquidity floor in order to force regions to invest more in the low risk asset than the risky asset. ◆

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Taxing Top CEO Incomes

Laurence Ales and Christopher Sleet

The authors of this paper note that recent research suggests that the marginal tax rate on top income earners should be perhaps as high as 70% or 80%, which is underpinned by the Diamond-Saez formula that relates the optimal marginal tax rate on top incomes to the elasticity of taxable income and a property of the right tail of the earnings distribution. They note that this formula is derived under the assumption that the policymaker's objective is to maximize tax revenues derived from top earners, but abstracts from any positive impact of the efforts of these earners on the incomes of other agents or on tax revenues collected from other sources. This paper considers the idea that the activities of high-earning CEOs have positive spillovers for others. The authors use a firm-CEO assignment framework to model the market for CEO effective labor. They show that in an assignment model augmented with an intensive CEO effort margin, the taxation of CEO incomes affects the equilibrium pricing of CEO effective labor and hence spills over and affects firm profits. The optimal marginal tax rate on CEO incomes is thus modified downwards. At their benchmark parameterization, a full reform of CEO income and profit taxation entails an optimal marginal tax on top CEO incomes of about 15%.

The model equilibrium features assortative matching of CEO talent with firm size. More talented CEOs supply more effort to larger firms. The indivisibility of the CEO position prevents combinations of less talented CEOs replacing more talented ones and equalizing the price for effective CEO labor across firms. On the other hand, competition amongst similarly talented CEOs for a position prevents any given CEO from extracting all of the surplus from a firm. In equilibrium, the price of a unit of CEO effective labor equals the marginal product of CEO effective labor at the firm at which this unit is the last hired. Since the marginal product of CEO effective labor is increasing in firm size, the matching of more talented CEOs to larger firms enhances the dispersion of top CEO incomes. Even if there is relatively little dispersion in CEO talent, large variations in firm size can translate into large variations in top CEO incomes. In their setting, an increase in the marginal tax rate above a threshold income induces an upwards adjustment in the pricing schedule for effective labor. This, in turn, redistributes from firm profits to CEO incomes and CEO income tax revenues. If the policymaker is indifferent to the allocation between income tax revenues and firm profits, then no such redistribution motive for higher marginal taxes exists.

The authors use nonlinear optimal tax formulas expressed in terms of underlying talent and firm size asset distributions to quantitatively characterize optimal taxes on CEOs across a range of high incomes and firm profit weights. If a comprehensive reform of income and firm profit taxation is implemented, then income taxes and firm profits are equally weighted and optimal marginal tax rates decline from around 18% at an income of 10 million to about 10% at an income of 100 million. If a partial reform of CEO income taxation occurs, holding profit taxes close to their empirical values in the US of about 60%, then optimal tax rates decline from 34% to 27% over a similar income range.

The paper's discussants wondered if the relation between talent and effort is critical in driving the results. The presenter noted that it is assuming elasticity is greater than zero. Another discussant wondered how the model would change if residual profit division between firm and worker is added into the current framework. Another discussant wondered how costly it would be if the model is wrong. The presenter commented that the current framework does not provide a decisive answer, but rather an upper bound on the tax rate on top earners, which is already lower than what is suggested by other papers. ◆

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