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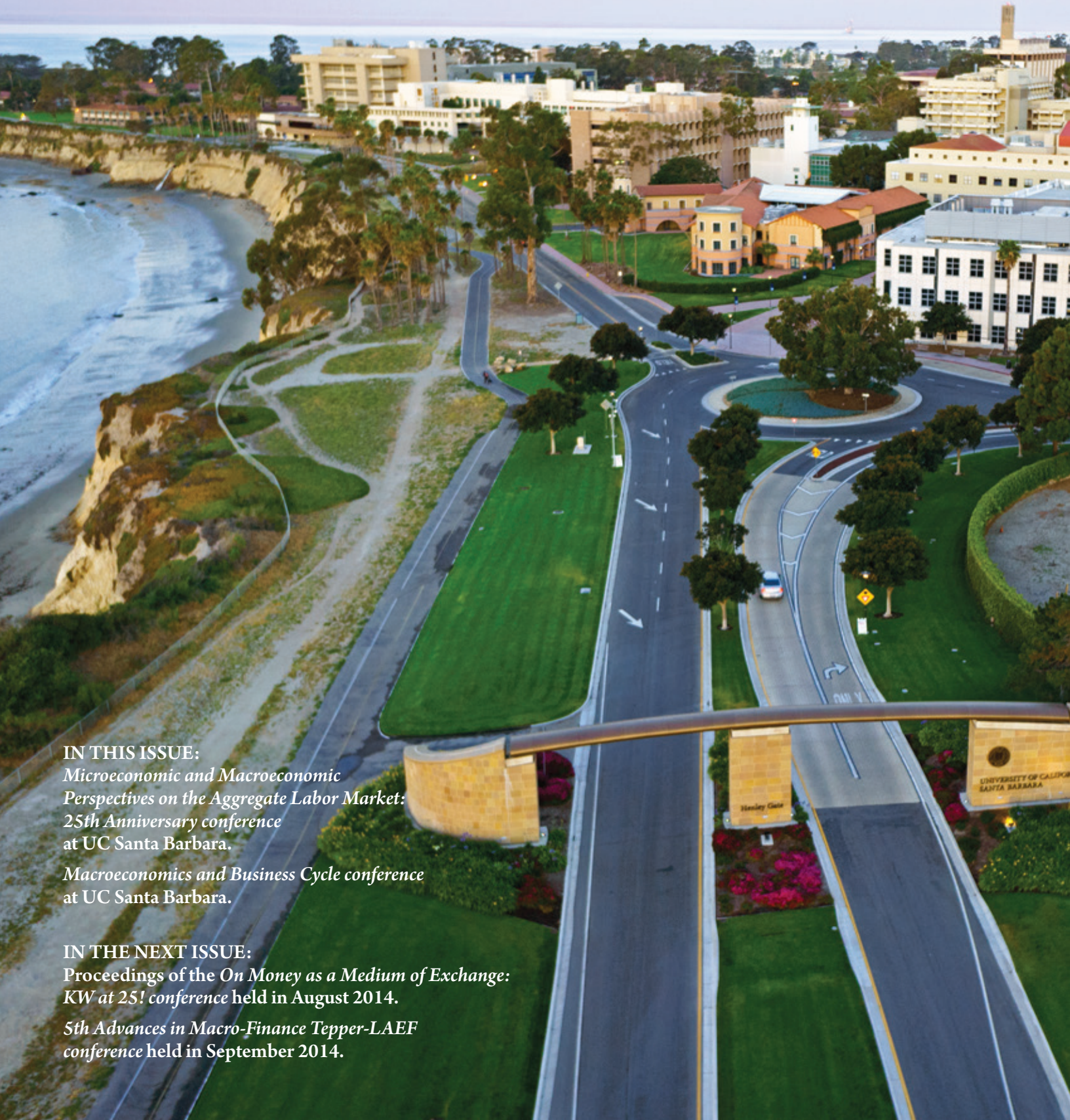
# FROM THE LAB

UC Santa Barbara | Laboratory for Aggregate Economics and Finance



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***Macroeconomics and Business Cycle conference*** **at UC Santa Barbara.**

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***5th Advances in Macro-Finance Tepper-LAEF conference*** **held in September 2014.**

UC Santa Barbara
Laboratory for Aggregate Economics & Finance

## Associate Director's Message

Peter Rupert

In this issue of ***From the Lab***, The Laboratory for Aggregate Economics and Finance held two very interesting conferences in the spring of 2014. April featured the 25th Anniversary Conference of the National Bureau of Economic Research (NBER) "Microeconomics and Macroeconomics Perspectives on the Aggregate Labor Market." The conference brought together leading economists to present and discuss issues involving various aspects of labor markets. Product markets, financial markets and institutional structure can have profound impacts on the functioning of the labor market. The focus on the conference was on models that help us understand key features of the data and how to better implement policy.

The May event was a four-day workshop on dynamic macroeconomic theory, "Macroeconomics and Business Cycles." Carlos Garriga of the Federal Reserve Bank of St. Louis was the academic organizer. The objective of the workshop was to combine recent developments in quantitative macro with frontier theoretical research. The workshop featured four talks each morning, allowing ample time for informal discussion among the participants in the afternoons. Following the success of the event, we are planning to hold the second conference on this topic in May of 2015.


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**Microeconomic and Macroeconomic Perspectives on the Aggregate Labor Force: 25th Anniversary Conference**

APRIL 18-19, 2014

CONFERENCE PARTICIPANTS

Kenneth Burdett — University of Pennsylvania
Lawrence Christiano — Northwestern University
Erik Hurst — University of Chicago, Booth
Chad Jones — Stanford University
John Kennan — University of Wisconsin, Madison
Rasmus Lentz — University of Wisconsin, Madison
Ellen McGrattan — University of Minnesota
Lee Ohanian — University of California, Los Angeles
Edward Prescott — Arizona State University, W.P. Carey School of Business
José-Víctor Ríos-Rull — University of Minnesota
Richard Rogerson — Princeton University
Robert Shimer — University of Chicago
Randall Wright — University of Wisconsin, Madison

## The Decline of the U.S. Rust Belt: A Macroeconomic Analysis

Simeon Adler, David Lagakos and Lee Ohanian

The Rust Belt, a heavy manufacturing area bordering the Great Lakes which includes cities such as Detroit and Pittsburg, has seen a significant decline in its share of aggregate economic activity since the end of WWII. Alder, Lagakos and Ohanian seek to see how much of this decline can be attributed to a lack of competition. They establish four facts regarding this. First, the Rust Belt's employment share declined between 1950 and 2000, with the share of aggregate employment dropping from 43 percent to 27 percent, and the manufacturing employment share dropping from 51 percent to 34 percent. Second, the Rust Belt has had a relatively large wage premium, as measured by estimating a Mincer equation, which has been in the range of 10 percent to 15 percent between 1950 and 1980. Third, productivity growth and innovation have been low in the Rust Belt, with an average total factor productivity (TFP) growth rate of 0.2 percent between 1958 and 1980, compared to a growth rate of two percent for the U.S. as a whole during that time. And fourth, all of these trends started to reverse somewhat in the 1980s. TFP growth increased to 0.8 percent after 1980, compared to a rate of 1.4 percent for the U.S., and the wage premium declined to five percent in the years after 1980.

Alder, Lagakos and Ohanian build a model exploring the role of competition in order to attempt to explain these facts. Their model includes competition in both labor and output markets and in two different regions, the Rust Belt and the rest of the country (ROC). In the labor market, wages can deviate from their competitive level because of labor unions that extract rents through threat of strikes. The union's share of the surplus is determined by Nash Bargaining and there are no unions in the ROC in this model. In the output markets, prices can differ from their competitive levels because of entry costs that lead to price markups. For both the Rust Belt and the ROC, there is an industry leader who competes with a competitive fringe. The leader is endowed with a superior productivity level, and can improve productivity by incurring a convex cost. The industry leaders then Bertrand compete with the fringe firms, which end up being priced out of the market due to the leader's superior productivity. The productivity gap between the fringe firms and the leaders is larger in the Rust Belt in this model.

Competition matters because it alters firm incentives to innovate. The lack of labor market competition creates a holdup problem. The firm makes a non-reversible technological investment before labor and pricing decisions are made. Since unions capture a share of the surplus without paying any of the costs of innovation, the firms choose less innovation in equilibrium than they otherwise would. The lack of output competition creates two opposing effects. There is an escape-competition effect, in which firms can increase prices by innovating since they can more easily price the fringe out of the market. There is also a Schumpeterian effect, in which more competition means there is less of an incentive to invest because future monopoly profits will be smaller. The union hold-up problem plays a key role in these two opposing output market effects, with equilibrium investment ending up lower in the Rust Belt.

Alder, Lagakos and Ohanian calibrate their model to start with the levels of competition from 1950. The model starts with very limited competition in the Rust Belt, with a large productivity gap, and unions having high bargaining power. The authors then calibrate the catch-up rate of the competitive fringe, the share of goods produced in the Rust Belt, and the scale and curvature parameters of the cost function to match a 10 percent markup in the Rust Belt, an initial Rust Belt employment share of 51 percent, a long-run growth rate of 2 percent per year, and an investment-to-GDP ratio of five percent. Over time, employment in the model moves to the region with the fastest productivity growth, the ROC, and this leads to a decline in the employment share for the Rust Belt. The authors find that roughly 50 percent of the decline in the Rust Belt's employment share can be accounted for by competition.

Conference participant discussion of the presentation revolved around the role of unions. There was some discussion about why unions and firms cannot find a payment arrangement that maximizes the firm's total surplus. In the long-run, it would be better for a union to find an arrangement in which the workers are paid a profit-maximizing competitive wage, and subsequently share the profits with the union. Ohanian explained that in the authors' model there is a lack of commitment because non-reversible investment decisions occur before wages are chosen. There was also some discussion about how the level at which unions bargain with firms can change the union's effect on equilibrium outcomes. In some Northern European countries, unions bargain at the national level which reduces rent seeking because rent seeking can become extremely expensive and destroy an entire economy instead of just a specific plant. ◆

## Financial Frictions, Asset Prices, and the Great Recession

Zhen Huo and José-Victor Ríos-Rull

Since 2008, the U.S. economy has experienced large declines in the main aggregate economic variables, including real GDP, unemployment, consumption, and investment. Meanwhile, private debt and housing prices have plunged. The paper by Huo and Ríos-Rull explores the recession from a perspective of the poor financial conditions faced by households. The authors find that financial shocks to households can trigger a recession that shares most of the features of the Great Recession. Though there have been numerous attempts to link the recession with financial difficulties by households by various channels, Huo and Ríos-Rull highlight the channel that goes from increased financial frictions to reductions in consumption, to reductions in productivity and employment due to search frictions in some consumption goods market.

The main ingredients of the model are households, two types of firms, two goods markets, a labor market, a housing market, a risk-free bond market, and a stock market. For the household

sector there is a continuum of households who live forever and are subject to both uninsurable idiosyncratic employment shocks and aggregate shocks in the economy. They consume housing and two types of consumption goods: a tradable good and a non-tradable service. The non-tradables can only be obtained through households' search efforts. Households like tradables, housing, quantities and varieties of non-tradables, while they dislike goods searching. Each household is endowed with a skill type and some amount of assets. The skill type follows a Markov chain, which moves slowly and accommodates opportunities to become rich. The asset can be allocated to houses and financial assets with collateral constraints. For the production sector, there are competitive firms with a unit measure which produce tradables. They input labor and capital to produce outputs that are used for exports, investment, and consumption. Meanwhile, there are monopolistic firms with a unit measure, each producing a different variety of non-tradable goods. In addition, the markets for housing and tradable goods are frictionless, whereas there are search frictions in the non-tradable goods market, so households need random searches for varieties. In the labor market, workers are rationed by various types. Firms pay hiring costs to hire as many workers as they wish. In the asset markets, including financial assets and houses, there is a fixed supply in total housing units. Negative financial assets are mortgages, which are made using houses as collateral, while positive financial assets are shares of a mutual fund. Finally, an equilibrium is defined such that households and firms optimize, all the markets above clear, and there is consistency between individual decisions and the aggregate.

Ríos-Rull showed the model calibration and the results of several experiments. A tighter financial market, including both a higher down payment requirement and a higher borrowing cost, drives the main aggregate economic variables down. However, a more relaxed financial market, with a lower down payment requirement, spikes the main aggregate economic variables up.

During the presentation, there were several audience questions focusing on the model setting. It is assumed that households allocate their asset endowment to houses and/or to financial assets with a collateral constraint. The population is therefore divided into two groups: the poor with some housing wealth and a mortgage, and the rich with houses and shares of the economy's mutual fund. One conference participant asked why there are no renters in the model. Ríos-Rull responded that the authors omitted the renters in the model on purpose since they don't want a "kink" in the model. Another participant asked why it is reasonable to assume that households need to research for varieties in the non-tradable service market all over again every period in the model setting. Ríos-Rull answered that it highlights the channel that richer people want to consume more varieties and therefore have to engage more in searching efforts instead of substituting labor. ◆

## Optimal Employment Contracts with Hidden Search

Rasmus Lentz

It is well known that workers search for new jobs both while employed and unemployed. Postel-Vinay and Robin (2002) have shown that this feature of labor markets can result in wage growth over a period of employment, both within-jobs and between-jobs, due to competition over workers. Lentz's paper adds optimal tenure-conditional contracts to the environment and produces a wage profile that increases within a job, independent of the search mechanism. The result is a realistic-looking wage profile in a model that can be used to analyze a number of other labor market features, including the minimum wage and human capital training.

The first key feature of the model is that workers' search behavior is unobservable and costly. The second is that firms cannot commit to not matching outside offers. As a result, if a worker receives an offer from an outside firm, the two firms compete using Bertrand competition on promised utility for the worker's services. If the outside firm is of a higher productivity than the current firm, the worker will leave the current firm for a better offer than what the current firm can afford. If the outside firm is less productive, the worker may still be able to negotiate a wage gain, provided the outside firm can offer a better deal than the current contract.

The major contribution of Lentz's paper is the analysis of the optimal contract in this environment. After a deal has been made with a worker for promised lifetime utility, the firm is free to set the wage path optimally in order to satisfy the lifetime utility. The solution is to offer a utility path which asymptotes to the firm's willingness to pay from below. This corresponds to an increasing wage profile within the firm in the absence of outside offers, as well as decreasing search intensity. The unanswered quantitative question is which wage effect is larger: the contracted wage growth or the growth resulting from competition between firms.

Finally, the paper considers two extensions: a minimum wage and training. In the model, firms may offer wages below the unemployment benefit, and take advantage of this fact to offer unemployed workers the same lifetime utility they would receive by remaining unemployed. A minimum wage may therefore improve welfare by incentivizing the unemployed to search. In addition, the paper finds that higher quality firms provide more training for their workers, as there is less chance that they will be recruited away.

Discussion topics included firm commitment, efficiency, saving and borrowing, and the distinction between consumption and wages. One conference participant asked why the author chose not to include a saving and borrowing decision in the model. Lentz responded by saying that it only serves to complicate the model. If workers could save and borrow, there would be an efficiency gain, but all the gains would go to firms, as workers would be required to purchase their jobs up front. A related question was whether we should think of the payment streams as wages or consumption, and the response was that we are intended to think of this as wages, because we know from an

empirical standpoint that wages tend to be backloaded, and we want to ask how much of this phenomenon is due to the moral hazard problem of hidden search. A brief discussion on efficiency concluded that this environment is not socially efficient. To understand why, consider a worker matched with the highest productivity firm, but being paid less than that firm's willingness to pay. This worker chooses to search in order to extract more rents from his employer, and this is inefficient because there is no way the worker can move to a more productive firm.

A lively discussion centered on the topic of firm commitment. In the model, firms are able to contract future wages. Several conference participants pointed out that we rarely see contracts for future wages in most settings. These contracts must then be considered to be implicit, and may be thought of as enforceable because of reputation costs of deviating. The other point raised was why firms were not able to contract on the arrival of outside offers. Conference participants agreed that any commitment about future offers is not renegotiation proof, and so the firms are indeed unable to commit to not matching offers. ◆

## On Financing Retirement with an Aging Population

Ellen McGrattan and Edward Prescott

The aging population and the decreasing number of workers per retiree around the world have sparked numerous discussions and political debates focused on how to continue financing retirement consumption. The U.S. currently has approximately 3.36 workers per retiree, and that fraction is falling. An increase in payroll taxes is needed to continue the current system of lump-sum retirement transfers. One proposal has been to move from this lump-sum transfer system to a saving-for-retirement system that would eliminate the payroll taxes needed to finance these transfers. However, doing so in a welfare-improving way for all generations is difficult, as a large increase in government debt would be needed during the time of transition. McGrattan and Prescott use an overlapping-generations model to show that there exists a feasible welfare-improving way to move from the current system to a saving-for-retirement system.

The model households are of basic OLG form: working, accumulating assets, and paying taxes on labor income and consumption. The households receive age-dependent lump sum transfers for early periods after which they retire but continue accumulating assets, paying consumption taxes, and receiving lump-sum transfers. There are two sectors of production in the economy. Sector 1 is subject to corporate income taxes and then redistributes profits to owners; Sector 2 redistributes all profits to owners and is not taxed. Roughly, their empirical counterparts are Schedule C corporations and Schedule S corporations, respectively. Each sector produces an intermediate good and the aggregate production function is Cobb-Douglas. Production within sectors is Cobb-Douglas with three inputs: labor, tangible capital, and intangible capital. The resource balance constraint is that aggregate output must equal aggregate consumption plus aggregate investment in both types of capital and government spending. Government debt increases by accumulation of interest on previous debt, the lump-sum retirement transfers, and other government spending. Government debt decreases though taxes on consumption and wages, corporate taxes from Sector 1, and capital taxes on the distributions from firms to owners in both sectors. In equilibrium, labor, capital and goods markets clear at each point in time.

McGrattan and Prescott calibrate the baseline economy under the current system of lump-sum transfers, approximately 3.4 workers per retiree, and a population growth rate of 1 percent such that the model's balanced growth path is consistent with U.S. statistics. The aggregate capital stock in the model – 5.8 times GNP – is larger than estimates used in the literature – 2.8 times GNP – because it includes consumer durables, inventories, land and business intangible capital. Using the calibrated parameters and changing the demographics, population growth rate of zero, and two workers per retiree, the model predicts that consumption taxes will rise between 10 and 14 percent in order to sustain the lump-sum transfers. McGrattan and Prescott use the transition from the baseline to the steady state with the new demographics as the baseline for welfare comparisons under three policy changes:

1. Elimination of FICA taxes, Medicare and social security
2. Elimination of FICA taxes, Medicare, social security, and capital taxes
3. Elimination of FICA taxes, Medicare, social security, capital taxes and implicit transfers.

For the first policy change, FICA taxes are immediately eliminated and transfers to the old system are slowly phased out. In order for this policy to be welfare improving for all generations, implicit transfers are temporarily reduced by half and new paths for tax rates on labor, capital, and consumptions are chosen. Implicit transfers are equal to the difference between actual tax revenues collected and what tax revenues would be if income was taxed at the income-weighted average marginal tax rates. Under this policy, future generations experience gains of about 15 percent of lifetime consumption. Under the second policy change, paths for non-capital taxes and implicit transfers are chosen as before while capital taxes are phased out. This policy change is also welfare improving for all cohorts and future generations. The last policy change is as before, however implicit transfers are eliminated. In essence, this policy flattens the income tax schedule and broadens the tax base. Gains from this policy change are as high as 25 percent of consumption for future cohorts. These gains are much larger than those typically estimated because the estimate of the capital stock is larger and the tax reforms considered result in a large increase in the value of private business equity.

During the discussion, a participant argued that these policy changes are always welfare improving and should be done regardless of what happens to social security. He followed by asking why the welfare gain from removing distortionary capital taxes should be used to fix the social security system instead of other policies. McGrattan agreed that these are tax reforms which are welfare improving regardless of what happens to social security but argued that the purpose of the paper was to find welfare improving ways to get out of the current pay as you go

system and that such ways exist by solely eliminating FICA taxes. Another participant asked why the size of the transfer is not dependent on wage history, since agents of different ages will respond to changes in labor taxes differently. McGrattan said that the next revision of the paper will include heterogeneity such that taxes and transfers will be dependent on wage histories. Toward the end of the presentation, a conference participant asked whether or not the disability insurance within social security is also removed and how large that portion is. McGrattan said that currently disability insurance is removed but they will have to think about how big that portion is and whether or not it should be removed. However, only when heterogeneity is added to the model can they assess the impacts on the minimum wage earners. ◆

## The Allocation of Talent and U.S. Economic Growth

Chang-Tai Hsieh, Erik Hurst, Chad Jones, and Peter Klenow

The occupational distribution of workers across the U.S. population has changed over the last 50 years. In 2008, for example, 62 percent of doctors and lawyers were white men, much lower than the 94 percent figure from 1960. The case of doctors and lawyers is part of the broad occupational convergence observed throughout this period, which suggests that the allocation of talent across occupations was suboptimal in 1960. This paper quantifies the effect that the reallocation of talent had on the growth of aggregate productivity. The authors find that changes in the occupational barriers affecting blacks and women during this period can explain 15-20 percent of the aggregate per capital output growth.

Hsieh, Hurst, Jones and Klenow derive these results by extending the Roy (1951)[1] model of occupational choice, where individuals with different talents across occupations maximize their utility by choosing the occupation with the greatest return. The authors take the model to general equilibrium, divide individuals into groups by race or gender, and incorporate three forces that influence individual's occupational choices. The first force is a group/occupation-specific wedge between a group's marginal product and their take-home pay. This friction represents preference-based discrimination in the labor market. The second force affects the accumulation of human capital, and acts as a group/occupation tax on goods used to produce human capital. This friction represents the educational restrictions faced by some groups: in particular, limited access to high-quality education. Lastly, the third force allows for changes across occupations in the returns to skill, accommodating skilled-biased technological change. These frictions, together with occupation-specific productivity and educational parameters, define the intertemporal path of the groups and the economy in general.

The authors use data from the U.S. Census and American Community Surveys to quantify the values for the labor market, human capital, and skilled-biased technological change frictions. They use their model to isolate each value's respective effect on output. They find that the frictions' dispersion was reduced from 1960 to 2008, corroborating their argument of a decline in talent misallocation during this period. Then they separate the effect improving talent allocation has on the output by using the calculated friction values in two different ways. The first approach holds each group's share of the working population, occupations' productivity, and schooling parameters constant, while letting the calculated frictions' values change one at a time. If the change in occupational allocation is only attributed to changes in the human capital friction, the model can explain 20.4 percent of the growth in output. On the other hand, if it is solely attributed to frictions in the labor market, the model can explain 15.9 percent of the growth in output. The other approach holds the frictions' values constant at 1960 levels, while letting each group's share of the working population, occupations' productivity, and schooling parameters evolve freely. They compare the output achieved when the frictions are constant to the output generated when one of the frictions evolve together with the other parameters. In the case when human capital frictions were allowed to evolve freely, output was 15 percent larger, while when labor market frictions were used, output rose by 11 percent.

These changes in output can be decomposed into the contributions of each racial and gender group. The largest contributor to total earnings growth is white women, at around 60 to 75 percent of the total gains, when relaxing either human capital or labor market frictions respectively. Most of these gains were driven by an increase in the proportion of women in high-skilled occupations. These movements accompanied changes in the real wages of men and women of both racial groups. White and black women experienced a 40 percent and 60 percent increase in their wages, respectively. For black men, the change in occupational barriers raised their real wage by 45 percent, while the same changes reduced white men's wages by 5 percent.

The reduction of white men's wages during this period emphasizes a methodological advantage of their model. The authors take into consideration the effect of changes in blacks' and women's talent allocation on white men. These two factors differentiate their results from calculations that rely only on wage gaps, which underestimate their model's productivity gains by 25 percent when using human capital frictions only, and by 75 percent when using only labor market frictions. This methodological advantage and the analysis of the effects the labor market and human capital frictions have on productivity represent a first step in answering how discrimination can affect occupational choice. Their paper also begins to answer how the resulting misallocation on aggregate affects output and productivity.

1 Roy, A.D., "Some Thoughts on the Distribution of Earnings", Oxford Economic Papers, June 1951, 3(2), 135-146. ◆

## Men not at Work

Mark Aguiar, Erik Hurst, and Loukas Karabarbounis

Male employment and hours worked have both been on a steady decline since the 1960s. This pattern is present for both high and low skilled workers, although these groups experienced very different labor market changes over this period. For high-skilled workers, the employment rate has fallen from roughly 96 percent to 87 percent since the late 1960s, and hours worked have fallen from 43 to 38 hours per week. These decreases are even more pronounced for low-skilled workers: employment has dropped from 90 percent to just above 70 percent while hours have fallen from 39 to 30 hours per week. Aguiar, Hurst, and Karabarbounis proposed two possible explanations for these observed changes: differences in before-tax wage changes and changes in female wages and earnings.

To begin examining the difference in before-tax wage changes between skill groups, Aguiar, Hurst, and Karabarbounis showed that average federal plus FICA marginal tax rates trended similarly for the skill groups over the past four decades. Comparing the trends of the employment rate to after tax wages for low-skilled workers, they find a correlation of 0.72 from 1967 to 2006. For high-skilled workers, this looks very different; the correlation between the employment rate and after tax wages is -0.3 over the same period. This suggests that after-tax wages may better explain employment patterns for low-skilled workers. Since after-tax wages for high-skilled workers has steadily increased since the early 1990s but employment has continued to decrease, the authors argue that other factors have affected labor supply since the 1990s.

Focusing on highly-skilled married men, Aguiar, Hurst, and Karabarbounis showed that the employment rate of this group is highly negatively correlated with the spousal employment rate (-0.84), spousal earnings (-0.94) and spousal wage (-0.9). The authors argue that relatively flat wages for this group, along with the increase in spousal earnings, could have caused employment rates to fall in the pre-1990 period. Post-1990, the continuing increase of spousal employment and earnings could have offset the increase in male after-tax wages, causing high-skilled married male employment to continue decreasing. However, if this were the case, why did the employment rate for low-skilled married men stay relatively flat post-1990, while wages remained relatively flat but spousal earnings increased? In an attempt to answer this question, the authors showed that the wages of low-skilled married men relative to their spouses' wages have continued to increase throughout the 1990s, whereas the wages for high-skilled married men relative to their spouses' wages increased from 1970 through the early 1990s, after which their relative wages plateaued.

Toward the end of the presentation, Hurst quickly introduced a Beckerian model of time allocation to explain these changes. In the model, households consist of two members. Each member chooses to allocate their time to the production of a market good or to the production of a non-market good. Labor is the only input for the market good, while labor and market goods are inputs for the non-market good. There is non-separability between goods and time in the production of the non-market good, and non-separability between household members' time in the production of the non-market good. Agents are heterogeneous with respect to gender and education in the model. Wages and tax rates depend both on gender and education. Agents also receive non-labor income dependent on education. The model predicts that, all else being equal, a relative rise in women's wages leads to a reduction of women's time allocation to the non-market good relative to men's time. It also predicts that a relative rise in the price of the market input leads to substitution from goods inputs to time inputs for the non-market goods. Hurst added that the model is very preliminary and that they were working on a model that includes leisure time and incorporates asset accumulation.

A conference participant asked how employment has changed by age within skill group. Hurst showed a graph of the employment rate for highly-skilled workers for three age groups: 25-44, 45-54, and 55-65. The first two groups look nearly identical, decreasing about 5 percent to an employment rate of 90% from the late 1960s to 2012. However, the oldest group looks very different, with a large decrease in the employment rate from about 90% to 65% through the 1970s and 1980s, with a small increase in the 1990s ending at about 73% in 2012. As a follow-up question, a participant asked where these men are getting their income. Hurst responded that a life cycle model with capital accumulation is needed to answer that question. A discussion of changes in retirement saving followed and Hurst agreed that such changes could be contributing to the trends he has shown. ◆

## Marriage, Markets and Money: A Coasian Theory of Household Formation

Kenneth Burdett, Mei Dong, Ling Sun, and Randall Wright

The Coasian theory of the firm is based on the idea that, while there are market alternatives to many goods and services, transaction costs can make it preferable to bring various types of economic activity in house. These transaction costs include in using the market, such as searching, bargaining, and taxation. This paper, presented by Wright, suggests that the formation of households can be studied with a similar spirit, since many of the goods and services individuals need or desire can be alternatively provided either by the market or within the household. The aforementioned market frictions, as well as inflation, make individuals more inclined to bring more economic activity in house. The presentation showed a model of a household under market restrictions, and measured the impact of macroeconomic factors to the formation of the household by using multi-country panel data.

Wright first explained the model mechanism. The total population contains half men and half women. Each period, these agents and firms perform three types of economic actives sequentially. First, there is a frictionless market, in the spirit of Arrow-Debreu (1954), where all agents trade labor, goods and assets. Next there is a goods market, in the spirit of Kiyotaki-

Wright (1989), incorporating the aforementioned frictions such as taxation. Finally, there is a market where single individuals search for marriage partners, in the spirit of Burdett-Coles (1997). Key economic results are derived from the model. Given marriage and markets are substitutes, individuals facing increased bargaining frictions are more inclined to marry. The reverse is also true: individuals with decreased bargaining frictions are less inclined to marry. Similarly, an increase or decrease in the sales tax and inflation rates raises or lowers their propensity to marry, respectively. These results, proven to be robust to different utility functions, are consistent with the way markets and firms are alternative methods to organize economic activity in Coase's original theory.

Wright then showed the empirical information to test the two predictions from the theory. First, to test the hypothesis that being single is cash intensive relative to marriage, the authors presented data from an Italian household survey on cash usage, income, and wealth. This survey showed that the cash holding and cash expenditure ratio per adult decrease as the household size increases. The Means of Payment Survey conducted by the Bank of Canada showed that the probabilities of cash usage in any given transaction for single and married people are 55.3 percent and 48.4 percent, respectively. Also, survey data form Boston Fed showed that separated or divorced people carry more cash than married individuals.

To test the hypothesis that an increase in market frictions, such as inflation, should increase the propensity to marry, the authors presented a constructed dataset containing annual information on marriage rates for the period 1950 to 2004 for 255 countries. The regressions of marriage rate on inflation rate find that the coefficients on inflation rate are positive and most of them are significant.

The presentation concluded with a discussion of future works on this topic. The framework presents many extensions and applications to the study of household, such as whether the shrinking of households is due to a secular decline in Coasian friction, or whether the notion of household can be expanded beyond marriage. During the discussion, a lot of questions were raised about the definition of household in the paper, because besides the variable that provides utility for two individuals staying together, marriage has no distinct difference from roommates. Wright responded that the model indeed does not require legal marriage to work since most of the Coasian friction can be prevented by producing household products together. Some other participants questioned the macroeconomic evidence provided, since cross-country comparisons tend to be less clean. Randall agreed that the macroeconomic evidence is a preliminary test of the model's prediction, and a cleaner test opens up opportunities for future works. ◆

## Understanding the Great Recession

Lawrence Christiano, Martin Eichenbaum and Mathias Trabandt

During the Great Recession, a number of phenomena arose that standard macroeconomic models were unable to explain. In particular, Christiano, Eichenbaum, and Trabandt note that models have been unable to explain why an observed rise in vacancies has not be associated with a rise in employment. Additionally, the standard models of the economy have been unable to explain why the shocks that occurred during the Great Recession caused only a small degree of inflation. They seek to explain these effects within a standard New Keynesian model augmented by shocks observed in the lead up to the Great Recession. They find that the zero lower bound is able to cause many of the dynamics observed with inflation, while a revised approach to modeling the labor market can account for its observed behavior in the business cycle as well.

The paper employs a medium-sized New Keynesian model in order to explain the mechanisms that could have combined to cause these outcomes. There is a representative household that consumes both home-produced and market goods, where consumption utility over these goods is given by a monotonic transformation of a Constant Elasticity of Sustitution (CES) aggregator. These households work inelastically in either the home or the labor markets, deciding each period how many members to send into the labor market. The labor market, rather than being competitive, is proxied by a search and matching model, in which each period the employed separate exogenously with some probability and the unemployed return to the home production market with some probability. They depart from the standard search model by using a novel bargaining procedure in which employers and the unemployed alternate making offers during each day of the period. During the negotiation, both sides pay a fee for rejecting an offer and face the possibility of the negotiation breaking down; in equilibrium, the firm offers exactly the amount that the worker will accept initially. Each period, a wholesaler employs workers in the labor market by opening a number of vacancies in order to produce an intermediate good. Using this intermediate good, a set of monopolistic retailers produce an input that is used in production of the final good, with some degree of substitutability between each of these inputs. This final homogeneous market good is consumed by the households after being produced by competitive and identical firms whose technology is described by a CES function. The authors then proxy the movement of the macroeconomy by including four shocks to different features of their model. They first allow a consumption shock that is modeled as a perturbation to the Euler Equation for the acquisition of the risk-free asset. The second shock models an increase in credit spreads following the start of the Great Recession, by including a wedge in the Euler Equation for capital. In order to incorporate this shock, they require that retailers borrow a fraction of their working capital. Third, they allow a neutral technology shock that is made up of a permanent and temporary shock, and is interpreted by the household using an unobserved components model.

Finally, they use a government consumption shock in order to allow unexpected changes in the behavior of the government during the Great Recession. They model monetary policy using a Taylor Rule, in which the Federal Reserve adjusts the interest rate gradually, while trying to hit a target level of inflation in each time period.

Christiano, Eichenbaum, and Trabandt match the features of their model to the data prior to 2008 and use this to explain the behavior of inflation and the labor market during the Great Recession. In order to estimate the model, the authors first restrict a set of parameters to their corresponding values in the literature. The real rate of interest, the growth rate of technology, the depreciation of capital, and the growth rate of investment specific technology are all set so that they match their sample averages prior to the Great Recession. They also calibrate parameters in order to match a labor force participation rate of 67 percent, a filling rate of 70 percent, a 5 percent unemployment rate, and a government to output spending ratio of 20 percent, all in the steady state. The remaining parameters they estimate using Bayesian methods. The authors first address the labor market, noting that the data suggests an upward shift in the Beveridge curve, as vacancies had risen to pre-recession levels while employment remained relatively stagnant. Previous papers interpreted this as a deterioration of match efficiency, requiring a parameter change in order to account for this behavior. Christiano and his co-authors argue that such an adjustment is not needed. These previous papers assume that the labor market is in a steady state, with the number of unemployed constant across each period, which is not true during the Great Recession. After allowing the labor market to transition, the shift in the Beveridge curve is captured by the model, without a deterioration of match efficiency. The authors find that the drop in the labor force participation rate is almost entirely explained by the consumption and financial wedges, which lead to the deterioration in the labor market. They next turn to the claim that inflation should have been much lower given the state of the economy during the Great Recession. In the absence of a large neutral technology drop, the authors note that inflation would be predicted to drop by a great deal. In the presence of the zero lower bound, however, a drop in neutral technology has two effects. The first raises the marginal cost on the retailers in the economy, which in fact drives up inflation. When the economy is at the zero lower bound, this has the effect of decreasing the real interest rate while increasing output and employment. The second effect, the wealth effect, leads to an increase in the labor force participation rate, decreasing marginal cost. Furthermore, the inclusion of risky working capital (the financial wedge) serves to increase the marginal cost for firms with bad balance sheets, further dulling the predicted deflation. Combined, these result in an overall increase in marginal cost, which causes moderate inflation. This helps to explain why there was no observed deflation during the Great Recession and only a modest amount of inflation.

One participant noted that the use of Cobb-Douglas in home production implies constant shares going to each factor of production, and seemed artificial. They were concerned about how this might have impacted the results. Christiano agreed that such an inclusion had not been carefully considered and they were not sure how this might impact the results. Another participant took issue with the Calvo pricing scheme, noting that it seemed silly for firms to be able to renegotiate wages each year, but only set their prices every few years. Many of the audience believed that the vacancy formation may have been incorrect, believing that vacancies in the Job Openings and Labor Turnover Survey (JOLTS) dataset were consistent with a different variable in the model. They believed that this may have resulted in a different Beveridge Curve and invalidated one of the key conclusions of the model. Finally, one audience member disputed the claim that the model contained no nominal frictions, arguing that the price stickiness was a nominal friction. Christiano noted that nominal frictions are typically imposed upon the model, but the frictions present in the model were primitives of the model. ◆

## Immigration Restrictions and Labor Market Skills

John Kennan

Although immigrants account for a substantial fraction of the population in many developed countries and there is a large literature on the economics of immigration, little attention has been given to the following question: what would happen if people could choose where they want to live? Kennan's presentation demonstrated his model and numerical estimates to answer this question.

Kennan first showed the focuses of existing immigration literature, which are assimilation, selection, and effects on wage levels and skill premia in host countries. Kennan acknowledged the importance of these topics but also proposed that the most important question remained largely ignored: how many immigrants would there be if there were no restrictions? Furthermore, what would the welfare gains and losses to the new immigrants and the existing ones be? He then critically reviewed the existing literature that initiated the quantitative analysis of the costs of immigration restrictions with a segmented labor market model. This approach, which assumes wage equalization, has major limitations. It ignores people's attachment to home, migration costs, and does not consider the extent to which wage differences are arbitraged through product markets. Thus, a wage premium must exist in the host countries for migration to happen. Kennan then showed his general equilibrium model in which efficiency differences are labor-augmenting and free trade in product markets leads to factor price equalization, so that wages are equal across countries when measured in efficiency units. Specifically, output is a power-linear function of capital and composite labor, which is a power-linear function of skilled and unskilled labor. When immigration restrictions are relaxed, the capital-labor ratios and factor-price ratios change, which leads to changes in real wages. These changes affect sending and receiving countries the same way. Factor price equalization holds both before and after the migration of labor, but migration reduces the wage per efficiency unit of labor, and therefore also reduces the wages of all workers who do not migrate. Workers in

this model consider their migration decisions based on the level of income in the home location, the highest income available elsewhere, and a migration cost of utility. In order to estimate the migration cost, the author calibrated the migration part of the model using the 2000 Census data on the proportion of Puerto Ricans who choose to stay in Puerto Rico rather than migrate to the U.S., which has an open boarder and a considerably higher wage.

Kennan then proceeded to present the estimate of effective world labor supply by using schooling level data from Barro and Lee (2010), and relative wage data from the U.S. Census. The results show that if there is no restriction on immigration, the effective labor supply of low-skilled workers (0-8 schooling years) will increase by 149%, that of mid-skilled workers (9-12 schooling years) will increase by 101%, and that of high-skilled workers (13-16 schooling years) will increase by 42%. Therefore, the ratio of skilled to unskilled workers would considerably decrease in the model. Kennan then showed the estimated income gains for different worker groups. Regardless of the skill level, immigrants experience about 100% gains in income.

Kennan concluded the presentation by discussing the long-term effect of the thought experiment. In steady state, the marginal product of capital is the sum of rate of time preference and capital deprecation rate. Since migration increases effective labor, the capital-labor ratio will fall below the steady-state level and marginal product of capital will rise above the steady-state level. In the long run, investment increases and effective capital-labor ratio will return.

One conference participant asked about generalizing the global migration cost as the utility cost from Puerto Rico to U.S., and considered it an underestimation. Kennan agreed that applying the Puerto Rico to U.S. cost to other parts of the world is a crude and preliminary estimation as this is a clean experiment for potential immigrants. ◆

**Macroeconomics and Business Cycles**

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## Trade Adjustment Dynamics and the Welfare Gains from Trade

George Alessandria, Horag Choi, and Kim Ruhl

Alessandria, Choi, and Ruhl develop a model that reflects the dynamics of international trade observed in their data. Their model delivers novel conclusions about changes in welfare that occur when barriers to trade are dropped. Earlier models of international trade ignored the evolution of exports following a decrease in the tariff, instead focusing on the economy in a new steady state. These previous papers argued that the steady state corresponded to the maximum level of welfare and thus the transition period could be ignored. In contrast to this previous work, Alessandria, Choi, and Ruhl show that the transition dynamics are important for welfare considerations when varieties are used in aggregate production. In particular, consumption rises far above its steady state level following a change in trade policy; this increases overall welfare by several percentage points. By accounting for these dynamics, this model also can account for observations on international trade more effectively than previous models.

The model presented by Alessandria, Choi, and Ruhl abstracts from some of the complexities of international trade by assuming that there are only two economies: home and foreign. Each economy contains a unit-mass of infinitely-lived consumers who provide labor inelastically, as well as a set of intermediate goods producers who receive technology and iceberg cost shocks each period. The two economies have each imposed a tariff of 10 percent and have the same aggregate production technology, which combines different varieties of intermediate goods. During each time period, intermediate firms produce goods by combining labor, capital and materials. These firms then decide whether to begin to export, if they have not already started. They make this decision based on their productivity and iceberg costs. Their productivity evolves according to an autoregressive process, while their iceberg costs are either infinite, high, or low. The iceberg cost can be thought of as the amount of trade that is lost in transit each period; necessarily, firms with infinite iceberg costs will never export. These iceberg costs evolve over time according to a Markov process that is estimated from the data. If the intermediate firms choose to export, they pay a high fixed fee immediately and then begin exporting the next period while paying a lower fixed fee. Firms that have already begun exporting choose what proportion of their production to export to the foreign country. Each period, intermediate producers also receive a shock which decreases their productivity and determines whether or not they continue to produce. In each country, a Constant Elasticity of Substitution (CES) aggregate production function combines these intermediate goods with some degree of substitutability between varieties. The representative household in each country then decides how to split this production between consumption and investment.

Alessandria, Choi, and Ruhl calibrate trade preferences using standard values for discount rate, depreciation rate, and risk aversion. They calibrate the elasticity of substitution across varieties so that intermediate good producers obtain a markup of 25 percent. The authors choose the set of parameters determining the dynamics of international trade, the distribution of firm characteristics, and the growth and destruction of exporters to match observations on their equivalent quantities in the data. In particular, firms in their model that choose to export begin with an export intensity which is half of its final value. The export intensity then increases over five years. They find the fixed cost of starting to export to be 40 percent larger than the fixed cost of continuing to export. They also find the high iceberg cost to be 63 percent larger than the low cost, and these iceberg costs to be extremely persistent. In order to assess the welfare implications of removing trade barriers, the authors implement a global tariff removal. Unlike in previous models, consumption has a hump-shape and peaks after seven years in this model. Prior to the tariff reduction, many of the intermediate good varieties had to be produced domestically, as trade barriers were cost-prohibitive. The elimination of these tariffs allows home consumers to decrease their investment in varieties they will now import, thus increasing consumption during the transition phase. They find welfare increases to be fifteen times larger than would be estimated by simply looking at the new steady state, lending credence to their conclusion that these transition dynamics are extremely important in determining welfare gains. In fact, consumption is more than nine percentage points higher during this transition than it is in the steady state. They find the short-run elasticity of trade to be 4.0, while the long-run elasticity is 11.55, figures they will use when comparing their model to alternatives. In order to assess the importance of the novel features of their model, they place parameter restrictions that emulate previous literature. They find that restricting iceberg costs to be constant results in lower long-run trade elasticities and less consumption overshooting than in the benchmark case. When they allow all establishments to export and match it to the long-run elasticity of the benchmark case, they find that consumption steadily increases and welfare is lower than in the benchmark case. They conclude that a steady state model that only focuses on the relationship between trade elasticity and welfare, ignoring the transition after a tariff change, is insufficient for analyzing trade policy.

One participant indicated that he didn't think the paper actually said anything about international trade, to which Alessandria responded that the literature wasn't so much about international trade as it was one country entering the market of another country. Another participant argued that it seemed strange that firms could decrease their iceberg costs, but had no way of decreasing their own fixed costs over time. Alessandria noted that this was possible, but would eliminate growth in the model. A third participant was concerned that the model didn't contribute anything novel to the literature, and wasn't really responding to observations in the data. Alessandria noted that the evolution of the trade elasticity was a novel contribution that hadn't been captured at the macro level prior to this paper. He further noted that the distinguishing feature was the welfare conclusions, which were in stark contrast to many of the static estimates. ◆

## The Risky Capital of Emerging Market

Joel M. David, Espen Henriksen and Ina Simonovska

In his seminal paper, Lucas (1990) showed that poor countries exhibit significantly higher returns to capital than do rich ones. According to neoclassical economic theory, capital returns should be equalized across countries to achieve efficient capital allocation as well as global output maximization. The inconsistency between data and theory gives rise to the so-called "Lucas Paradox" – why capital does not flow from rich countries to poor countries until returns are equalized. The paper by David, Henriksen and Simonovska revisited the "Lucas Paradox." The authors investigate the role of long-run risk of capital in poorer countries. They find that long-run risk can quantitatively account for about 75 percent of observed return disparities between the U.S. and a group of the poorest countries in the world.

Henriksen began his presentation by showing the average return to capital for a U.S. investor across 152 countries over the period from 1950 to 2009. It is shown that there are large differences in capital returns around the world, and that poor countries tend to offer significantly higher returns than do rich ones. He then presented their first-round attempts of using risk-return tradeoff to account for the dispersion in international capital returns with a consumption-based capital asset pricing model (CCAPM). The model assumes that a representative U.S. investor has access to both domestic and international capital assets. Specially, when measuring the returns to capital assets, portfolios are created by grouping assets from the countries with different income levels. There are three types of primary asset structures in the portfolios constructed: three, five and 10 units of international capital assets respectively, with a single unit of the US asset. Risk premiums are then determined by the covariance of returns to each constructed portfolio with consumption growth of the US investor, multiplied by the degree of risk aversion. However, it is shown that the covariances are too small to generate the large return disparities in the data, which makes "Lucas Paradox" another form of risk premium puzzle.

Next, Henriksen presented their resolution to use a long-run risk exposure with the capital in poorer countries as an explanation. The model is built on Bansal and Yaron (2004), where the representative investor has a recursive preference of the Epstein and Zin (1989) form, and is endowed with a stream of consumption and dividend payments from an asset. Both consumption growth and dividends are modeled to have a small but persistent component. Consumption growth of the investor and international capital payment each exhibit different levels of exposure to the long-run risk. For calibration, parameters that govern U.S. consumption growth are adopted directly from the existing literature. Since calibrating the cash-flow process for each capital asset is challenging, the co-movement in cash-flow growth rates and returns to capital is used to infer the exposure of each asset to the long-run shock. It is shown that the calibrated model accounts for 60-70 percent of the spread in returns between the U.S. and the portfolio of the poorest countries in the world, depending on how the portfolios of the international capital assets are grouped.

At the beginning of the presentation, when Henriksen showed the empirical evidence of the negative relationship between capital return and log GDP per worker, several participants inquired about whether the capital share is kept constant. Espen responded that their model is a partial equilibrium model, which takes the capital share as an exogenous parameter and calibrated to be 0.3 as in the existing literature. When Henriksen introduced the portfolio bundling strategy, a participant had a question about whether the composition of the portfolios varied. Henriksen responded that they do not because they applied different sorting when constructing the portfolios. Another participant asked why the model used return to capital from the aggregate account instead of stock returns. Henriksen responded that it is because the stock market is underdeveloped and therefore really thin in some poor countries. ◆

## Too Big to Cheat: Efficiency and Investment in Partnerships

Emilio Espino, Julian Kozlowski and Juan Sanchez

About 30 percent of the total net income of all business in the U.S. comes from firms established as partnerships. A partnership consists of two or more individuals joining together in a trade or business, where each partner contributes with money, time, and skills, expecting to share in the firm's profits and losses.[1] This firm structure allows entrepreneurs to pool their resources and minimize their need for external financing, possibly mitigating the effects of financial frictions. This advantage over sole proprietorships comes with its costs: each party in the partnership has private information about their respective contributions and needs, making this firm structure susceptible to moral hazard problems.

Espino, Kozlowski and Sanchez study the optimal design of a partnership. They investigate how partners' liquidity requirements (their need to withdraw capital from the firm) affect investment, payouts, and the firm's ownership structure over time. The authors model two risk-averse partners which contribute some initial capital to start a partnership. From period to period, the partners reinvest their earnings into their business and are exposed to stochastic liquidity shocks. The design of the model specifies the benefit each partner receives from their investment, how much gets reinvested into the business, and their total stake in the company via ownership shares.

The authors find that when there is full information about partners' liquidity shocks, the partners' ownership shares are constant through time. Conversely, under private information, the optimal design of the partnership uses ownership shares and investment in the firm as tools to provide the partners with incentives to truthfully report their liquidity needs. For this case, either the partners become "too big to cheat," with enough ownerships shares to prevent them from misreporting their liquidity needs, or they converge to "immiserization," where one party eventually owns the entire business. During this process, the optimal mechanism prescribes that the partners' investment in the firm should move in the opposite direction. For example, when one partner faces high liquidity needs, the

optimal partnership agreement will give her a larger payout this period while increasing her ownership shares. This occurs at the expense of the other partners' payout and investment in the firm. Eventually, if the partner's liquidity needs persist, the reduction of investment accompanied by an increase in her ownership of the company would reduce her future expected payout, eliminating the incentives for misreporting; she is now "too big to cheat." At this point, either the other partners have large enough ownership shares in the business to become "too big to cheat" themselves or they leave the partnership, leaving a sole individual as the proprietor. The former results in their ownership share and investment in the firm remaining constant, while the latter results immiserization.

Espino, Kozlowski and Sanchez's results stand out from the rest of the literature because they motivate the role of investment and partners' risk-averse preferences in explaining data on a partnership's ownership structure over time. The Kauffman Firm Survey shows that partnerships with equal ownership shares retain this ownership structure over time, while those that have unequal shares have a less stable ownership profile. Under private information, without a partner's investment there wouldn't exist a "too big to cheat" condition that promotes stability in ownership shares. Similarly, without both partner's risk-aversion, the partnership could achieve the optimal full information outcome of constant ownership share forever, ruling out the firms' ownerships dynamics found in the data.

During the conference a participant asked the presenter whether the authors had considered firms' size in their calculations. Sanchez responded that capital stands for the firm's size in their model, and the partners' promised utility depends directly on capital. As capital grows, the partnership decides how much to invest in the company, and how much to distribute earnings amongst the parties. Another participant asked why they didn't model costly auditing as way to ease informational frictions. The presenter answered that if the partner could be verified, then he would not deviate in his reports, and the model would predict the same behavior as in the full information case, ruling out the need for audits. Finally, another participant noted that a partner in a business invests more than capital. He asked whether the model can incorporate alternatives forms of investment like labor and skills. Sanchez said that the shock to liquidity could be interpreted as a variable cost of putting effort into the business, and it would be isomorphic to requiring larger earning distributions.

[1]Definition of Partnerships by the IRS ◆

## Commodity Price Booms: Macroeconomic and Distributional Implications

Marina Mendes-Tavares, Adrian Peralta-Alva and Irina A. Telyukova

After staying roughly constant between 1982 and 2003, the UN's Food and Agriculture Organization's global real food price index started increasing, and is expected to be 50% higher than the 2003 level by the end of 2014. On average, consumers in low-income countries spend a large portion of their budget on food. However, a larger share of households in low-income countries produce staple foods as well. As a result, the final impact of an increase in staple food prices in low-income countries can be potentially positive because of income effects, or negative because of price effects. Mendes-Tavares, Peralta-Alva, and Telyukova's presentation showed their understanding of the impact of food price shocks on income inequality, and the analysis of the macro and distributional impacts of the policies that arose in response to these shocks.

The presentation first showed a multi-sector dynamic general equilibrium model that has the key features of low-income countries. The model has multiple sectors, including an industrial sector, exporters of agricultural goods, and small farmers. The labor force in these sectors is comprised both of wage earners who work for firms and of household enterprises. To focus on inequality, the agents in the model are considered to be heterogeneous and have idiosyncratic and aggregate shocks. Regarding financial markets, it is assumed that some agents can borrow abroad, while others can only access a market for domestic state-uncontingent bonds, in zero net supply. All agents have the same preferences over non-food items and food, which is a composite of imported food and domestically produced agriculture goods. Peralta-Alva then showed that, if domestic and imported food are complements, then higher imported food prices have an ambiguous effect on domestic food prices. If domestic and imported food are substitutes, then higher imported food prices increase domestic food prices.

The presentation continued with a quantitative analysis using panel household data in Ghana from 2004 to 2013. The model is calibrated towards relative price of imported and domestic produced, household expenditure on imported food, total export over GDP, ratio of urban over rural household income, and expenditure of domestic food over expenditure of non-food goods. The calibrated benchmark economy is able to reach all targets, with the exception of the total share of exports over the GDP. Peralta-Alva then showed two exercises with the calibrated model. First, they consider the impact of a 50% increase in real agricultural good prices, which is the actual change between 2003 and 2013 reported by the FAO. This will cause a reduction in relative price of food produced domestically by 2%. The main force behind this result is that in the benchmark model domestic food and imported food are complements. Consequently, an increase in the price of imported food reduces demand for domestically produced food, because farmers supply more food to the market and consume less of it themselves. This reduces the price of domestic food. The final effect is that the consumption of

imported food decreases drastically for all consumers, while the consumption of domestic produced food increases slightly for all consumers except for farmers. Second, the authors consider one policy that can mitigate the food consumption drop, which is to subsidize the consumption of domestically produced food. The authors assume in the model that the government directly subsidizes domestic food price for all consumers, and finances this subsidy by lump-sum taxation on firms. This is in line with the data that few workers in the economy pay taxes. The result shows that even after the subsidy, the consumption of food is still below the benchmark consumption, but it is 0.3% higher than the case without subsidy. The households that benefit most from this policy are farmers, thus reducing the inequality in the overall economy.

One participant asked about the choice of data for calibration. Peralta-Alva responded that Ghana represents the low income countries very well in terms of GDP per capita and inequality levels. Also, the Ghana Urban Household Panel Survey is a unique panel dataset for low-income countries. Several participants asked about the missed target in the calibration; Peralta-Alva responded that this part is still a work in progress, as the total share of exports over the GDP is too far off from the actual data. ◆

## Bank Liquidity and Capital Regulation

Francisco Covas and John C. Driscoll

Basel III, developed in response to the financial crisis of 2007-2008, will introduce several new capital requirements over the upcoming years. One of the key elements of Basel III is the introduction of a minimum liquidity coverage ratio (LCR) starting in 2015. The LCR requirement is supposed to ensure that banks hold enough high quality liquid assets that could sustain a period of stress lasting 30 days. Covas and Driscoll seek to understand the effect of the new liquidity standard on the supply and cost of credit for borrowers who require credit from banks. They also seek to better understand the general equilibrium effects of the new regulation on the risk-free rate and what role macroprudential regulation can play to mitigate the effects of a future financial crisis.

Covas and Driscoll develop a dynamic general equilibrium model with incomplete markets to study the effects of liquidity requirements. Their model features three types of agents: bankers, workers, and entrepreneurs. Bankers are heterogeneous in their wealth holdings, loan balances, deposit balances, and in their ability to generate noninterest income from loans, which represents half of net income for large banks. Bankers hold two types of assets: risky loans and riskless securities. Bankers receive interest income from both asset types and also receive noninterest income, which is a nonlinear function of their holdings of loans. The banker's ability to generate noninterest income can change over time and this represents the banker's uninsurable "profitability" risk. As a bank's profitability or level of deposits changes, it may want to adjust its asset portfolio. There is no adjustment cost to changing holdings of securities, but there is a quadratic adjustment cost to changing the stock of loans. This difference in adjustment costs represents the difference in liquidity between the two asset types.

Bankers provide loans for entrepreneurs and receive deposits from households. Each bank's share of total deposits is exogenous and follows a four-state Markov chain. Banks must satisfy two constraints. The first constraint, a capital constraint, requires equity to surpass a percentage of risky loans. The second constraint, a liquidity constraint, requires the amount of cash on hand to be greater than the amount of deposits that would be lost if the bank's share of total deposits were to decline. This liquidity constraint is designed to mirror the LCR requirement that will be implemented with Basel III.

Entrepreneurs in the Covas and Driscoll model operate a risky technology. The technology is risky because levels of capital and labor are chosen before productivity is observed. Entrepreneurs hold two types of assets, risky investment and riskless securities. Entrepreneurs can borrow from bankers to finance consumption or capital. Workers in this model are very similar to households in the standard Aiyagari incomplete markets model. Workers supply their inelastic labor to a representative firm, called the corporate sector, and receive idiosyncratic productivity shocks. The only difference is that in addition to having a capital asset, workers in the Covas and Driscoll model can also save through deposits. Both types of capital are riskless but deposits enter the worker's utility function. The corporate sector has an aggregate production function with capital, labor, and a constant aggregate productivity. Capital for the corporate sector is supplied by workers and labor is supplied by both workers and entrepreneurs.

To understand the quantitative effect of this regulation, Covas and Driscoll calibrate their model. They use standard parameter values for workers and entrepreneurs. For the banker, they set some parameters directly from outside sources, like capital requirements, and calibrate other parameters internally to match moments from the bank holding company call reports (FR Y-9C). They find that relative to their baseline policy (of 6 percent capital requirements), the introduction of liquidity requirements increases holdings of securities by 28.6 percent, the amount of loans declines by 9.1 percent, the liquidity constraint binds for 25 percent of firms, and the equilibrium returns on securities decline by 28 basis points to 1.34 percent. Moreover, output declines by 2.2 percent and consumption declines by 1.2 percent. They consider an alternative regime, with no liquidity requirements but an increase in capital requirements to 10 percent. In this case, relative to the baseline, holdings of securities still increases by 13.5 percent, but there is a very small impact on both loans (-0.8 percent) and the loan rate (+3 basis points). This policy regime also has a very small impact on output (-0.2 percent) and consumption (-0.4 percent). Their key finding is this difference in the effects of the two regimes on output and consumption. These results depend on the supply of safe assets. In their model, the supply of riskless securities is fixed and they find that having a large supply of these safe securities dampens the effects of implementing the LCR. Implementing the LCR in countries with small supplies of riskless securities would have much larger effects.

Liquidity requirements are effective in dampening the effects of capital shortfalls. Covas and Driscoll simulate the recent financial crisis by implementing a capital shock to bankers equivalent to 7.5 percent of steady state output. The magnitude of this shock represents the estimated size of bank losses reported in the 2009 Supervisory Capital Assessment Program. The key requirement to make the LCR effective at dampening the effects of this shock is allowing banks to fall below the liquidity requirement during the period following the shocks. The increased level of securities holdings under the liquidity requirement allows banks to better endure the immediate impact of the sharp decline in deposits. Relaxing the constraint during the crisis allows banks to adjust their portfolio in the transition period following the shock. Without this macroprudential policy, bank loans fall by 1 percentage point more in the first year following the shock and 4 percentage points more in the second year.

The discussion focused on the quadratic adjustment costs used as a stand-in for the liquidity difference between securities and loans. The adjustment costs are calibrated assuming that the cost of adjusting the stock of loans downwards is larger than the cost adjusting it upwards, since in practice calling in or selling loans is more costly than originating loans. Some conference participants were interested in whether or not the adjustment costs could be explicitly modeled. Covas explained that this could be modeled more explicitly but the model would become significantly more difficult to solve. There was also some discussion about why there are a vast number of banks in the U.S. whereas in Canada and some European countries there are far fewer banks. Covas explained that in both the U.S. and Canada, a small number of banks hold a disproportionate percentage of all assets (75 to 80 percent), and that their model matches the data in this regard. ◆

## Aggregate Consequences of Dynamic Credit Relationships

Stéphane Verani

Young firms are special; they are the most important net job creators. They are also very volatile, expanding rapidly after their formation or disappearing shortly after. Their success and growth prospects are determined in great measure by their access to external financing. In this paper, Verani studies the effects of financial frictions in the interactions between lenders and entrepreneurial firms and their consequence for the growth of new firms, industry dynamics, resource allocation, and transmission of aggregate shocks.

Verani creates an environment where entrepreneurs and lenders interact. The environment shows how the structure of the financial system – in terms of the degree of lenders contract enforcement and auditing capabilities – affects the optimal lending contract between the parties. Entrepreneurs are modeled as risk neutral agents, who have access to a production technology and are subject to short-term productivity shocks. They need external financing to start their business, and can sign long-term contracts with lenders who share their surplus. However, since the realization of entrepreneurs' productivity shocks is private information, the split of this surplus is dependent on their production reports, which can be misrepresented by entrepreneurs to obtain short-term gains. Lenders, on the other hand, are financial intermediaries which sell annuities to households, who are the source of funds, and provide long-term financing to entrepreneurs. The lending relationship between lenders and entrepreneurs depends on the formers' contract enforcement and auditing capabilities: either the lenders can or cannot audit the entrepreneurs, and are either able or unable to exclude misreporting entrepreneurs from financial markets in the future. Each of these four possible combinations generates different optimal contract structures. Under each possibility, the flow of funds between entrepreneurs and lenders varies, which determines the growth prospects of entrepreneurial firms.

The four different contract structures have different effects on firms' output and volatility. In the first type of contract, when there are no audits, new entrepreneurial firms' have more volatile output. This is a result of the discipline that lenders have to impose on firms when they can't audit their production: lenders cut their investment when firms report negative productivity shocks, while increasing it when they receive positive reports. These swings in investment cause the firms' output volatility. Under this type of contract there are two possibilities: either lenders can exclude misreporting entrepreneurs from future funding or they can't. In the first case, output is reduced by 5.8 percent when compared to the first best model without asymmetric information. In the second case, output is reduced by 6.5 percent. Alternatively, when lenders are allowed to audit, output is 1 percent lower than in the first model under exclusion and 2.3 percent lower under no exclusion. Additionally, to lower output losses, firms' output is less volatile under auditing. This is a result of increasing flow of information between the contracting parties.

Firm size also varies depending on which type of contract is available. Exclusion makes a large difference when lenders can audit. New firms more than double in size and the average firm size in the economy increases by 14 percent when lenders audit. The same is observed when firms can't audit, but the benefit of exclusion is only 30 percent for new firms and 5 percent for all firms over the non-exclusion contract. The intuition behind these gains in firms' size comes from the optimal behavior of lenders, who give them a large contingency fund in case of a negative shock to prevent firms from defaulting. This large contingency fund reduces the surplus of the contract, leading lenders to reduce their investment when they can't exclude misreporting firms from financial markets.

During the conference a participant asked what the presenter meant by financial market exclusion. Verani responded that exclusion is a red mark; it's a signal that broadcasts to all lenders that a particular entrepreneur is a cheater. Another conference participant as whether free auditing, an assumption made when firms are allowed to audit, is any different from an environment without private information. Verani answered that both cases are similar, with one main difference. While there is no lenders' auditing cost, the lenders loose revenue that cannot be recovered when firms cheat; it is the cost of reneging the contract, which means that auditing is still limited enforcement. ◆

## Mortgages and Monetary Policy

Carlos Garriga, Finn E. Kydland and Roman Šustek

Mortgage debt amounted to between 30 and 100 percent of annual GDP in the developed world in 2009. Mortgage payments amount to between 15 and 22 percent of net income in United States and United Kingdom, and 29 percent in Germany and France. Because of the magnitude of mortgage debts, it has a non-trivial influence on the effects of monetary policy. Garriga, Kydland, and Sustek present a study of the macroeconomic consequences of the nominal rigidity inherent in standard mortgage loans. Their paper aims to characterize the channels through which the rigidity facilitates the transmission of monetary policy into the real economy, particularly into housing investment, and to investigate the strength of this transmission in general equilibrium.

Garriga first presented a simple three period model of housing investment to illustrate the nature of the nominal rigidity and the resulting two channels of monetary policy transmission. There are two forms of rigidity considered in the paper. The first is fixed-rate mortgage (FRM), which carries a fixed nominal interest rate and prescribes constant nominal installments for the entire life of the loan. The second is an adjustable-rate mortgage (ARM), which also prescribes nominal installments, calculated each period so that, given the current short term nominal interest rate, the loan is expected to be repaid in full by the end of its life. The simple model shows that current inflation produces standard wealth effects under both FRM and ARM, as well as under one-period loans. In addition, mortgages have expected future wealth effects. When a higher current short rate transmits one for one into a higher inflation rate next period, as the Fisher effect dictates, it unambiguously reduces future real payments on outstanding mortgage debt under FRM. Under ARM, however, it increases the payments in the immediate periods, but reduces them in later periods of the life of the mortgage. The more persistent the inflation rate increase is, the larger expected future reduction in the real value of mortgage payments is.

Garriga then showed an extended version of the aforementioned model. This infinite-horizon model has a population of homeowners and capital owners. Houses consist of land and structures. Mortgages resemble standard 30-year mortgage loans and households have some ability to smooth the impact of mortgage payments through financial assets. Moreover, the household's income, the short-term nominal interest rate, and the real interest rate are all endogenous. The model also includes various taxes, transfers, and government expenditures to facilitate a sensible mapping of the model into data. Calibration of the model with U.S. data showed that monetary policy affects housing investment more under ARM than under FRM. In addition, shocks to long-run inflation have larger effects than cyclical fluctuations in inflation and nominal interest rates, occurring due to TFP (Total Factor Productivity) shocks. Finally, the distributional consequences of monetary policy depend on the type of the mortgage loan. A persistent increase in the inflation rate redistributes real income from lenders to borrowers under FRM, but from borrowers to lenders under ARM. The presentation was concluded with an implication from the analysis for the current policy debate. Other things being equal, low nominal interest rates are likely to have a larger effect on the housing market in ARM than in FRM countries. The effect of such a policy will be larger the longer the time horizon is for which the rates are expected to stay low.

One participant asked about the risk structures of ARMs and FRMs and their role in the model's outcome. Garriga responded that this paper focuses only on conditional first moments in agents' decisions and risks play no role in the model. Taking risks into consideration would be an interesting extension in the future. ◆

## Explaining the Evolution of Educational Attainment in the U.S.

Rui Castro and Daniele Coen-Pirani

Education in the U.S. underwent many changes over the 20th century, resulting in wide swings in the fraction of males who received a four-year college degree. The major trends among white male cohorts are a big increase in four-year college degrees for birth cohorts 1935 to 1950, followed by a decrease for cohorts 1950 to 1960, and finally a tepid increase for cohorts 1960 to 1970. Meanwhile, wage premiums for a four-year degree followed a virtually uninterrupted upward trend over the entire period, which would lead us to expect a parallel trend for attainment. The lack of parallel trend therefore presents a puzzle. This paper sets out to find and quantify the drivers of these movements in educational attainment over this period.

The model features forward-looking, non-borrowing-constrained agents in an overlapping generations framework. At age fifteen, the agents make their schooling choice from among the following options: four-year college and above, some college, high school degree, and high school dropout, requiring eight, six, four, or two years of schooling, respectively. The decision depends on several exogenous factors: learning ability, quality of education, schooling preferences, expected skill premiums, and tuition. Two specifications are considered, each allowing for different expected skill premiums. The first is perfect foresight, in which agents know the future path of premiums, and the second is a static expectation, in which agents assume that future skill premiums will remain at their current level. This model is then calibrated for birth cohorts 1932 to 1972.

The calibration exercise is done in three parts. First, skill prices are estimated over the period 1950 to 2010 for each education level, relative to the high school degree. Second, the authors choose several parameters a-priori, including interest rates, and working lifetime, borrowing several human capital evolution parameters from Heckman, Lochner, and Taber (1998) and You (2014). Finally, Castro and Coen-Pirani use sixteen moments of history to calibrate the remaining parameters. Included in these moments are shares of workers at each education level in 1932 and 1972, as well as premiums for each education level in 1932 and 1972, in order to anchor the model to the first and last cohorts in the sample. The key moment matched is the inclusion of an exogenous change in learning ability. The

authors document a 0.37 standard deviation decrease in average eighth grade standardized test scores between the 1948 and 1963 cohorts. This pattern is incorporated as a proportional decrease in learning ability for cohorts.

The two specifications yield starkly different predictions for educational attainment over the period. In the perfect-foresight specification, the model predicts a steadily increasing rate of four-year college degrees. On the other hand, the static expectation model follows the actual data more closely. In particular, the latter model predicts an increase in four-year attainment until approximately the 1950 cohort, followed by a decrease lasting about 10 years, and finally a mild increase over the last 10 to 15 years.

Finally, the paper attempts to disentangle which trends are the determining factors for these patterns. Castro and Coen-Pirani find that skill premiums predict the initial high-growth period, but also predict an increase over the period 1950 to 1960. However, the decrease in average learning ability strongly contributes to the 1950 to 1960 stagnation.

The discussion centered on several key features of the paper, but in particular on the role of learning ability. First, several participants were in interested in the composition of the standardized tests, and especially in whether they varied over time. In addition, there was some question as to what were the proposed causes of the decline in mean ability. It was decided that family and school inputs were important factors, but that the model was not equipped to distinguish between the two. Finally, there was some interest in the role of education subsidies. According to the model, education subsidies should act through a tuition channel, which played only a minor role after the model was calibrated. ◆

## Occupational Choice, Human Capital, and Financing Constraints

Rui Castro and Pavel Ševčik

Borrowing constraints can create major distortions in firm financing, and may also play an important role in human capital accumulation. To this point, financing frictions have entered the analysis of cross-country differences in productivity and output primarily through the firm investment channel. This paper's novel approach investigates the role of firm investment decisions, human capital investment, and occupational choice for entrepreneurs. The authors argue that the results may have important implications in countries with under-developed financial systems.

Castro and Sevcik's overlapping-generations model has dynastic households, which make four decisions and are allowed to depend on household wealth and two stochastic ability parameters for the child: learning ability and entrepreneurial ability. First, the household decides how much to invest in human capital for the child, which requires both time and money. Then, saving and consumption decisions are made. Next, the household decides whether the child will be an entrepreneur or a worker in the following period. Finally, if the child is to be an entrepreneur, the household raises capital and hires labor to run the firm. All of the firms in the economy are operated by entrepreneurs. Combining the human capital and firm financing decisions with a borrowing constraint creates a tension between investment in human capital and physical capital for the constrained household. There is then potential for borrowing constraints to cause underinvestment in both human capital and firm capital, creating large productivity deficiencies.

In particular, it can be shown that for capital-constrained entrepreneur-households, the marginal return to physical capital is higher than for unconstrained entrepreneurs, and the marginal return to human capital accumulation is lower than for unconstrained entrepreneurs. Saving relaxes the capital constraint and allows the firm to expand closer to the optimal unconstrained scale. In addition, since human and physical capital are complements in production, the marginal return to human capital is decreased. Therefore, the constrained households underinvest in human capital relative to unconstrained households.

A preliminary calibration allows for the qualitative nature of these distortions to be investigated cross-sectionally. Entrepreneurship rates are highly distorted in the presence of frictions, with low-wealth households under-represented, and high-wealth households disproportionately choosing entrepreneurship. Productivity is similarly harmed. In the absence of frictions, all firms have the same productivity. With frictions, low-wealth households who become entrepreneurs suffer large decreases in productivity. High-wealth households are also harmed, though not to the same extent.

Finally, the model is taken to the data to decompose Total Factor Productivity (TFP) distortions to determine which sources are most important for cross-country differences. The findings are that human capital investments and the misallocation of physical capital combine to lower aggregate TFP by approximately thirty percent.

The discussion centered on the structure of ability transmission. In the model, learning ability and entrepreneurial ability are both autoregressive. This means that high ability parents are likely to have high ability children. The preliminary calibration found a very high intergenerational correlation of entrepreneurial ability. However, it was unclear how this is identified, and indeed what the effects of allowing for a lower transmission rate would be. ◆

## Occupational Hazards and Social Insurance

Amanda Michaud and David Wiczer

The social insurance system in the United States is gigantic. In 2012, disability insurance provided benefits to 4.7% of working aged adults and cost $200 billion (1.7 percent of GDP). A large portion of life-time disability risk is tied to occupational choices. Certain occupations, including mechanics, machine operators, and construction workers, face higher disability risk than other occupations. Social insurance programs alter occupation choice incentives and can alter the equilibrium composition of occupations. Michaud and Wiczer seek to better understand

how disability insurance can change the equilibrium occupation distribution and how the changing occupational composition affects both welfare and output.

Michaud and Wiczer start by examining data from the Health and Retirement Study to show that disability risk differs systematically across occupations. They fit a mixture of two normal distributions to the empirical distribution of occupational disability to assign occupations to either high or low risk categories. They find that the low risk occupations have a mean disability risk of 8 percent and contain 83 percent of all workers. The high risk occupations have a 16 percent chance of disability and contain the remaining 17 percent of workers. Once the high and low risk groups are established, Michaud and Wiczer use an Oaxaca decomposition between the high risk group and the low risk group to decompose the differences in disability risk between observable differences in workers (such as age, sex, education, marital status, race, smoking, and BMI) and unobservable differences. They find that 42 percent of the difference in risk across groups is accounted for by occupation while 58 percent can be accounted for by these observable differences.

Michaud and Wiczer then develop an overlapping generations model with two periods, incomplete markets, and a discrete number of occupations. Total output in each period is the aggregation of labor from each occupation using a constant elasticity of substitution (CES) aggregator. The CES aggregator allows labor from each occupation to be modeled as an imperfect substitute. In the first period, workers choose their occupation. Each occupation earns an occupation-specific wage and has a probability that the worker cannot work in the second period because of a disability. In equilibrium, wages will make workers indifferent between each occupation. All workers pay taxes to fund disability insurance and receive disability benefits if they receive a disability shock and cannot work in the second period.

Efficient allocation in this economy can be generated by having an occupational distribution in which the marginal products of labor are constant across occupations. A complete markets competitive equilibrium with full Arrow securities can achieve this allocation. However, an incomplete markets competitive equilibrium cannot maintain this allocation because the risk premium necessary to incentivize workers to enter the risky occupations cannot fully insure these workers against that risk. This generates an inefficient allocation of labor across occupations, with too few workers in risky occupations. The degree of this inefficiency depends both on the level of risk aversion of workers and the elasticity of substitution across workers. As risk aversion increases, fewer workers choose risky jobs and the inefficiency grows. As the elasticity of substitution increases, fewer workers are needed in the risky jobs and the incomplete markets equilibrium is closer to the efficient allocation.

Implementing disability insurance generates a Pareto improvement. Workers in high risk occupations benefit because this increases risk sharing between occupations and helps insure them against disability. Workers in low risk occupations also benefit because labor reallocates towards risky occupations and the higher risk occupations are complements for lower risk occupations. Michaud and Wiczer find that the socially optimal social disability insurance is 8 to 9 percent of GDP, which improves welfare by up to 10 percent of consumption. The elasticity of substitution between occupations is key to determining the magnitude of the improvement. Additionally, if disability insurance is implemented such that tax rates and benefits are occupation-dependent, then it can recover the first best allocation.

There were several comments from the audience about the use of incomplete markets in this model. Several conference participants pointed out that nothing in the model, other than the exogenous exclusion of complete markets, prohibits the private market's ability to provide the same insurance as the government. Wiczer said that the main reason their model uses government insurance is because in the real world there does not exist private insurance similar to disability insurance. Workers' compensation, which is privately provided in some states, is much smaller in magnitude than disability insurance. Further, disability insurance is different because it protects workers against the buildup of health effects over the life-time that affect workers later in life. Workers' compensation only provides coverage for acute injuries that occur while working.

The presenter also described some future work related to this paper. The authors plan to explore how much people know about their own disability risk. If workers in higher risk occupations save more than workers in lower risk occupations, then this indicates they may understand the risk and are using precautionary savings to protect against the increased risk. In their preliminary analysis, it appears people don't save against this disability risk. He and his co-author also plan to add heterogeneity in discount rates to the model. Workers who highly value current consumption may disproportionately select high risk jobs, because they want to receive higher wages today and are not as concerned about future disability risks. These workers would dislike disability insurance because it takes away their income today to protect them against future risks. This could impact the measured welfare effects of disability insurance. ◆

## Incarceration and Labor Markets: A Macroeconomic Analysis

Bulent Guler and Amanda Michaud

There has been a large and consistent increase in the incarceration rate in the United States commencing in the 1970s. This increase is not strongly related to changes in crime or economic conditions as both violent and non-violent crime rates stayed roughly constant over the same period. Microeconomists have provided many estimates of the effect of incarnation on an individual's labor market outcomes, finding negative effects of incarceration on wages and employment. However, understanding the full impact of a rising incarceration rate on aggregate labor market conditions is more difficult since the majority of the current working population entered adolescence when the incarceration rate was five times lower.

Guler and Michaud use a life cycle model to study the aggregate effects of this increase in incarceration rates on labor markets.

The model is an overlapping generations model with four labor market states: employed, unemployed, incarcerated, and not in the labor force. The model also uses three simultaneous cohorts: young, middle-aged, and old. Workers are ex-post heterogeneous in human capital and criminal propensity. Human capital depreciates at a higher rate when incarcerated. While employed or not in the labor force, human capital increases through time investment. There are two criminal types: addicted, those who always search for crime, and non-addicted who chose their search intensity. Agents switch types at an exogenous rate. Employed agents and agents not in the labor force maximize utility by choosing time investment in human capital growth. Higher investment in human capital increases wages but decreases the likelihood of finding a crime opportunity. Unemployed agents maximize job search intensity; searching more increases the likelihood of finding a job and decreases the likelihood of finding a crime opportunity. Criminals are caught at an exogenous rate, receive zero flow utility when incarcerated, and get released at an exogenous rate.

Using prison records for statistics at entry, probation officer reports for statistics after release, and census data for the general labor market variables, Guler and Michaud calibrate the model to the 1970s steady state. Then they compute the transition to a new steady state from an increase in the probability of incarceration conditional on having committed a crime to analyze the effects on all agents, across criminal types and labor market states. The model predicts that the incarceration rate is non-monotonic in the probability of getting caught. As the probability of getting caught increases, crime unambiguously decreases. Therefore, the effect on the incarceration rate is ambiguous; lower crime decreases incarceration but a higher probability of getting caught increases incarceration. The model also predicts that the employment-population ratio is non-monatomic in the probability of getting caught. As the probability of getting caught increases, agents spend less time searching for crime and more time accumulating human capital. This increases the transition rate of crime non-participation, unambiguously increasing the employment-population ratio. The effect on unemployment is ambiguous; as the incarceration rate increase, the flows to unemployment increase which in turn increases matches, increasing the flow out of unemployment. For lower levels of incarceration, the change in the inflow is larger than the change in the outflow, thus increasing unemployment.

During the presentation. Michaud argued that the full effects of a policy change, aimed at increasing the probability of arrest, do not occur until several generations later. Upon increasing the probability of arrest, there may be a lower elasticity of crime due to a higher measure of addicted types. Michaud showed evidence of this effect by graphing arrest rates by age group from 1980 to 2010. In this graph, the peaks of each age group occur roughly every five years starting around 1989 with the 20- to 25-year-olds, implying that this generation may have a lower elasticity of crime.

A conference participant asked why it was necessary for the model to include the "addicted" type of agents. Michaud responded that the data shows that people who leave prison and are in high paying jobs continue to commit crimes in the same way as people who leave prison to lower paying jobs; therefore, it is needed to match the elasticity of certain crimes with respect to labor market outcomes better to the data. Another participant suggested that the increase in the incarceration rate could have occurred due to substitution out of mental institutions or the military and into prison. Michaud acknowledged this issue and suggested it may be one of the reasons the data is hard to match. Along the same lines, another participant suggested that the decrease in incarceration rate beginning in 2010 could be accounted for by a substitution out of incarceration and into other forms of punishment due to overcrowding of prisons. Michaud stated that crime rates have also been decreasing over this time suggesting that the cohort story told by their model may be better suited to account for the recent decrease. ◆

## Aggregate Unemployment and Household Unsecured Debt

Zachary Bethune, Guillaume Rocheteau, Peter Rupert

From 1980 to 2007, the U.S. experienced an expansion in the use of and access to unsecured debt. Balances on unsecured loans more than tripled over this time period. At the peak of the unsecured credit expansion, more than 73 percent of all U.S. households held at least one credit card and nearly half of all households carried balances month to month. These trends were abruptly reversed during the Great Recession as borrowing fell and credit became more difficult to obtain. An outstanding question is how changes in households' ability to finance consumption impact the real economy. In the aggregate, there is a positive correlation between GDP and household unsecured debt, while there is a negative relationship between debt and unemployment. The goal of this paper is to provide a tractable dynamic general equilibrium model with trading frictions in which to analyze these relationships, both qualitatively and quantitatively, in order to explain what mechanisms drive these correlations.

The model builds off the Mortensen and Pissarides (1994) framework to understand equilibrium unemployment. The authors depart from this model by assuming that goods are also traded in a frictional, decentralized market with limited commitment. Matching shocks in the goods market motivate a need for short-term credit and are analogous to liquidity shocks in banking models. The period is closed with a round of centralized trading where households have linear utility. The key friction regarding trade with credit is that households cannot commit to repay debts. Following Kehoe and Levine (1993), these households face endogenous borrowing constraints that are disciplined by the ability of lenders to punish defaulting borrowers, the value of maintaining access to credit markets, or the cost of being punished by losing future access.

The model predicts a strategic complementarity between credit and labor markets. First, the aggregate state of the labor market affects households' debt limit through the frequency of trade,

modeled by the severity of search frictions, in the goods market. If the labor market is tight, employment is high and there are more firms wanting to sell goods in the labor market. This increases the frequency of trading shocks in the goods market, which makes exclusion from unsecured credit very costly. As a result, an increase in aggregate employment loosens debt limits. In the other direction, as debt limits are relaxed, firms expected revenue increases, which also increases the incentive to post vacancies, lowering unemployment.

The authors calibrate a version of the model to match the U.S. economy pre-Great Recession and illustrate the equilibrium effects of a long-term expansion in the availability of unsecured credit. The model is able to explain 70 percent of the trend decline in the unemployment from 1980 to 2007. These results suggest that the prevalence of unsecured credit can explain long-term movements in the efficiency of the labor market. ◆

## Loopholes
Daniel Moncayo

Taxpayers can systematically manipulate their income reports to the government in order to reduce the amount of taxes they pay. Their actions, broadly named income falsification, consist of more than just "lying" or sending an incorrect signal. Tax avoidance, exploiting weaknesses in the tax code or finding legal ways to alter reported income, can require the services of a tax accountant or a tax attorney. On the other hand, tax evasion, reducing taxable income by illegal means, imposes an expected cost of being discovered and punished. These activities make income falsification costly, and provide evidence that governments can not observe taxpayers' income perfectly.

In this paper, Moncayo explains how taxpayers' costly income falsification affects the optimal tax schedule, and illustrates its effect on tax revenues and income redistribution. To do so, he extends the optimal non-linear income taxation model built by Mirrlees (1971)[1] to allow for costly income falsification. He relaxes the standard assumption that income is perfectly observable by incorporating taxpayers' opportunities to manipulate their displayed income. In the model, agents choose the amount of income that are going to display and how much labor they will supply. Just like taxpayers, they can pay to display income different from their realized income or change their labor supply in response to marginal taxes. In turn, optimal marginal taxes are characterized by an incentive-feasible mechanism that maximizes aggregate welfare, which takes the agents' income falsification and labor supply decisions as given.

The author shows that the optimal tax mechanism is non-falsification, where agents report all of their realized income. Since, the cost of income falsification is unproductive, any mechanism that involves income falsification is Pareto dominated by one where agents report of all of their income. A social planner can achieve non-falsification through lump sum taxes by making the agents indifferent between falsification and fully displaying their income. These taxes collect more revenue than those in the falsification mechanism, making them feasible while allowing more income redistribution, raising aggregate welfare in the process.

The marginal taxes implied by the allocation of resources in the optimal mechanism depend on the cost of income falsification, with three incentive compatible regions for different values of this cost. For the first two regions, when the cost of income falsification is low, the optimal marginal taxes for high ability agents are negative. Negative marginal taxes provide the incentives for high ability agents to report all of their income. At the same time, they encourage these agents to exert more effort, which increases production and relaxes constraints on tax revenue. They achieve this by encouraging higher incomes, thus increasing the size of the tax base, which in turn translates into larger lump sum taxes. As the cost of income falsification increases, the solution converges to the static Mirrleesian solution, the third incentive compatible region. In the case of low ability agents, marginal taxes are positive throughout the three regions, monotonically rising as the cost of income falsification increases until reaching its highest rate at the Mirrleesian solution.

The argument in this paper emphasizes the need to provide wealthy taxpayers with incentives to report their income in full. It also suggests, through the non-falsification result, that governments could achieve this while increasing tax revenue. Indirectly, they also point out that increasing the cost of income falsification by eliminating the most readily available income sheltering channels, legal or illegal, can relax the government's constraints for raising more tax revenue.

During the conference, a participant ask whether there is an inconsistency between the social planner's capacity to design the tax system and taking the cost of income falsification as exogenous. Particularly, why doesn't the social planner eliminate income falsification channels so that agents are not able to use them to reduce their taxes? Moncayo responded that the optimal mechanism must take into account the taxpayers' behavior as given if the implementation of the mechanism is to be successful in a decentralized economy. Since income falsification is observed in real life, a pragmatic policy recommendation would take into consideration its implementation in the current legal environment. Also, the social planner is tasked with finding the optimal tax schedule, which is only a small part of the tax system. Changing the tax system would involve modeling forces outside of the scope of the paper. Another conference participant asked if the agent's cost of income falsification could be made endogenous. The presenter responded that the cost of income falsification could be modeled as the result of a political economy equilibrium, which is taken as given for the purposes of this paper.

[1]Mirrlees, James A. 1971. "An exploration in the Theory of Optimum Income Taxation." Review of Economic Studies, 34(114): 157-208. ◆

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