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Articles

Monetary Policy in a Low Inflation Economy with Learning
by John C. Williams

State Business Taxes and Investment: State-by-State Simulations
by Robert S. Chirinko and Daniel J. Wilson

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Federal Reserve Bank of San Francisco

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Executive Vice President and
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April 2010

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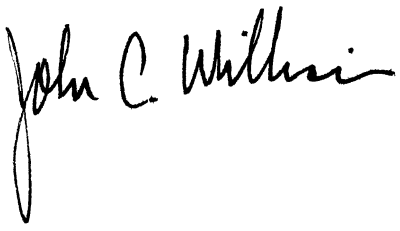

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Monetary Policy in a Low Inflation Economy with Learning*

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In theory, monetary policies that target the price level, as opposed to the inflation rate, should be highly effective at stabilizing the economy and avoiding deflation in the presence of the zero lower bound on nominal interest rates. With such a policy, if the short-term interest rate is constrained at zero and the inflation rate declines below its trend, the public expects that policy will eventually engineer a period of above-trend inflation that restores the price level to its target level. Expectations of future monetary accommodation stimulate output and inflation today, mitigating the effects of the zero bound. The effectiveness of such a policy strategy depends crucially on the alignment of the public's and the central bank's expectations of future policy actions.

This article considers an environment where private agents have imperfect knowledge of the economy and therefore continuously reestimate the forecasting model that they use to form expectations. I find that imperfect knowledge on the part of the public, especially regarding monetary policy, can undermine the effectiveness of price-level targeting strategies that would work well if the public had complete knowledge. For low inflation targets, the zero lower bound can cause a dramatic deterioration in macroeconomic performance with severe recessions occurring with alarming frequency. However, effective communication of the policy strategy that reduces the public's confusion about the future course of monetary policy significantly reduces the stabilization costs associated with the zero bound. Finally, the combination of learning and the zero bound implies the need for a stronger policy response to movements in the price level than would otherwise be optimal. Such a policy is effective at stabilizing both inflation and output in the presence of learning and the zero bound even with a low inflation target.

1. Introduction

The successful reduction of inflation to low levels in many countries raises the question of how to best design monetary and fiscal policies to reduce the risk of deflation and to facilitate a rapid return to price stability if deflation occurs. The experience of deflation and near-zero short-term interest rates in Japan and the brief flirtation with inflation and interest rates around 1 percent in the United States led to a renewal of research into the design of monetary policy that takes account of the zero lower bound on nominal interest rates. A recurring finding in this literature is that monetary policy strategies that explicitly or implicitly target the price level, as opposed to the inflation rate, should be highly effective at both mitigating the effects of the zero lower bound and at minimizing the duration and depth of deflationary episodes (see Reifschneider and Williams 2000, Svensson 2001, and Eggertsson and Woodford 2003). In these models, the promise of future, indeed at times distant future, above-trend inflation aimed at restoring the price level to its target level provides a powerful pull on an economy experiencing deflation and constrained by the zero lower bound. Indeed, according to this research, a central bank can successfully target a constant price level with virtually no cost in terms of macroeconomic stabilization resulting from the zero bound.

These results rely on two crucial assumptions. The first assumption is that the central bank can credibly commit to follow such a price-level targeting policy. Eggertsson (2006) challenges the assumption that the central bank can necessarily commit to future high inflation following a period of deflation associated with monetary policy being constrained by the zero lower bound. If the central bank lacks the ability to commit to future high inflation, the upward pull on in-

*This article is a slightly edited version of a paper originally published in 2006 in the conference volume *Monetary Policy in an Environment of Low Inflation* by the Bank of Korea. As such, it does not reflect the events of the past three years. The views expressed herein are those of the author and do not necessarily reflect those of the management of the Federal Reserve Bank of San Francisco or the Board of Governors of the Federal Reserve System.

flation and output from the future is diminished as the public rightly anticipates that the central bank will choose only to bring inflation back to its target level and let the fall in the price level be a bygone.

The second critical assumption is that private agents properly anticipate the implications of the monetary policy strategy for the future path of policy and the economy. Reifschneider and Roberts (2006) show that price-level targeting monetary policy rules may lose some of their effectiveness in the presence of the zero bound when expectations are allowed to deviate from rational expectations. In this article, I examine the role of expectations formation on the effectiveness of monetary policy strategies in the presence of the zero bound. I follow the recent literature on learning and consider environments where agents have imperfect knowledge of the structure of the economy and monetary policy strategy and regularly update their beliefs about both based on past experience. I explore the conditions under which imperfect knowledge weakens or even disables the expectations channel that is essential to many proposed monetary policy strategies in the face of the zero lower bound. In addition, I examine the implications for monetary policy design to make it more robust to the presence of both imperfect knowledge and the zero bound.

This article also creates a framework to analyze the effects of communication strategies that help the public predict the future course of monetary policy. A number of papers that propose specific policy actions such as pegging the exchange rate, influencing longer-term bond rates, and increasing the monetary base when the interest rate is already zero highlight the communication aspect of such policy actions (see Meltzer 2001, Svensson 2001, McCallum 2002, Okina and Shiratsuka 2004, and McGough, Rudebusch, and Williams 2005). But these papers typically assume that the public is fully informed about the determination of monetary policy and the behavior of the economy, so the benefits of central bank communication cannot be analyzed directly. Orphanides and Williams (2005a) show that improving the public's understanding of the policy rule reduces errors in private expectations and, in so doing, improves macroeconomic performance. But, this analysis ignores the zero bound. As shown in this article, the presence of the zero bound further complicates the public's learning problem and amplifies the costs associated with expectation errors. Therefore, the benefits of clearly communicating policy are heightened.

This analysis reveals three main findings. First, imperfect knowledge on the part of the public, especially regarding monetary policy, can undermine the effectiveness of monetary policy strategies that would be highly effective if the public had complete knowledge. For low inflation targets, the zero lower bound can engender a dramatic deterioration in macroeconomic performance, with severe recessions occurring relatively frequently. Second, effective communication of the policy strategy that reduces the public's confusion about the future course of monetary policy also significantly reduces the stabilization costs associated with the zero bound. Third, the combination of learning and the zero bound implies the need for a stronger policy response to movements in the price level than would otherwise be optimal. Indeed, such a policy rule is better at stabilizing both inflation and output in the presence of learning and the zero bound, and is highly effective even in the case of an inflation target of only 1 percent.

The remainder of the article is organized as follows. Section 2 describes the model and monetary policy. Section 3 describes the formation of expectations. Section 4 outlines the model simulation methodology and describes the calibration of model parameters. Section 5 reports the results of the monetary policy analysis. Section 6 concludes.

2. The Model

This section describes the empirical macroeconomic model used for this analysis. The model is a so-called hybrid New Keynesian model (see Woodford 2003 for further details and references regarding similar models). The model contains key features of output and inflation dynamics of many recent micro-founded models used for monetary policy evaluation (see, for comparison, Levin et al. 2006). Each period in the model corresponds to one quarter of a year.

2.1. Output and Inflation

The output gap (the deviation of output from its natural rate), denoted by y_t, is given by:

$$(1) \qquad y_t - \eta y_{t-1} = -\phi (i_t - F_{t-1}\pi_{t+1} - r_t^*)$$
$$-\phi F_{t-1}\{\sum_{j=1}^{\infty}(i_{t+j} - \pi_{t+j+1} - r_{t+j}^*)\}, \;\; r_t^* \sim N(\bar{r}^n, \sigma_r^2),$$

where F_{t-1} refers to the agents' forecast based on information available at the end of period $t-1$, i_t is the short-term nominal interest rate, π_t is the inflation rate, and r_t^* is the stochastic natural rate of interest (around a fixed long-run value of $\bar{r}^*$, assumed to follow an independently and identically distributed (iid) Gaussian distribution with variance σ_r^2. The lag of the output gap in the equation captures the effects of habit in preferences. Note that because I consider deviations from rational expectations where agents have imperfect knowledge of the true structure of the economy, I replace the standard mathematical expectations with private agents' forecasts. In addition, as emphasized by Preston (2005), under imperfect knowledge one cannot make the substitutions that are commonly used in the literature to rewrite this equation in terms

of finite leads of the output gap. Instead, I assume that decisions are based explicitly on expectations of the fundamental determinants of the output decision.

The equation for inflation is based on a Calvo pricing model with partial indexation of prices to lagged inflation:

$$(2)\quad \pi_t - \rho\pi_{t-1} = \kappa(y_t - \theta y_{t-1}) + u_t + F_{t-1}\{\sum_{j=1}^{\infty}\beta^j[\kappa(y_{t+j} - \theta y_{t+j-1}) + u_{t+j}]\},$$
$$u_t \sim N(0, \sigma_u^2),$$

where u_t is a markup shock, assumed to follow an iid Gaussian distribution with variance σ_u^2. As in the case of the output equation, pricing decisions are assumed to be based on expectations of their fundamental determinants.

2.2. Monetary Policy

I assume that the central bank's objective is to minimize the weighted sum of the unconditional variances of the inflation gap (the difference between the inflation rate and its target), the output gap, and the short-term nominal interest rate. The central bank loss, $\mathcal{L}$, is given by

$$(3)\quad \mathcal{L} = \mathrm{VAR}(\pi_t - \pi^*) + \lambda\mathrm{VAR}(y_t) + \nu\mathrm{VAR}(i_t),$$

where $\mathrm{VAR}(x)$ denotes the unconditional variance of a variable x, λ is the relative weight on output gap variability, and ν is the relative weight on nominal interest rate variability. In the following, I assume that $\lambda = 0.5$ and $\nu = 0.1$. This choice of ν assures that the degree of interest rate variability is similar to the historical experience in the United States over the past period of 1985 to 2005.

Based on the findings of the theoretical literature, I assume that monetary policy follows a reaction function that reacts to the gap between the price level and a deterministic trend. I start with the "difference rule" specification of monetary policy similar to that advocated by Orphanides and Williams (2006), given by

$$(4)\quad i_t = \max\{i_{t-1} + \gamma_\pi(\pi_{t-1} - \pi^*) + \gamma_{\Delta y}\Delta y_{t-1}, 0\},$$

where Δ denotes the first difference operator, and the "max" function reflects the presence of the zero lower bound on nominal interest rates.[1] I assume that the central bank responds to data with a one-quarter lag. Note that by integrating this equation (and assuming the rule is followed without deviation), it is identical to a policy rule where the level of the interest rate is determined by the price level gap (that is, the difference between the price level and a deterministic trend), the level of the output gap, and a constant. Orphanides and Williams (2006) show that rules of this form are robust to uncertainty regarding the model of agents' expectations, be it rational expectations or learning. However, that analysis abstracts from the zero lower bound on interest rates.

As noted by Reifschneider and Williams (2000), the zero lower bound poses a problem for difference rules in that past deviations owing to the zero bound are carried forward into an excessively high current interest rate mechanically through the effects of the lagged interest rate. An alternative implementation that is equivalent in the absence of the zero bound but avoids this problem with the zero bound is for monetary policy to follow the integrated version of the rule:

$$(5)\quad i_t = \max\{\gamma_\pi(p_{t-1} - p_{t-1}^*) + \gamma_{\Delta y}y_{t-1} + \bar{i}^*, 0\},$$

where p_t is the log of the price level, p_t^* is the target price level that follows $p_t^* = p_{t-1}^* + \pi^*$, and the final term

$$\bar{i}^* = \pi^* + \bar{r}^*$$

is the long-run neutral nominal interest rate.

2.3. Fiscal Policy

Eggertsson and Woodford (2004) show that fiscal policy can be used to complement monetary policy when the zero bound is a constraint on policy. In order to explore the ability of monetary policy alone to cope with the zero bound, this model does not consider the use of government spending or distortionary taxes as a complement to monetary policy. Instead, I assume that in general the fiscal authority is entirely passive. Given this assumption, in periods of severe deflation, the economy can get stuck in a deflationary trap. In such cases, I assume that fiscal policy will take steps that limit the duration of such an episode to five years, at which time the economy is brought back to steady state. From then on, fiscal policy reverts to a passive role. As discussed later, this "backstop" fiscal intervention occurs very rarely when monetary policy is doing a good job of stabilizing the economy on average, and therefore is best viewed as a means of keeping the computation of model moments from being dominated by extreme outliers. Regular occurrences, on the other hand, indicate that the stipulated monetary policy rule does not stabilize the system effectively.

3. Expectations Formation

In the model, agents form expectations using a reduced-form forecasting model of the economy as opposed to using the

1. I could impose a slightly positive lower bound of i^{LB}. In terms of the analysis, this corresponds exactly to an inflation target for $\pi^* - i^{LB}$. The experience of Japan over the past decade suggests that the lower bound is very near zero.

full structural model that would be the case under model-consistent (i.e., rational) expectations. I specify the forecasting model such that it exactly corresponds to the reduced form of the structural model under the joint assumptions of rational expectations and the absence of the zero lower bound on nominal interest rates. I assume that agents continuously reestimate the forecasting model based on past observations using a constant-gain least squares algorithm (see Sargent 1993 and Evans and Honkapohja 2001 for a fuller discussion of constant gain learning). Given the structure of the model and the stipulated form of the monetary policy rule, under rational expectations and ignoring the zero bound, five variables—the inflation rate, the output gap and its first lag, the interest rate, and an intercept—fully describe the state of the economy at the end of a period. In the model, agents compute forecasts using a linear forecasting model with these five explanatory variables. At the end of each period, agents reestimate this forecasting model using the currently available data and then use the resulting model to construct forecasts. I also consider alternative assumptions regarding how agents forecast interest rates within the context of their forecasting model.

Let Y_t denote the 1×3 vector consisting of the period t values of the variables to be forecast: $Y_t = (\pi_t, y_t, i_t)$. Let X_t denote the 1×5 vector consisting of the explanatory variables: $X_t = (\pi_{t-1}, y_{t-1}, i_{t-1}, y_{t-2}, 1)$. Estimation is described as follows: Let c_t be the $j \times 5$ vector of coefficients of the forecasting model. Then, using data through period t, the parameters for the constant-gain least squares forecasting model can be written as:

$$c_t = c_{t-1} + \mu R_t^{-1} X_t (X_t - X_t' c_{t-1}), \tag{6}$$

$$R_t = R_{t-1} + \mu (X_t X_t' - R_{t-1}), \tag{7}$$

where $\mu > 0$ is the gain.

In the case of forecasts of the interest rate, I deviate from this simple forecasting method. First, I impose the zero lower bound on forecasts of all future nominal interest rates. Specifically, in period t I compute the forecast for $t + 1$ variables. If the forecasted value of the interest rate in period $t + 1$ is negative, that value is set to zero. I then compute the $t + 2$ forecast of all variables and follow the same procedure, and so on. In this way, the zero bound is enforced both on the actual value of the interest rate and on expectations of future interest rates.[2] In principle, agents need forecasts for infinitely many periods in the future. However, to keep the problem tractable, I approximate this infinite sum with a truncated sum of k periods, replacing the terms for periods $k + 1$ and beyond with the period $k + 1$ forecast of the appropriate variables, as follows:

$$\begin{aligned} y_t - \eta y_{t-1} = &-\phi (i_t - F_{t-1}\pi_{t+1} - r_t^*) \\ &- \phi F_{t-1}\{\sum_{j=1}^{k} (i_{t+j} - \pi_{t+j+1} - r_{t+j}^*)\} \\ &+ F_{t-1}\{y_{t+k+1} - \eta y_{t+k}\}, \end{aligned} \tag{8}$$

$$\begin{aligned} \pi_t - \rho \pi_{t-1} = &\kappa (y_t - \theta y_{t-1}) + u_t \\ &+ F_{t-1}\{\sum_{j=1}^{k} \beta^j [\kappa (y_{t+j} - \theta y_{t+j-1}) + u_{t+j}]\} \\ &+ \beta^{k+1} F_{t-1}\{\pi_{t+k+1} - \rho \pi_{t+k}\}. \end{aligned} \tag{9}$$

Given the dynamics of the system, $k = 20$ is sufficient to get accurate solutions, and I use that value for all results reported here. The results with $k = 40$ are generally very close to those for $k = 20$.

I consider two alternative ways for agents to form forecasts of the interest rate. The first approach is simply to use the model as described above. Absent the zero bound, the interest rate equation in the forecast model is identical to that describing policy, so the fit of the forecasting equation is perfect. The presence of the zero bound, however, introduces positive deviations from the simple linear policy rule. The basic forecasting model implicitly treats these deviations as part of the interest rate process, and these deviations affect the forecast of future interest rates directly through the lagged interest rate in the model, and indirectly through the effect on the estimated parameters of the interest rate equation in the forecasting model.

The second approach to modeling agents' interest rate forecasts is for agents to use the actual policy rule in forming forecasts, conditional on the forecasts of inflation and the output gap. This is accomplished by substituting the policy rule for the interest rate equation in the forecasting model. In particular, if the nominal interest rate depends on the lagged price level and output gap, then agents will not be fooled by deviations from the rules and will forecast monetary policy to eventually restore the price level to its target.

4. Model Solution and Calibration

This section describes the method used to compute model statistics and the calibration of the model parameters. Owing to the presence of the zero lower bound and learning, the standard methods of solving and computing unconditional moments of linear rational expectations models do not apply. Instead, I use simulated moments as approximations of the unconditional moments.

2. Note that this method implicitly imposes certainty equivalence by ignoring the distribution of interest rate forecasts and its effect on the expected interest rate from the zero bound. Incorporating this channel requires the use of computationally intensive nonlinear methods and is beyond the scope of this article.

4.1. Model Simulation Methodology

For a given parameterization of the model, the simulated model moments are computed based on a single stochastic simulation consisting of 101,000 periods, where the first 1000 observations are dropped in order to remove the effects of initial conditions.[3] The initial conditions for all model variables and the forecasting model matrices c and R are given by the corresponding steady-state values of the rational expectations equilibrium with no zero bound. The shocks are generated using MATLAB's Gaussian pseudo-random number generator "randn."

The presence of either the zero bound or learning introduces a nonlinearity into the model that can generate explosive behavior in a simulation of 100,000 periods, even for policy rules that are stable under rational expectations. One potential source of instability under learning is the possibility that the forecasting model itself may become unstable. To mitigate the possibility that instability in the forecasting model generates explosive behavior in the model economy, I do the following. During each period of the simulation, I compute the root of maximum modulus of the forecasting VAR excluding the constants. If the modulus of this root falls below the critical value of 1.1, the coefficients of the forecast model are updated as described earlier; if not, I assume that the forecast model is not updated and the matrices c_t and R_t are held at their respective previous period values. This cutoff is invoked only extremely rarely in the simulations.

However, stability of the forecasting model is not sufficient to assure stability of the full model in all situations. For this reason, I impose a second condition that restrains explosive behavior. In particular, if the absolute values of the inflation gap, output gap, or interest rate gap (the nominal interest rate less the long-run neutral rate), exceed very large values, then the offending variables are simply set to the relevant boundary value. I use a bound of 20 percentage points for the interest rate and the output gap and 10 percentage points for the inflation rate. The upper bounds are included for symmetry. Of course, this lower bound on the nominal interest rate is irrelevant given the zero lower bound that is part of the determination of the interest rate. These bounds are set wide enough that they bind only very rarely or never when policy is effective at stabilizing the economy, but bind more frequently when policy is ineffective, as discussed later.

4.2. Model Calibration

The model simulations consider a range of values of the constant-gain learning parameter, μ. One extreme assumption considered is where the public does not change its estimates at all, but rather uses the parameters associated with the rational expectations equilibrium ignoring the zero bound. Given the presence of the zero bound, the case of $\mu = 0$ is not the same as rational expectations, but is closely related in that the parameters of the forecasting model are constant. As such, it provides a benchmark that replicates key features of outcomes under full model-consistent expectations.

For the case of learning, I use 0.02 as the benchmark value of μ, and consider alternative values of 0.01 and 0.03 as a robustness exercise. A number of researchers have estimated the value of μ within a learning framework using postwar U.S. data (see Sheridan 2003, Milani 2007 and 2008, Orphanides and Williams 2005b, and Branch and Evans 2006). Although the estimates differ across specifications and samples, and are in some cases quite imprecise, the central tendency of these estimates is between 0.02 and 0.03. The value of 0.02 implies that the data from the past 10 years account for a little more than one-half of the weight in the estimation, data from the preceding 10 years account for one-quarter of the weight, and data more than 20 years old account for the remaining weight. The average age of the data used in estimation is about 12.5 years, the same as would be the case if agents used standard least squares regressions with 25 years of data. This seems a plausible value given the data limitations that people face in the real world.

I calibrate the model parameters describing the output gap and inflation dynamics using Milani's (2008) estimates of a very similar model under learning.[4] The upper part of Table 1 reports these parameter values. Note that they are fixed across the different specifications of the learning rate.

The calibration of the long-run neutral real interest rate is important in terms of interpreting the results with respect to the optimal choice of an inflation target. The neutral long-run nominal interest rate, $\bar{i}^*$, measures the average "cushion" that the central bank has in lowering rates, starting from the deterministic steady state. The larger the cushion, that is, the larger is $\bar{i}_t$, the less frequently the zero lower bound constrains policy and the shorter the periods during which the constraint is binding. In terms of this analysis, the decom-

3. Based on simulations under rational expectations in which I can compute the moments directly, this sample size is sufficient to yield very accurate estimates of the unconditional variances. In addition, testing indicates that 1000 periods is sufficient to remove the effects of initial conditions on simulated second moments.

4. Milani (2008) estimates a model where the shocks to the natural rate of interest and the markup follow AR(1) processes. This model is quite similar to the one used in this article, once one applies the appropriate transformation to eliminate the serial correlation to the shocks. Therefore, Milani's estimates are reasonable for the model used in this article. Moreover, the parameter estimates are within the range of other estimates of similar models in the literature.

TABLE 1
MODEL CALIBRATION

Parameter	Calibrated values			
φ	0.200			
η	0.945			
β	0.990			
κ	0.078			
ρ	0.849			
θ	0.849			
μ	0.000	0.010	0.020	0.030
σ_r	7.500	7.500	7.250	6.750
σ_u	0.550	0.539	0.528	0.507

Notes: Parameter values reported in the upper part of the table are taken from Milani (2006), Table 3.3. The calibration of the values of the long-run neutral real interest rate, $\bar{r}^*$, and the innovation standard deviations are described in the text.

position of the long-run neutral nominal interest rate into its real and inflation components is irrelevant. However, to aid in the interpretation, it is useful to discuss the results in terms of the inflation target as opposed to the neutral nominal rate. For this purpose, I assume that the long-run real neutral rate is 2.5 percent, near its long-run average in the postwar U.S. economy.[5] Thus, in the following, results for the case of an inflation target of x percent refer to an economy with a neutral long-run nominal interest rate of $x + 2.5$ percent.

The innovation variances are crucial for conducting analysis with the zero bound on interest rates. All else equal, the larger the variances, the more often the zero bound constrains policy and the larger are the effects of the zero bound. I therefore take pains to calibrate these variances in a manner consistent with the empirical evidence on the U.S. economy over 1985–2005. First, I compute the variances of the GDP price index inflation rate and the federal funds rate over the sample of 1985–2005. I then choose the innovation variances so that the model-generated unconditional variances assuming rational expectations and no zero bound are close to their respective empirical counterparts for the federal funds rate and the inflation rate. (I assume no covariance in the innovations.) This method yields the values of the calibrated standard deviations of the innovations, which are reported in the first column of the lower part of the table.

As noted by Orphanides and Williams (2005a), the presence of learning tends to raise the magnitude of fluctuations in a model economy relative to that which occurs under rational expectations. This is also true for the model analyzed in this article. Therefore, in order to make the models with the different values of μ comparable in terms of baseline unconditional moments before introducing the zero bound, I calibrate the innovation variances separately for each value of μ, so that the model-generated unconditional variances of inflation, the output gap, and the short-term interest rate are about the same in all variants of the model.[6] The innovation variances decline slightly as the value of μ rises.

5. Monetary Policy Evaluation

In this section, I analyze the performance of monetary policy rules in environments where the zero lower bound is occasionally binding under alternative assumptions regarding the formation of expectations.

5.1. Benchmark Monetary Policy Rule

I start by constructing a benchmark monetary policy rule. For this purpose, I use the methods described in Levin, Wieland, and Williams (1999) to compute the coefficient values for γ_π and $\gamma_{\Delta y}$ in the monetary policy rule that minimizes the central bank loss assuming rational expectations and abstracting from the zero lower bound. The resulting coefficient values are given by $\gamma_\pi = 0.1$ and $\gamma_{\Delta y} = 1$. Orphanides and Williams (2005a, 2006) show that optimal policy under learning responds more strongly to inflation than under rational expectations, so I also consider a more aggressive variant of the rule with $\gamma_\pi = 0.25$. I consider two versions of the policy rule, the "difference rule" given by equation (4) and the explicit price-level targeting rule given by equation (5). As noted earlier, these rules are identical in the absence of the zero bound but differ in an economy where the zero bound is occasionally binding.

5.2. The Effects of the Zero Bound without Learning

I first consider the case where the public does not reestimate its forecasting model, that is, $\mu = 0$. I assume that the parameters of the forecast model are those implied under rational expectations and the absence of the zero lower bound. This might be a reasonable assumption if the zero bound had not been a constraint on policy in the past.

As expected, the "difference" specification of the policy rule fares very poorly with low inflation targets. The upper part of Table 2 shows the results under the difference rule. For these experiments, I assume that the public uses the benchmark forecasting model. For inflation targets of 1.5 percent and above, the zero bound has little effect and the economy

5. This calculation is based on using the personal consumption deflator as the price measure. This is the same value for $\bar{r}^*$ used by Reifschneider and Williams (2000). For alternative assumptions regarding this value of $\bar{r}^*$, one can translate the results in the following section by modifying the assumed values of π^* so that the underlying values of $\bar{i}^*$ are the same.

6. For this calibration exercise, I use a policy rule of $\gamma_\pi = 0.25$ and $\gamma_{\Delta y} = 1$.

TABLE 2
THE EFFECTS OF THE ZERO BOUND WITHOUT LEARNING ($\mu = 0$)
BASELINE POLICY RULE: $\gamma_\pi = 0.1$, $\gamma_{\Delta y} = 1$

	Root mean square				Frequency	
Inflation target (π^*)	Inflation	Output gap	Interest rate	Central bank loss	$i_t = 0$	$y_t \leq -20$
Policy follows difference rule (equation 4), and public forecasts with same						
0.0	3.7	7.5	1.8	28.0	22.8	12.0
0.5	2.2	4.5	1.8	10.1	10.2	3.4
1.0	1.2	2.6	1.8	3.4	3.7	0.4
1.5	0.9	2.0	1.8	2.2	1.5	0.0
2.0	0.9	2.0	1.8	2.1	0.7	0.0
3.0	0.9	1.9	1.8	2.0	0.1	0.0
4.0	0.9	1.9	1.8	2.0	0.0	0.0
Policy follows price level rule (equation 5), but public forecasts with difference rule						
0.0	1.5	3.1	1.7	4.9	12.3	1.3
0.5	1.0	2.2	1.8	2.5	6.4	0.2
1.0	0.9	2.0	1.8	2.1	3.2	0.0
1.5	0.9	2.0	1.8	2.0	1.6	0.0
2.0	0.9	1.9	1.8	2.0	0.7	0.0
3.0	0.9	1.9	1.8	2.0	0.1	0.0
4.0	0.9	1.9	1.8	2.0	0.0	0.0
Policy follows price level rule (equation 5), and public forecasts with same						
0.0	0.9	1.9	1.7	2.0	8.2	0.0
0.5	0.9	1.9	1.7	2.0	4.9	0.0
1.0	0.9	1.9	1.8	2.0	2.7	0.0
1.5	0.9	1.9	1.8	2.0	1.4	0.0
2.0	0.9	1.9	1.8	2.0	0.7	0.0
3.0	0.9	1.9	1.8	2.0	0.1	0.0
4.0	0.9	1.9	1.8	2.0	0.0	0.0

never experiences severe recessions, as indicated by the percent of the time that the output gap is below –20 percent. But, for inflation targets of 1 percent and lower, the zero bound causes a significant deterioration in macroeconomic performance as measured by the simulated root mean squared values of the inflation rate and the output gap. For an inflation target of zero, this policy rule no longer effectively stabilizes the economy and severe recessions are a regular occurrence.

The problem with the difference rule as specified in equation (4) is that it implicitly allows upward drift in the price-level target when the zero bound is constraining policy, or is expected to constrain policy in the future. Thus, by including the lagged interest rate in the rule, this policy undermines the price-level targeting feature that is crucial for success in the face of the zero bound. For this reason, the remainder of the article focuses on rules that explicitly target the price level, in the form of equation (5).

The middle panel of the table shows the results for the explicit price-level targeting policy rule, where the public uses the benchmark forecasting model. This policy does a better job than the difference rule with low inflation targets. For inflation targets of 1 percent and above, the zero bound has little effect on macroeconomic performance. However, for inflation targets below 1 percent, the zero bound causes a marked rise in the average magnitude of fluctuations.

This deterioration in performance occurs because agents do not understand that the central bank will eventually bring the price level back to its target value. Instead, they implicitly assume that following periods when the zero bound is constraining policy, the central bank will let bygones be bygones and will act to stabilize the inflation rate, irrespective of the realized price level. For example, assume that the current interest rate is zero and policy is constrained. Agents forecast the future path of interest rates conditional on the current level of interest rates. As a result, interest rate forecasts will be higher than implied by the monetary policy rule, which accounts for the price level. As a result, the expectations channel—which is so powerful and helpful when the public understands the central bank is intent on restoring the price level to its target—is distorted and macroeconomic stabilization suffers.

If the public understands that the central bank is targeting the price level and incorporates this information in its forecasting model, then the zero bound has no discernible effects

on macroeconomic performance even with an inflation target of zero percent. The lower part of Table 2 reports the results. Although this framework does not encompass fully model-consistent expectations, these results where the public knows the policy rule mimic those in the literature where the zero bound is not a problem under price-level targeting (see, for example, Reifschneider and Williams 2000 for comparison).

5.3. The Effects of the Zero Bound with Learning

The presence of learning exacerbates the effects of the zero bound on the economy. The upper part of Table 3 reports the simulation results assuming policy follows the explicit price-level targeting rule but the public uses the benchmark forecasting model with $\mu = 0.02$. The losses associated with the zero bound are much larger than in the case of no learning. Indeed, under these conditions, this policy rule does not effectively stabilize the economy for inflation targets below 2 percent. The zero bound introduces persistent deviations from agents' forecasting models, just as in the case of no learning discussed earlier. But, with learning, there is a second channel by which the zero bound affects expectations. During a prolonged episode in which the zero bound is constraining policy, the behavior of monetary policy and the economy systematically deviate from that implied by the forecasting model. These deviations set in motion movements in the estimated parameters of the forecasting model.

Removing public uncertainty about monetary policy significantly reduces the costs associated with the zero bound under learning. The lower part of Table 3 reports the results where the public's forecasts incorporate knowledge of the monetary policy rule. However, even with full public knowledge of the policy rule, the effects of the zero bound interact with the learning involved with the other equations of the model. As a result, inflation targets below 1 percent carry significant costs in terms of stabilization. Therefore, in the face of imperfect knowledge and the zero bound, more than communication of policy intentions is needed. The parameters of the policy rule need to be modified as well, as shown in the next subsection.

5.4. More Aggressive Monetary Policy

A more aggressive policy rule response to inflation is more effective at minimizing the deleterious effects of the zero lower bound. Table 4 shows the results for the economy with learning where policy follows the more aggressive version of the rule with $\gamma_\pi = 0.25$. The more aggressive rule is effective because it reduces the likelihood of deflation and therefore entering a liquidity trap and it promises prompt and aggressive action once the zero bound is no longer constraining policy.

Assuming the public understands the rule, there is little cost to zero inflation under this rule. Comparing these results to those in the previous table, this rule delivers better stabi-

TABLE 3
THE EFFECTS OF THE ZERO BOUND WITH LEARNING ($\mu = 0.02$)
BASELINE POLICY RULE: $\gamma_\pi = 0.1$, $\gamma_{\Delta y} = 1$

	Root mean square				Frequency	
Inflation target (π^*)	Inflation	Output gap	Interest rate	Central bank loss	$i_t = 0$	$y_t \leq -20$
Policy follows price level rule (equation 5), but public forecasts with difference rule						
0.0	6.7	13.3	3.3	89.8	50.7	40.6
0.5	4.7	9.4	2.9	45.3	27.1	19.5
1.0	3.3	6.6	2.6	22.8	13.4	9.2
1.5	2.5	5.1	2.3	13.4	7.1	5.0
2.0	2.0	4.0	2.2	8.6	3.8	2.8
3.0	1.4	2.9	2.0	4.3	1.2	0.9
4.0	1.0	2.3	1.9	2.7	0.3	0.2
Policy follows price level rule (equation 5), and public forecasts with same						
0.0	1.7	3.8	1.9	6.8	12.3	2.1
0.5	1.5	3.3	2.0	5.2	7.3	1.3
1.0	1.2	2.8	1.9	3.9	4.2	0.8
1.5	1.1	2.5	1.9	3.0	2.2	0.3
2.0	1.0	2.3	1.9	2.8	1.3	0.3
3.0	1.0	2.1	1.9	2.3	0.3	0.1
4.0	0.9	2.1	1.9	2.3	0.2	0.0

lization of both inflation and output at a zero percent inflation target than does the baseline rule with a 1 percent inflation target. Figures 1 and 2 show the distributions of the inflation rate and the output gap, respectively, under the benchmark and more aggressive rules when the inflation target is zero. For these figures, the public forms expectations using the true monetary policy rule. For the inflation rate, I summed the observations below 5 percent into the leftmost bar (and likewise summed the inflation rates above 5 percent into the rightmost bar). For the output gap, I summed the observations that are greater than 10 percent in absolute value. Without learning, given the stipulated objective function, this rule stabilizes inflation too much at the cost of more variability in the output gap. However, with learning, its better containment of inflation helps anchor inflation expectations and avoids deflation and the associated severe recessions.

5.5. Robustness to Alternative Learning Rates

The qualitative results are the same for other values of the learning rate, μ, but quantitatively the losses with low inflation are much larger when the learning rate is 0.03. Tables 5 and 6 show the results for the economy with alternative learning speeds of $\mu = 0.01$ and $\mu = 0.03$, respectively, where policy follows the more aggressive version of the rule with $\gamma_\pi = 0.25$. For the case of $\mu = 0.03$, if the public knows the policy rule, the costs associated with the zero bound rise for inflation targets below 1 percent.

6. Conclusion

The historical experiences of deflation with interest rates constrained at zero in the United States in the 1930s and more recently in Japan suggest that it may be prudent to avoid such situations. One solution is to target an inflation rate a few percentage points above zero. Indeed, for this reason and others, inflation-targeting central banks tend to target an inflation rate around 2 percent. Theoretical research on monetary policy yields a far more optimistic view on the ability of monetary policy to stabilize the economy even with an inflation target of zero. This article suggests a note of caution regarding the effectiveness of monetary policy in the presence of the zero bound if one abandons the assumption that the public has perfect knowledge of the economy and the monetary policy strategy. In a world with imperfect knowledge, policies that would work well if expectations were rational can perform very poorly if the public has imperfect knowledge, especially when the public is uncertain of the policy strategy itself. Although not studied in this article, a clear corollary of the potential difficulty in stabilizing the economy in the presence of the zero bound is the potential use of fiscal policy interventions when policy is constrained at zero, and the need for more research in this area.

The message of the article is not, however, entirely negative. First, I show that effective communication of the monetary policy strategy can reduce the costs associated with the zero bound. In this respect, the results relate to Eggerts-

(text continues on page 12)

TABLE 4
THE EFFECTS OF THE ZERO BOUND WITH LEARNING ($\mu = 0.02$)
MORE AGGRESSIVE POLICY RULE: $\gamma_\pi = 0.25$, $\gamma_{\Delta y} = 1$

	Root mean square				Frequency	
Inflation target (π^*)	Inflation	Output gap	Interest rate	Central bank loss	$i_t = 0$	$y_t \leq -20$
Policy follows price level rule (equation 5), but public forecasts with difference rule						
0.0	2.0	4.4	1.9	9.2	15.9	3.0
0.5	1.5	3.4	1.9	5.3	8.4	1.3
1.0	1.2	2.8	1.9	3.7	4.5	0.6
1.5	1.0	2.5	1.9	2.9	2.3	0.3
2.0	0.9	2.3	1.9	2.4	1.0	0.1
3.0	0.9	2.2	1.9	2.3	0.2	0.0
4.0	0.8	2.2	1.9	2.3	0.1	0.0
Policy follows price level rule (equation 5), and public forecasts with same						
0.0	0.9	2.7	1.8	3.0	10.8	0.2
0.5	0.9	2.5	1.9	2.6	6.2	0.1
1.0	0.8	2.3	1.9	2.4	3.4	0.0
1.5	0.8	2.3	1.9	2.4	1.8	0.0
2.0	0.8	2.3	1.9	2.4	0.9	0.0
3.0	0.8	2.3	1.9	2.4	0.3	0.0
4.0	0.8	2.2	1.9	2.3	0.1	0.0

FIGURE 1
DISTRIBUTIONS OF INFLATION RATE WITH A ZERO INFLATION TARGET

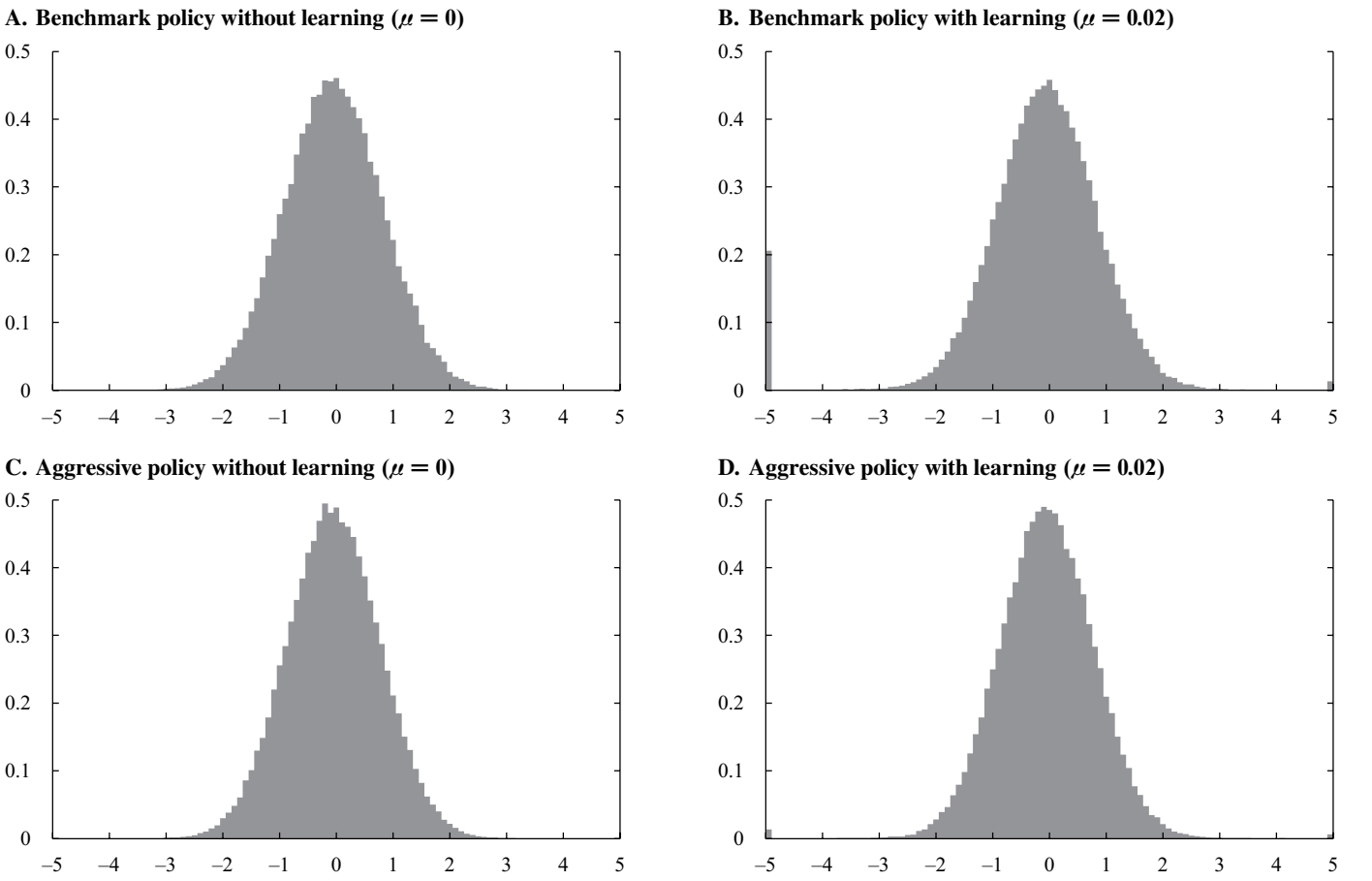

TABLE 5
THE EFFECTS OF THE ZERO BOUND WITH SLOWER LEARNING ($\mu = 0.01$)
MORE AGGRESSIVE POLICY RULE: $\gamma_\pi = 0.25$, $\gamma_{\Delta y} = 1$

	Root mean square				Frequency	
Inflation target (π^*)	Inflation	Output gap	Interest rate	Central bank loss	$i_t = 0$	$y_t \leq -20$
Policy follows price level rule (equation 5), but public forecasts with difference rule						
0.0	1.2	2.9	1.8	3.9	13.0	0.6
0.5	1.0	2.6	1.8	3.1	7.2	0.3
1.0	0.9	2.3	1.8	2.4	3.7	0.0
1.5	0.8	2.2	1.9	2.3	1.9	0.0
2.0	0.8	2.2	1.9	2.2	0.9	0.0
3.0	0.8	2.2	1.9	2.2	0.2	0.0
4.0	0.8	2.2	1.9	2.2	0.0	0.0
Policy follows price level rule (equation 5), and public forecasts with same						
0.0	0.8	2.3	1.7	2.3	10.2	0.0
0.5	0.8	2.2	1.8	2.2	6.0	0.0
1.0	0.8	2.2	1.8	2.2	3.2	0.0
1.5	0.8	2.2	1.8	2.2	1.7	0.0
2.0	0.8	2.2	1.9	2.2	0.9	0.0
3.0	0.8	2.2	1.9	2.2	0.2	0.0
4.0	0.8	2.2	1.9	2.2	0.0	0.0

FIGURE 2
DISTRIBUTIONS OF THE OUTPUT GAP WITH A ZERO INFLATION TARGET

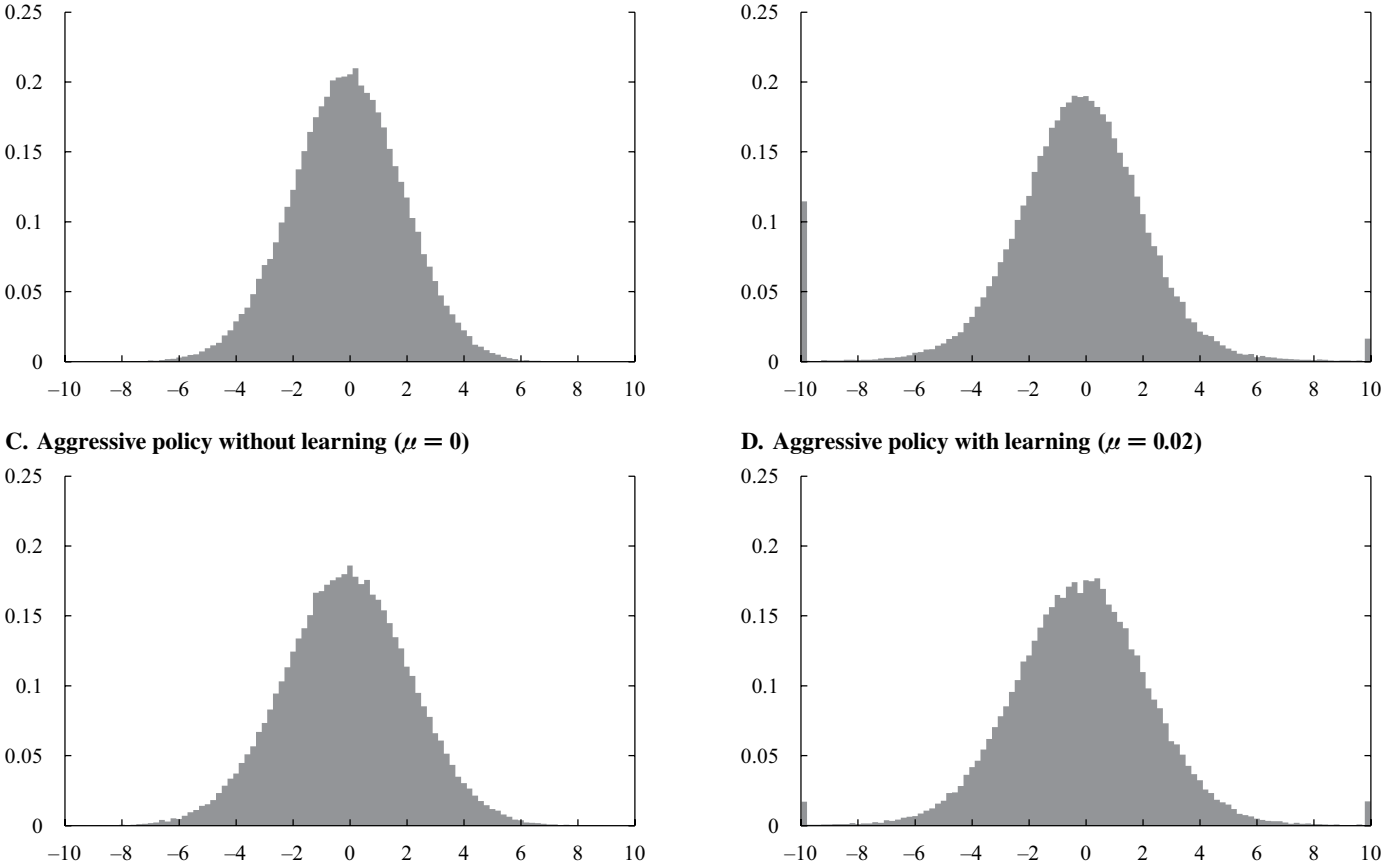

TABLE 6
THE EFFECTS OF THE ZERO BOUND WITH FASTER LEARNING ($\mu = 0.03$)
MORE AGGRESSIVE POLICY RULE: $\gamma_\pi = 0.25$, $\gamma_{\Delta y} = 1$

	Root mean square				Frequency	
Inflation target (π^*)	Inflation	Output gap	Interest rate	Central bank loss	$i_t = 0$	$y_t \leq -20$
Policy follows price level rule (equation 5), but public forecasts with difference rule						
0.0	3.8	8.1	2.5	31.3	24.7	13.6
0.5	2.4	5.3	2.2	13.1	11.4	5.0
1.0	1.7	3.9	2.0	7.0	5.5	2.2
1.5	1.4	3.3	1.9	5.1	3.1	1.3
2.0	1.2	2.9	1.9	4.0	1.7	0.8
3.0	1.0	2.6	1.9	3.1	0.7	0.4
4.0	0.9	2.4	1.9	2.6	0.3	0.2
Policy follows price level rule (equation 5), and public forecasts with same						
0.0	1.2	3.4	2.0	4.8	11.1	0.9
0.5	1.1	3.0	2.0	3.9	6.5	0.5
1.0	1.0	2.7	1.9	3.2	3.5	0.3
1.5	0.9	2.5	1.9	2.7	1.9	0.1
2.0	0.9	2.5	1.9	2.7	1.1	0.1
3.0	0.9	2.4	1.9	2.5	0.5	0.1
4.0	0.8	2.3	1.9	2.4	0.2	0.0

son's (2008) analysis of the effectiveness of the sudden regime shifts in monetary and fiscal policies in 1933 in the United States. Second, I find that a robust strategy to cope with both imperfect knowledge and the zero bound is to respond more strongly to inflation than would be optimal under rational expectations. This policy rule, assuming it is communicated effectively to the public, is highly effective at stabilizing inflation and output even with an inflation target of 1 percent.

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State Business Taxes and Investment: State-by-State Simulations*

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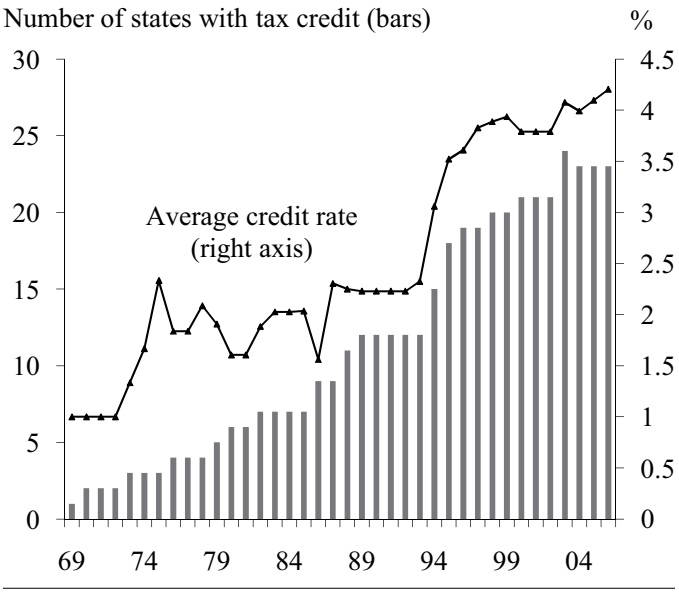
This article develops a framework for simulating the effects of state business taxes on state investment and output. Our simulations provide the predicted increase in investment—both in equipment and structures (E&S) and in research and development (R&D)—and the predicted increase in output for a given state resulting from a specified change in one of its three tax policies—the E&S investment tax credit, the R&D tax credit, or the corporate income tax. The simulations depend on a set of formulas linking economic parameters and state data to investment and output, all of which are reported in this article. We report results, based on our preferred set of parameters, for each of the 48 contiguous states. We also discuss alternative parameter values and explore the resulting sensitivity of predicted changes in state investment and output. Finally, we describe a simple web tool that we have made available online (www.frbsf.org/csip/taxapp.php) that allows users to insert their own preferred parameter values and simulate the economic effects for the state and tax policy of their choosing.

1. Introduction

Business tax incentives have become a powerful weapon in states' fiscal arsenals in recent years. Tax incentives have been used both for countering recessions in the short run and fostering sustainable economic growth in the long run. For example, California's initial budget for fiscal year 2009 passed in February 2009 expanded business tax incentives by $1 billion, even while the state cut spending by $20 billion and hiked personal taxes and fees.[1]

State tax policy has become much more business-friendly in recent years. The first broad, statewide tax credit for investment in equipment and structures (E&S) was enacted in 1969 by New York. By 2006, 23 states offered similar credits and the average credit rate among those states had grown to over four percentage points (see Figure 1). Similarly, state tax credits for investment in research and development (R&D) have become increasingly common and generous since the first such state credit was enacted in 1982 by Minnesota. By

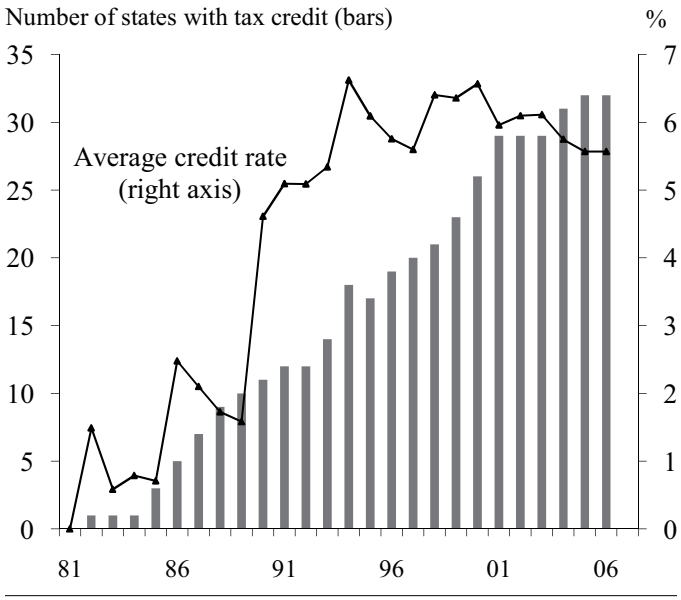
FIGURE 1
STATE INVESTMENT TAX CREDITS FOR EQUIPMENT AND STRUCTURES (E&S), 1969 TO 2006



*We thank Robert Tannenwald for suggesting that we translate our research on state taxation and capital formation into the simulation analysis contained in this article. We also thank Ted Wiles for excellent research assistance and Judy Feria for her programming assistance on the web applet described in this article. Financial support from the Federal Reserve Bank of San Francisco is gratefully acknowledged by the first author. All errors and omissions remain the sole responsibility of the authors and the conclusions do not necessarily reflect the views of the organizations with which they are associated.

1. These tax incentives were later rescinded because continued deterioration in state receipts and the failure of certain ballot initiatives led to a further imbalance in the budget.

Figure 2
State Research and Development (R&D) Tax Credits in the United States, 1981 to 2006



2006, 32 states had an R&D tax credit, and the average rate among those states was 5.5 percentage points (see Figure 2). The proliferation of tax credits in subsequent years, combined with aggressive tax planning vis-à-vis apportionment formulas and passive investment companies, has led to a general decrease in average corporate tax collections over the past 25 years.[2] In response to recently slumping economies, states have accelerated their use of business tax incentives (Silver-Greenberg 2009). Whether such incentives are good public policy is a matter of great debate and controversy. Nonetheless, it is clear that states' reliance on such incentives have increased tremendously over the past few decades.

What impacts should state policymakers expect from granting investment tax incentives? This article offers a partial answer to this question and contributes to the quantitative evaluation of state business taxes. We present a framework that translates a given change in state business tax policy into changes in E&S investment, R&D investment, and overall state economic output. The links among tax policies, investment, and output depend on a set of channels determined by economic theory and a set of parameters whose values are drawn from empirical research. Some of these parameters depend on extant tax policy at the state level, and we provide the information needed for the computations. Other parameters represent structural characteristics of the economy. We rely on prior studies to determine our preferred parameter values, though we also consider the sensitivity of our results to alternative values of these parameters.

Our article proceeds as follows. Section 2 introduces the framework for simulating the impact of state business taxes. The user cost of capital is a fundamental concept linking legislated tax policies to economic incentives. The mobility of capital across states presents a particular challenge for analyzing state tax policy, because the incentive effects of the resulting tax competition must be quantified. A change in incentives affects investment and production through three sets of channels: direct and indirect (reflecting capital mobility and tax competition) user cost channels, substitution and scale channels, and direct production and multiplier channels. All of the relevant economic parameters are discussed. Section 3 reviews the literature and provides some perspective on reasonable ranges for the structural parameters. Section 4 presents state-by-state simulation results for all 48 contiguous states. We illustrate exactly how these results are obtained by walking through the process for one particular state, California. Last, we describe a simple web tool that we have made available online that allows users to insert their own preferred parameter values and simulate the economic effects for the state and tax policy of their choosing. Section 5 summarizes and discusses other state tax policies.

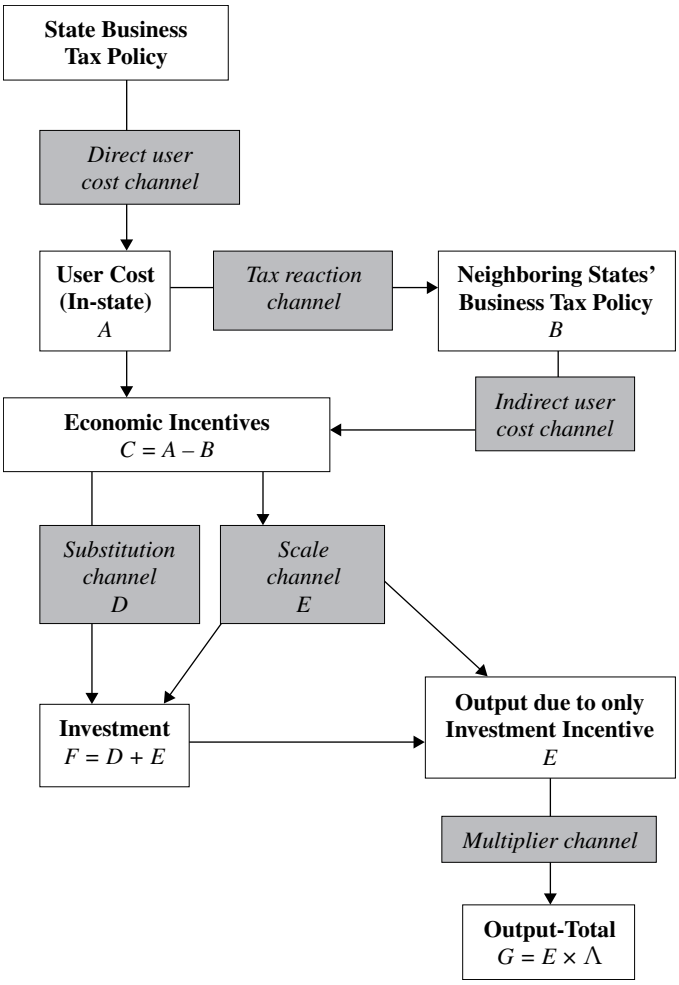
2. A Framework for Simulating the Impact of State Business Taxes

This section develops a framework that links legislated changes in a state's business taxes to resulting changes in the state's stock of equipment and structures capital, its stock of research and development capital, and output.[3] Our framework is depicted in Figure 3. A change in a given tax policy (e.g., a decrease in the corporate income tax rate) affects economic incentives embedded in the user cost of capital (explained later) that, in turn, affect investment and output. These economic variables—the user cost, investment, and output—are linked together by a series of channels that depend on theoretical relations and assumed parameters. (The channels and parameters are summarized in Table 1.) The structural parameter values underlying the simulations are not restricted in our framework, and any values can be inserted in the online applet that accompanies this study. We rely on the literature discussed in Section 3 for guidance on

2. See Wilson (2006) and Gupta et al. (2009) for further discussion of state corporate tax collections and the reason for the decline in recent years.

3. Technically, the quantity of investment analyzed in this article is net investment, defined as the increase in the capital stock due to the stimulus less depreciation of the existing capital stock. Since we think of depreciation as largely exogenous to the tax policies under consideration, it is not considered explicitly in our analysis.

FIGURE 3
FRAMEWORK RELATING STATE BUSINESS TAX POLICY TO INVESTMENT AND OUTPUT



the range of appropriate parameter choices, and we show in Section 4, through simulations, the sensitivity of the economic effects of business tax policies with different parameter values.

Before proceeding to the specific channels, we note four characteristics of our framework. First, the framework for simulating the impacts of tax policies affecting E&S or R&D investment is the same, though the underlying parameter values will differ. The user cost framework applies equally to the tangible capital built up from past and present E&S investment and to intangible knowledge capital built up from past and present R&D investment. A state's user cost of R&D capital and its user cost of E&S capital will differ due to differences between R&D and E&S in the investment tax credit rate and tax depreciation allowances. Second, the simulations are based on a change relative to the status quo, which differs by state. Third, we restrict our attention to state business taxes and do not consider the additional and potentially important roles of state personal and sales taxes. Fourth, the simulations are most appropriate for economic environments where resources are fully utilized. With this long-run focus, which particularly affects the assumed value for the production multiplier, tax policies designed to stimulate investment in response to a temporary downturn in economic activity would need to be analyzed in a different framework. Our framework is more appropriate for long-run considerations and provides a "roadmap" from tax policy to its ultimate effects on investment and output through three sets of channels we will discuss. But first, we turn to the user cost of capital, the key variable for representing the economic incentives provided by legislated tax policies.

2.1. The User Cost of Capital

The user cost of capital is the fundamental concept for quantifying the effects of tax legislation on capital formation. This concept was introduced by Jorgenson (1963) and is based on the economic equivalence between renting and owning a piece of durable capital. In both cases, the user of that capital good can be thought of as making a periodic payment for capital services. The only difference is that renters of capital are making an explicit payment, whereas owners of capital are effectively renting the capital from themselves and hence making an implicit payment. With this insight, durable capital can be assigned a rental price or user cost that is easy to measure and can be readily analyzed with the standard tools of price theory. Furthermore, the economic impact of several tax policy instruments—investment credits, depreciation allowances, and income taxes—can also be quantified. The user cost provides an enormously convenient framework for translating the effects of legislated tax changes into numerical estimates useful in quantitative policy analysis.

The user cost of capital (UC) depends on several components—the opportunity cost of financial capital, the depreciation of physical capital, the relative price of investment goods, and taxes. The opportunity cost of financial capital, ρ, is the expected return from investing in financial markets, instead of spending the funds on equipment and structures or research and development, and can be specified in several ways that depend on auxiliary assumptions about corporate financing. One approach measures ρ in terms of the real cost of the marginal source of funds—retained earnings (internal equity), external debt, or external equity.[4] Under the

4. See Sinn (1991) for a taxonomy of different funding sources and the associated taxes and Auerbach (1983) for the relationship between taxes and corporate financial decisions. The real cost of funds is usually calculated by subtracting an estimate of the expected rate of inflation stated in terms of the producer price. To be consistent with the theoretical derivation of the user cost, the inflation correction should be stated in terms of the price of new investment.

Table 1
Glossary of Parameters and Variables

Parameter	Name	Description
Panel A. Structural (non-state-varying) Parameters		
α	Slope of the tax reaction function	The percent change in $UC^{\#}$ for a 1% change in UC (where the superscript $^{\#}$ represents neighboring states considered as a singular unit). Range of values {–1.0, +1.0}. (equation 5)
σ	Elasticity of substitution between capital and other factors of production	The percent change in the capital stock with respect to a 1% change in UC, holding output and output price constant. Range of values for E&S {0.0, 1.5}; range of values for R&D {0.0, 3.0}. (equation 8)
ω^K	Factor share of capital	Capital's factor share. Range of values for E&S {0.25, 0.50}; range of values for R&D {0.0, 0.1}. (equation 8)
η	Price elasticity of demand for output	The percent change in output demand with respect to a 1 percent change in the price of output. Range of values {0.0, 10.0}. (equation 8)
Λ	Multiplier effect	
Panel B. State-Specific Data Variables		
Variable	Name	Description
UC	User cost of capital	equation (1)
P^I	Price of new investment goods	equation (1)
P^Y	Price of output	equation (1)
ρ	Opportunity cost of financial capital	equation (1), assumed to be 10 percent.
δ	Rate of economic depreciation	equation (1), estimated from depreciation in the manufacturing sector at the national level.
$ITCR^{R\&D}$	Investment tax credit for research and development	equation (2b)
$ITCR^{E\&S}$	Investment tax credit for equipment and structures	equation (2b)
$CITR$	Corporate income tax	equation (2b)
TDA	Tax depreciation allowances	equation (2b), set to 0.70 for all states. $TDA = 1$ for the user cost of research and development.
K	Capital stock	
Y	Output	
Panel C. State-Specific Economic Variables (Channels)		
Channel	Name	Description
A	Direct user cost channel	Parameter A: the percent change in UC for a one percentage point change in τ, where τ equals $ITCR^{E\&S}$, $ITCR^{R\&D}$, or $CITR$. See Table 2 for the values of $A_s^{ITCR(E\&S)}$, $A_s^{ITCR(R\&D)}$, and A_s^{CITR} that correspond to the $ITCR^{E\&S}$, $ITCR^{R\&D}$, and the $CITR$, respectively. Note that the s subscript reflects that the change in the UC with respect to the same change in τ varies by state. (equation 3)
B	Indirect user cost channel	The percent change in $UC^{\#}$ for a one percentage point change in τ and equals $\alpha \times A_s^{ITCR(E\&S)}$, $\alpha \times A_s^{ITCR(R\&D)}$, or $\alpha \times A_s^{CITR}$. (equation 6)
C	Net user cost channel	Direct user cost channel minus indirect user cost channel, $(1-\alpha) \times A_s^{\tau}$. (equation 7)
D	Substitution channel	The percent change in the capital stock with respect to a one percentage point change in τ, holding output constant, $D_s^{\tau} = (\sigma - \sigma \times \omega^k) C_s^{\tau}$.
E	Scale channel	The percent change in the capital stock with respect to a one percentage point change in τ, absent any capital-labor substitution, $E_s^{\tau} = \omega^k \times \eta \times C_s^{\tau}$. E_s^{τ} also gives the percent change in output due directly to the net change in economic incentives.
F	Net investment channel	The percent change in capital stock due to a one percentage point change in τ, $F_s^{\tau} = D_s^{\tau} + E_s^{\tau}$.
G	Multiplier channel	The percent change in total statewide output with respect to a one percentage point change in τ. Leads to the following amount of total output, $G_s^{\tau} = E_s^{\tau} \times \Lambda$.

trade-off theory of capital structure, financial policies equalize the costs of the marginal sources of funds (adjusted for risk and taxes), and thus ρ can be properly measured by either marginal cost. The "pecking order" model also relies on the marginal sources of funds but provides an alternative theory of capital structure that emphasizes asymmetric information in financial markets. In this model, there exists a hierarchy of costs, increasing from internal equity to debt to external equity, and thus our assumptions about the marginal source of funds matter. A third approach measures ρ as a weighted average of the real costs of debt and equity, where the weights represent the proportion of debt and equity in the capital structure. While the marginal funding used in any given year likely differs from the average capital structure reflected in these weights, it must ultimately correspond to the capital structure, and the weighted-average formulation is appropriate for a long-run analysis. The calculations presented in this article sidestep these corporate finance issues and are based on the assumption that $\rho = 10$ percent. This figure is somewhat higher than that used in some other studies but reflects the higher risk premium associated with the manufacturing firms analyzed here.

The next component of the user cost of capital is economic depreciation. Economic depreciation (which differs from tax depreciation discussed later) can be viewed as a "nonrefundable security deposit," reflecting that only a fraction of the rented capital good will be returned at the end of the period because of depreciation. In the standard user cost formula, capital is assumed to depreciate geometrically at rate δ, and our simulations are based on a δ estimated from depreciation in the manufacturing sector at the national level.[5]

The third component of the user cost involves a relative price: the price of new investment goods (P^I) divided by the expected benefit from the output generated by the new unit of capital. For a profit-maximizing firm, the value of that incremental output is its selling price (P^Y). Apart from tax considerations, these three components—the opportunity cost, economic depreciation, and relative prices—lead to the following specification of the user cost,

$$UC = (\rho + \delta) \times (P^I/P^Y). \tag{1}$$

Taxes also affect the user cost of capital, and we consider the roles played by state investment tax credits and the corporate income tax on investment incentives. (For ease of exposition, we do not discuss in this section federal corporate tax policies—that is, the federal R&D tax credit rate, the federal corporate income tax rate, and federal tax depreciation allowances—but they are accounted for in our simulations.)

5. Even if capital depreciates according to some other pattern, long-run replacement requirements tend to a geometric pattern (Jorgenson 1974).

As shown in Figures 1 and 2, state policymakers have frequently sought to stimulate investment by offering tax credits on investment. An investment tax credit is a reduction in a corporation's income tax liability in proportion to the value of investment that the firm does in the state. That proportion is determined by the investment tax credit rate *(ITCR)*. Corporate profits are subject to a corporate income tax that enters the user cost in two ways. In its simplest form, the corporate income tax rate *(CITR)* lowers the pretax income a firm generates from production by a factor of $(1 - CITR)$ multiplied by the price of output appearing in the denominator of the user cost.

Complications arise with tax depreciation allowances that accrue over the useful life of the asset.[6] Since the pioneering work of Hall and Jorgenson (1971), these allowances have been modeled as a present value that depends on tax service lives, tax depreciation patterns, and discount rates. In general, these factors determining depreciation allowances do not vary by state because states normally piggyback on federal IRS depreciation rules. A recent exception is the federal government's temporary accelerated depreciation rules; not all states adjusted their depreciation rules to account for this temporary acceleration. Nonetheless, given that these temporary deviations between state and federal rules are rare, we assume the present value of tax depreciation allowances *(TDA)* is the same across states. The value of *TDA* used in this study is set, for all states, to 0.70 for equipment and structures, slightly lower than the average across asset types reported by Gravelle (1994) in order to make a rough adjustment for the basis reduction due to the investment tax credit. Because 100 percent of R&D investment may be expensed (that is, fully depreciated) in the first year, for all states and at the federal level, *TDA* for R&D is 1.0. Since the benefit of these allowances is to lower the amount of income subject to tax, *TDA* is multiplied by *CITR*. These three tax variables enter the user cost of capital in the following manner:

$$UC = (\rho + \delta) \times (P^I/P^Y) \times TAX \tag{2a}$$

6. There are two additional considerations that affect the *CITR* in the user cost formula. First, property taxes enter the user cost in a manner similar to tax depreciation allowances; both involve a stream of commitments that follow upon purchasing an asset. The present value of property taxes enters the user cost both as a direct cost and as a deduction against taxable income; hence the present value of property taxes would be multiplied by $(1 - CITR)$. Second, for determining corporate income tax liability in a given state, corporations that do business in multiple states must apportion their national income to each state using formulary apportionment. The apportionment formula is a weighted average of the company's sales, payroll, and property (E&S capital), but the weights vary by state. The capital weight can be thought of as a capital tax instrument with effects similar to the corporate income tax. We do not have sufficient information to analyze the effects of either the property tax or capital apportionment at the state level.

$$(2b) \qquad TAX = \frac{1 - ITCR - (CITR \times TDA)}{(1 - CITR)}.$$

Equation (2) captures in a succinct fashion the costs from tax and nontax factors that a profit-maximizing firm faces when evaluating the acquisition of the marginal piece of capital.[7]

There are three considerations to keep in mind in using equation (2) to assess tax policy. First, an important assumption underlying the above derivation of the user cost is that the firm has sufficient profits to pay taxes. Absent this condition, (nonrefundable) tax credits and deductions are not immediately useful, and the calculation of tax incentives becomes considerably more complicated.[8] Second, we assume that the firm does not face a corporate alternative minimum tax. Third, for firms whose cost of external finance exceeds that for internal funds, tax cuts provide two stimuli. Changing internal finance affects the behavior of financially constrained firms over and above the incentive represented by variations in the user cost. A higher investment tax credit, for example, may have standard incentive effects on the demand for capital but, for financially constrained firms, the resulting increase in cash flow raises capital formation further than if the firm did not face finance constraints. While these three factors may affect the quantitative impact of tax policy in the short run, they will have much less impact on the long-run calculations that are the focus of this article.

2.2. Investment Incentives via Direct and Indirect User Cost Channels

There are two channels through which changes in a state's tax policy may affect the state's user cost of capital and, in turn, investment and output. We illustrate these two channels by considering a tax policy change by the state of California. The first channel is the direct user cost channel whereby the change in one of California's tax variables discussed above implies a change in California's user cost. The second, which we call the indirect user cost channel, is more complex. Because capital (either E&S or R&D) in its pursuit of the highest net-of-tax return may well be mobile across states, investment in California can be affected by the user costs of capital in other "neighboring" states (which we discuss further in the literature review in Section 3). In addition, policymakers in the neighboring states may react to the California tax change, a phenomenon known as tax competition. Thus, the California tax change will not only have a direct effect on California's investment by changing California's user cost, but also an indirect effect on California investment by changing the user costs in neighboring states.

We first consider the percentage change in *UC* due to a one percentage point decrease in *CITR* that leads to the following *direct user cost channel*. (Note that the equation is the same whether the *UC* refers to an E&S or R&D investment, though parameter values will differ.)

$$(3) \quad \frac{\partial UC/UC}{-\partial CITR} = \frac{-1.0}{(1 - CITR)} + \frac{(TDA)}{(1 - CITR) \times TAX} \equiv A_s^{CITR}.$$

A decrease in *CITR* has two opposing effects. Of the two terms in the middle expression in equation (3), the first term captures a decline in *UC* because the lower *CITR* raises the net-of-tax return from a unit of output. But the lower *CITR* also implies that the value of tax deductions associated with *TDA* is worth less, thus raising *UC*. This latter effect is captured by the second term. In our data, A_s^{CITR} is always negative for the E&S user cost, but always positive for the R&D user cost. The magnitude of the decrease in *UC* depends on all tax variables discussed above. Since some of these tax variables vary by state, equation (3) is evaluated on a state-by-state basis. (We have added a subscript *s* to indicate that the effect varies by state.)

A one percentage point increase in the *ITCR* creates an alternative *direct user cost channel* (stated as a percentage change),

$$(4) \qquad \frac{(\partial UC/UC)}{\partial ITCR} = \frac{-1}{(1 - CITR) \times TAX} \equiv A_s^{ITCR(E\&S)} \ \left(\text{or } A_s^{ITCR(R\&D)}\right).$$

The increase in *ITCR* lowers *UC*. As with the change in *CITR*, equation (4) is evaluated on a state-by-state basis and differs for E&S and R&D user costs. We refer to the percentage change in the user costs for E&S and R&D by parameters $A_s^{ITCR(E\&S)}$ and $A_s^{ITCR(R\&D)}$, respectively.

As discussed earlier, the indirect user cost channel captures the effect that a change in a given state's tax policy may have on other states' tax policies (via tax competition) and, in turn, other states' user costs of capital. Recall that other states' user costs could negatively affect investment in a given state to the extent that investment is geographically mobile or "footloose." Letting a superscript # represent the neighboring states considered as a singular unit, we compute the following *tax reaction channel* relating the percentage change in $UC^{\#}$ to a given percentage change in *UC*,

7. For additional details about the construction of the user cost, see King and Fullerton (1984), Cordes, Ebel, and Gravelle (2005), and Chirinko and Wilson (2008, Appendix; 2009b).

8. See Auerbach and Poterba (1987), Mintz (1988), Altschuler and Auerbach (1990), and Devereux, Keen, and Schiantarelli (1994) for further discussion of tax incentives and tax-loss status. A few states have a refundable investment tax credit whereby a business in a tax-loss position can receive a direct payment from the state for the value of the credit.

$$\frac{(\partial UC^{\#}/UC^{\#})}{(\partial UC/UC)} \equiv \alpha. \tag{5}$$

The actual change in investment incentives due to the one percentage point change in *CITR* or *ITCR* is the product of the implied change in *UC* determined by equations (3) or (4), respectively, and the change in $UC^{\#}$ determined by equation (5). This interaction leads to the following indirect user cost channel for *CITR*, $ITCR^{E\&S}$, and $ITCR^{R\&D}$,

$$\frac{(\partial UC^{\#}/UC^{\#})}{(\partial UC/UC)} \times \frac{(\partial UC/UC)}{\partial ITCR^{CIT}} = \alpha \times A_s^{CITR} \equiv B_s^{CITR}. \tag{6a}$$

$$\frac{(\partial UC^{\#}/UC^{\#})}{(\partial UC/UC)} \times \frac{(\partial UC/UC)}{\partial ITCR^{E\&S}} = \alpha \times A_s^{ITCR(E\&S)} \equiv B_s^{ITCR(E\&S)}, \tag{6b}$$

$$\frac{(\partial UC^{\#}/UC^{\#})}{(\partial UC/UC)} \times \frac{(\partial UC/UC)}{\partial ITCR^{R\&D}} = \alpha \times A_s^{ITCR(R\&D)} \equiv B_s^{ITCR(R\&D)}, \tag{6c}$$

Equations (3) through (6) quantify the economic incentives for investment in a given state due to a change in tax policy. The net effect on economic incentives for a given tax instrument (τ) in state s is represented by C_s^{τ}, the difference between A_s^{τ} and B_s^{τ},

$$C_s^{\tau} \equiv A_s^{\tau} - B_s^{\tau} = (1-\alpha)A_s^{\tau} \qquad \tau = \{CITR, ITCR^{E\&S}, ITCR^{R\&D}\}, \tag{7}$$

Equation (7) represents how much (in percentage terms) the user cost in a given state changes relative to how much user costs in neighboring states change. Traditional neoclassical production theory implies that only the in-state user cost matters for economic incentives (that is, $\alpha = 0$). We diverge from the traditional theory and posit that this relative difference determines economic incentives.

2.3. Investment via Substitution and Scale Channels

The change in economic incentives represented by equation (7) is translated into changes in investment *I* through standard microeconomic substitution and scale channels.[9] A particularly convenient formula has been derived by Hicks (1932/1963) that quantifies these two channels in terms of a limited set of parameters describing the production function and market conditions faced by the firm. Hicks's formula is written as follows,

$$\frac{(\partial I/I)}{-(\partial UC/UC)} = \sigma - \sigma \times \omega^K + \omega^K \times \eta, \tag{8}$$

where σ is the elasticity of substitution between capital and the other factors of production, ω^K is the factor share of capital (i.e., the portion of the value of output devoted to capital costs), and η is the price elasticity of demand for output.[10] Note that these parameters will vary by E&S and R&D capital, though our derivation here does not explicitly recognize these differences.

Equation (8) captures in a succinct manner the substitution and scale effects that link a change in the user cost to the change in investment. Suppose that the user cost has fallen because of a decrease in *CITR* or an increase in *ITCR*. The first term on the right side of equation (8), σ, represents a substitution effect holding output and its price constant. The larger σ is, the more that firms will substitute capital for labor (and other factors of production) for a given change in *UC*. The second term represents an additional substitution effect driven by the lower marginal cost of production. Under competitive conditions, the decline in marginal cost due to the lower user cost translates into a decline in the output price. The extent of this decline is determined by the relative importance of capital in production, as represented by ω^K. The decline in the output price raises the relative price of capital and lowers demand for capital (cf. equation 2); hence the negative sign in equation (8). The net substitution effect resulting from a specific tax policy change—a one percentage point reduction in *CITR* or a one percentage point increase in *ITCR*—is measured by $\sigma - \sigma \times \omega^K$ multiplied by the effect of the policy change *UC*. This substitution effect is represented by $D_s^{\tau} = (\sigma - \sigma \times \omega^K) \times C_s^{\tau}$.

The third term in equation (8), $\omega^K \times \eta$ represents the impact of a lower output price that allows the firm to slide down the product demand curve and increase output. Firms in markets where customers are very price-sensitive are able to reap greater benefits from being able to reduce the price of their output and hence will produce more. As with the substitution effect, the magnitude of this scale effect, E_s^{τ}, in response to a specific tax policy change, will be the product of the effect of a change in the user cost on investment, $\omega^K \times \eta$, multiplied by the effect of the policy change on the user cost, C_s^{τ}. This scale effect is represented by $E_s^{\tau} = \omega^K \times \eta \times C_s^{\tau}$.

9. In our long-run analysis, no difference exists between changes in investment and changes in the capital stock *(K)*. This equivalence holds because, in the long-run, investment is proportional to the capital stock, with proportionality factor equal to the sum of the depreciation and long-run growth rates. Hence the percentage change in investment equals the percentage change in the capital stock that, in turn, equals the percentage change in the user cost multiplied by parameters reflecting substitution and scale effects (cf. equation 8).

10. See Chirinko and Mallick (2009) for a derivation and further discussion of Hicks's formula.

Combining the direct and indirect user cost channels that affect investment incentives and the substitution and scale channels that affect investment, we can represent the impact of a one percentage point decrease in *CITR* or increase in *ITCR* by $F_s^\tau = D_s^\tau + E_s^\tau$.

2.4. Output via Scale and Multiplier Channels

State tax policy affects the amount of output produced by firms through scale and multiplier channels. The scale channel is the same as the one that affects investment in the preceding subsection whereby a reduction in the user cost of capital lowers the marginal cost of production that, in turn, lowers the price of and raises the demand for output. As stated above, the scale effect is represented by $E_s^\tau = \omega^K \times \eta \times C_s^\tau$.[11]

Many studies of tax and other government policies introduce a multiplier channel, arguing that the spending generated from the policy initiative will stimulate additional rounds of spending and production. We are not comfortable with multiplier analyses. For the long run we focus on in this article, the additional resources needed in the multiplier rounds of spending must be drawn away from other activities. Thus, while it is possible that the tax policy stimulates activity in one sector, this increase will be at the expense of other sectors. The net effect could be close to zero in the long run. There may be greater scope for multiplier analysis in the short run, but multiplier parameters are not usually based on models that allow for a temporary period of deficient demand and a gradual transition to a long run with reasonable steady-state properties. These caveats notwithstanding, we allow for the possibility of multiplier effects; specifically, we multiply the output from the direct production channel, E_s^τ, by Λ. The parameter Λ reflects assumptions about the size of the multiplier and varies from 0 to whatever number may be of interest. A value below 1.0 suggests negative within-state externalities from the direct production effect. For example, if the induced investment and increased production by firms that benefit from a tax change crowd out investment and production by other firms in the state, then Λ could be less than one. Total output arising from the tax policy is represented by $G_s^\tau = E_s^\tau \times \Lambda$.

11. It may seem odd that the scale channels for investment and output are equal. However, it should be kept in mind that the scale channel is stated as a percentage change. In the previous subsection, investment is raised by E_s^τ percent. When evaluating the response of output, both capital and other factors of production (e.g., labor) are raised by equal percentages of E_s^τ percent. In turn, the extra capital and labor are weighted by their respective factor shares. Since the factor shares sum to one, the effect on output is just the initial shock, E_s^τ percent.

3. A Brief Literature Review

This section offers a brief review of several papers and issues that are relevant for determining the values of the some of the key parameters and the economic variables introduced in Section 2. Note that channels B through G are transformations of these "primitive" economic variables and parameters and that channel A is determined by variables entering the user cost formula in equation (2). See Table 1 for a glossary providing the symbols, names, and descriptions of each of the parameters and variables used in this article.

It is worth commenting on five parameters that are central to the simulation results. First, the elasticity of substitution between capital and labor, $-\sigma$, plays a central role in determining the size of the substitution channel, and thus it is very important in assessing the quantitative impact of business tax policies. Given certain assumptions about the production function, $-\sigma$ turns out also to be the elasticity of the capital-output ratio with respect to a change in the user cost of capital *(UC)*. An increase in the user cost must have a nonpositive effect on capital demand, so $-\sigma \leq 0$. The larger σ is, the more responsive capital formation is to a given change in the user cost. Estimates in the literature have varied widely. The largest values tend to cluster around 1.0, a value consistent with a Cobb-Douglas production function. Other studies have reported much lower estimates. Chirinko (2008) reviews a large number of studies and concludes that the weight of the evidence suggests a value for σ ranging from 0.40 to 0.60.

Chirinko and Wilson (2008) estimate this parameter for a panel of states in a model with the user cost (current and lagged) and report that σ equals 0.71. When the user cost for neighboring states is included and the model estimated with a relative user cost variable, the value of σ equals 0.76.[12] In this article, we use this as our preferred estimate.

Second, the slope of the reaction function of the user costs in a given state (e.g., California) and its "neighboring" states governs how states might react to one another's policy changes. Practical considerations dictate that the user costs for the neighboring states be condensed into a single variable, and the standard procedure in the literature is to use spatial weights to aggregate all of California's neighboring states. The weights can be defined in several ways. In this study, we use weights based on geographic proximity—i.e., the inverse of the distance between the population centroids of California and all other 47 contiguous states.[13] Thus, all 47 states are

12. This value comes from Column 12 of Table 2 in Chirinko and Wilson (2008).

13. We use Census Bureau data on the latitude and longitude of states' population centroids and what is known as the "great circle distance formula," which accounts for the curvature of the earth, to calculate distances between states.

California's neighbors, with Nevada receiving a large weight and New York a very small weight. Alternative weighting schemes used in the literature include population weights (which would give New York a much larger impact on California), bordering states (which would give New York a zero weight for California), and commodity trade flows (based on the shipments of goods from and to California from a given state, a procedure which would give New York a weight between the values from the two other weighting schemes).

Given a definition of neighboring states, the slope of the reaction function for business taxes has been estimated in many studies, all but one of which find that the slope is positive.[14] As one example of this class of studies, Devereux, Lockwood, and Redoano (2008) find a value of α equal to 0.70 for the slope of the reaction function among countries in the European Union in terms of their corporate income tax rate. By contrast, Chirinko and Wilson (2009a) look at U.S. states and find that, when time lags and aggregate time effects are properly accounted for, the slope of the reaction function is negative. Their preferred estimates of α are –0.59 for $ITCR^{E\&S}$ and –0.08 for *CITR*, which we use in our benchmark simulation for this article. While the negative signs are surprising given the extant literature, they are fully consistent with a theoretical model in which the marginal preference of the representative voter for private goods relative to public goods with respect to an increase in income is positive. Thus, the α parameter can range widely, though considerations of stability require that the absolute value of the slope be less than one. We are unaware of any studies estimating the slope of the reaction function for the R&D investment tax credit. In our simulations, we will assume that the slope for the R&D credit is the same as that for the E&S credit.

A third important parameter in our framework is the price elasticity of demand for output, $-\eta$. This parameter plays a large role in macroeconomics, both in calibrating dynamic stochastic general equilibrium models and in assessing the role of market power on economic fluctuations. Econometric estimates of η (or other parameters from which η can be deduced) based on industry data have ranged widely from 1.04 (Chang, Hornstein, and Sarte 2009) to 4.68 (Chirinko and Fazzari 1994). The η parameter can also be inferred from industry accounting data on sales and costs. These estimates range from 2.59 (Chirinko and Fazzari 1994) to 3.45 (Domovitz, Hubbard, and Petersen 1987). These latter estimates are based on average costs that more closely measure long-run costs and long-run behavior than the econometric estimates. We use 3.0 as our benchmark value of η.

The parameter Λ reflects the additional rounds of spending and production that may follow from the output that is directly related to the tax policy. We noted our reservations about this parameter in subsection 2.4. Our simulation results below assume neither a positive nor a negative multiplier effect; hence, $\Lambda = 1$.

Last, capital's factor share in production, ω^K, is a parameter that can be measured directly from the data. This parameter plays a critical role in determining the magnitude of both substitution and scale effects. Given that compensation data are usually more readily available than data on payments to capital, this variable can be estimated as one minus labor's factor share. Estimates range from 0.25 to 0.50 for all capital, including E&S and R&D. We use $\omega^{E\&S} = 0.30$ and $\omega^{R\&D} = 0.05$ as baseline values in our model simulations.

4. Simulation Results: Predicted Responses of Investment and Output to Tax Policy Changes

This section contains a variety of simulation results by state, based on the framework described in Section 2 for hypothetical changes in three tax policies—*CITR*, $ITCR^{E\&S}$, and $ITCR^{R\&D}$. Subsection 4.1 presents the responses of investment and output to these tax policies based on our preferred structural parameters. As the discussion in Section 3 indicated, however, there is uncertainty over the precise values of these structural parameters, and subsection 4.2 documents the sensitivity of the results to alternative parameter values. To allow users flexibility, we have developed an online applet discussed in subsection 4.3 that permits users to choose their preferred parameter values.

4.1. Preferred Parameters

Results for our preferred parameters are shown in Tables 2 through 4. The first two columns of Table 2 contain the percentage changes in the user cost of capital due to a one percentage point decrease in *CITR* (column 1) and a one percentage point increase in $ITCR^{E\&S}$ (column 2). These computations are based on equations (3) and (4), respectively. The user cost differs for E&S and R&D capital by the value of the investment tax credit for either type of capital. Columns 3 and 4 present comparable calculations for R&D capital, specifically the percentage changes in the user cost of capital due to a one percentage point decrease in *CITR* (column 3) and a one percentage point increase in $ITCR^{R\&D}$ (column 4). The entries in Table 2 reflect both the direct and indirect user cost channels linking tax policy to economic incentives.

14. See Heyndels and Vuchelen (1998), Brueckner and Savaadra (2001), Hayashi and Boadway (2001), Altschuler and Goodspeed (2002), Revelli (2002), Devereux, Lockwood, and Redoano (2008), and Overesch and Rincke (2009). Brueckner (2006) surveys the literature estimating tax reaction functions.

At least four observations can be made about the results in Table 2. First, there is a great deal of variation in the response of user cost to different tax instruments. A one percentage point increase in $ITCR^{E\&S}$ or $ITCR^{R\&D}$ has a much larger effect on UC than a one percentage point decrease in *CITR*. Second, for a given tax instrument, there is much less variation across states. For example, the unweighted average change in the E&S user cost due to a one percentage point decrease in *CITR* is −0.66 percent, and the comparable entries in column 1 cluster rather closely around this average. Third, the decrease in *CITR* has radically different effects on economic incentives, decreasing the E&S user cost (column 1) but increasing the R&D user cost (column 3). This difference in *CITR*'s effect on E&S versus R&D is traceable to different values of *TDA*. E&S capital is depreciated over several years. Given the time value of money, $TDA^{E\&S}$ is less than 1.0; our simulations are based on a value of 0.70. By contrast, R&D capital is expensed, and hence $TDA^{R\&D}$ equals 1.0. When equation (4) is evaluated with this relatively higher value of *TDA*, the second term dominates, and the derivative is positive. Intuitively, the drop in *CITR* removes one of the primary tax advantages of R&D investment vis-à-vis E&S investment, thereby lowering incentives to invest in R&D and raising incentives to invest in E&S. Fourth, the increase in the $UC^{R\&D}$ is larger for those states with R&D investment tax credits (cf. equation (4) where the $(1/TAX)$ term will be larger the larger is $ITCR^{R\&D}$). For example, California has one of the largest effective R&D credit rates with its $ITCR^{R\&D}$ equal to 13.7 percent and the second largest increase in $UC^{R\&D}$. The positive entries in column 3 indicate that a decrease in *CITR* actually increases the user cost qua price of R&D investment, thus increasing incentives for firms to substitute away from relatively costly R&D capital towards E&S capital, labor, and other factors of production.

Columns 1 and 2 of Table 3 show the predicted increases in E&S investment in response to the hypothetical tax policy changes mentioned earlier. The patterns are driven by the effects of the tax policy changes on user costs (Table 2) multiplied by parameters reflecting substitution and scale effects. For example, according to Table 2, a one percentage point decrease in *CITR* lowers California's user cost by –0.71 percent. This decrease is multiplied by 1.54, equal to our preferred values of the parameters entering the right side of equation (8). This multiplicative factor links each of the state entries in Table 2 to the corresponding state entries in Table 3. Columns 3 and 4 show the predicted change in R&D investment in response to a decrease in *CITR* and an increase in $ITCR^{R\&D}$. As indicated in the discussion of Table 2, the former effect is negative and the latter is positive.

Table 4 presents the predicted changes in state output in response to each of the three hypothetical tax policy changes.

TABLE 2
EFFECT OF SELECTED TAX POLICIES ON E&S OR R&D USER COSTS OF CAPITAL, BY STATE

	Change in E&S user cost due to 1 percentage point change		Change in R&D user cost due to 1 percentage point change	
State	drop in *CITR*	increase in $ITCR^{E\&S}$	drop in *CITR*	increase in $ITCR^{R\&D}$
Alabama	–0.59%	–2.35%	0.42%	–2.81%
Arizona	–0.69	–2.29	1.09	–2.73
Arkansas	–0.53	–2.63	0.45	–3.24
California	–0.71	–2.36	1.38	–2.85
Colorado	–0.66	–2.20	0.43	–2.60
Connecticut	–0.63	–2.45	0.77	–2.98
Delaware	–0.70	–2.37	0.52	–2.86
Florida	–0.67	–2.23	0.44	–2.65
Georgia	–0.56	–2.53	0.99	–3.08
Idaho	–0.66	–2.40	0.71	–2.90
Illinois	–0.68	–2.32	0.48	–2.78
Indiana	–0.70	–2.35	1.06	–2.83
Iowa	–0.65	–2.60	0.86	–3.20
Kansas	–0.68	–2.33	0.47	–2.80
Kentucky	–0.69	–2.29	0.45	–2.74
Louisiana	–0.67	–2.22	0.84	–2.64
Maine	–0.71	–2.36	0.49	–2.85
Maryland	–0.69	–2.29	0.50	–2.74
Massachusetts	–0.67	–2.49	1.09	–3.05
Michigan	–0.62	–2.13	0.40	–2.49
Minnesota	–0.72	–2.40	0.61	–2.91
Mississippi	–0.59	–2.37	0.43	–2.85
Missouri	–0.67	–2.22	0.46	–2.63
Montana	–0.68	–2.28	0.70	–2.72
Nebraska	–0.54	–2.69	0.47	–3.34
Nevada	–0.61	–2.04	0.38	–2.37
New Hampshire	–0.71	–2.38	0.48	–2.87
New Jersey	–0.71	–2.37	1.08	–2.86
New Mexico	–0.69	–2.31	0.46	–2.77
New York	–0.64	–2.44	0.46	–2.96
North Carolina	–0.61	–2.47	0.59	–3.00
North Dakota	–0.66	–2.20	0.61	–2.60
Ohio	–0.68	–2.41	0.50	–2.92
Oklahoma	–0.66	–2.28	0.44	–2.72
Oregon	–0.68	–2.27	0.69	–2.71
Pennsylvania	–0.72	–2.41	0.53	–2.92
Rhode Island	–0.65	–2.51	1.73	–3.07
South Carolina	–0.66	–2.21	0.67	–2.62
South Dakota	–0.61	–2.04	0.38	–2.37
Tennessee	–0.67	–2.30	0.45	–2.75
Texas	–0.66	–2.19	0.66	–2.60
Utah	–0.66	–2.21	0.72	–2.62
Vermont	–0.65	–2.58	0.53	–3.18
Virginia	–0.67	–2.25	0.44	–2.68
Washington	–0.61	–2.04	0.38	–2.37
West Virginia	–0.64	–2.55	0.63	–3.12
Wisconsin	–0.70	–2.32	0.70	–2.79
Wyoming	–0.61	–2.04	0.38	–2.37
Unweighted average	–0.66%	–2.33%	0.63%	–2.80%

TABLE 3
EFFECT OF TAX POLICIES ON CAPITAL STOCK BY STATE

State	Change in E&S capital due to 1 percentage point change: drop in *CITR*	Change in E&S capital due to 1 percentage point change: increase in $ITCR^{E\&S}$	Change in R&D capital due to 1 percentage point change: drop in *CITR*	Change in R&D capital due to 1 percentage point change: increase in $ITCR^{R\&D}$
Alabama	0.90%	5.34%	–1.16%	11.27%
Arizona	1.06	5.20	–2.96	10.97
Arkansas	0.81	5.98	–1.22	12.99
California	1.09	5.37	–3.76	11.42
Colorado	1.02	5.00	–1.16	10.43
Connecticut	0.97	5.58	–2.09	11.94
Delaware	1.08	5.39	–1.41	11.46
Florida	1.03	5.07	–1.19	10.63
Georgia	0.86	5.75	–2.69	12.36
Idaho	1.01	5.45	–1.94	11.61
Illinois	1.05	5.27	–1.30	11.14
Indiana	1.09	5.34	–2.88	11.34
Iowa	1.00	5.91	–2.33	12.85
Kansas	1.04	5.31	–1.29	11.24
Kentucky	1.06	5.20	–1.23	10.97
Louisiana	1.03	5.06	–2.29	10.59
Maine	1.09	5.38	–1.34	11.44
Maryland	1.06	5.20	–1.35	10.97
Massachusetts	1.04	5.67	–2.97	12.21
Michigan	0.96	4.83	–1.09	9.99
Minnesota	1.11	5.46	–1.67	11.66
Mississippi	0.92	5.40	–1.17	11.44
Missouri	1.03	5.05	–1.24	10.56
Montana	1.05	5.18	–1.90	10.91
Nebraska	0.83	6.13	–1.28	13.40
Nevada	0.94	4.63	–1.05	9.49
New Hampshire	1.10	5.41	–1.30	11.52
New Jersey	1.10	5.38	–2.93	11.46
New Mexico	1.07	5.26	–1.25	11.12
New York	0.98	5.55	–1.25	11.88
North Carolina	0.93	5.62	–1.62	12.04
North Dakota	1.02	5.00	–1.66	10.44
Ohio	1.04	5.49	–1.35	11.72
Oklahoma	1.02	5.19	–1.20	10.92
Oregon	1.05	5.17	–1.89	10.88
Pennsylvania	1.11	5.48	–1.45	11.71
Rhode Island	1.01	5.70	–4.70	12.29
South Carolina	1.02	5.03	–1.81	10.52
South Dakota	0.94	4.63	–1.05	9.49
Tennessee	1.03	5.23	–1.22	11.04
Texas	1.01	4.99	–1.79	10.41
Utah	1.02	5.03	–1.96	10.52
Vermont	0.99	5.87	–1.44	12.74
Virginia	1.04	5.11	–1.20	10.74
Washington	0.94	4.63	–1.05	9.49
West Virginia	0.98	5.79	–1.70	12.52
Wisconsin	1.07	5.28	–1.89	11.19
Wyoming	0.94	4.63	–1.05	9.49
Unweighted average	1.01%	5.30%	–1.72%	11.24%

TABLE 4
EFFECT OF TAX POLICIES ON OUTPUT BY STATE

State	Increase in output due to 1 percentage point change: drop in *CITR*	Increase in output due to 1 percentage point change: increase in $ITCR^{E\&S}$	Increase in output due to 1 percentage point change: increase in $ITCR^{R\&D}$
Alabama	0.50%	3.35%	0.67%
Arizona	0.49	3.27	0.65
Arkansas	0.44	3.76	0.77
California	0.46	3.37	0.68
Colorado	0.57	3.14	0.62
Connecticut	0.49	3.50	0.71
Delaware	0.60	3.39	0.68
Florida	0.58	3.19	0.63
Georgia	0.38	3.61	0.73
Idaho	0.52	3.42	0.69
Illinois	0.58	3.31	0.66
Indiana	0.51	3.35	0.67
Iowa	0.49	3.71	0.76
Kansas	0.58	3.34	0.67
Kentucky	0.59	3.27	0.65
Louisiana	0.51	3.18	0.63
Maine	0.61	3.38	0.68
Maryland	0.59	3.27	0.65
Massachusetts	0.48	3.56	0.73
Michigan	0.54	3.04	0.59
Minnesota	0.60	3.43	0.69
Mississippi	0.51	3.39	0.68
Missouri	0.57	3.17	0.63
Montana	0.55	3.26	0.65
Nebraska	0.45	3.85	0.80
Nevada	0.53	2.91	0.56
New Hampshire	0.61	3.40	0.68
New Jersey	0.51	3.38	0.68
New Mexico	0.60	3.30	0.66
New York	0.54	3.49	0.71
North Carolina	0.49	3.53	0.72
North Dakota	0.54	3.14	0.62
Ohio	0.58	3.45	0.70
Oklahoma	0.57	3.26	0.65
Oregon	0.55	3.25	0.65
Pennsylvania	0.61	3.44	0.70
Rhode Island	0.35	3.58	0.73
South Carolina	0.54	3.16	0.62
South Dakota	0.53	2.91	0.56
Tennessee	0.57	3.29	0.66
Texas	0.53	3.13	0.62
Utah	0.53	3.16	0.62
Vermont	0.54	3.69	0.76
Virginia	0.58	3.21	0.64
Washington	0.53	2.91	0.56
West Virginia	0.52	3.64	0.74
Wisconsin	0.56	3.32	0.66
Wyoming	0.53	2.91	0.56
Unweighted average	0.53%	3.33%	0.67%

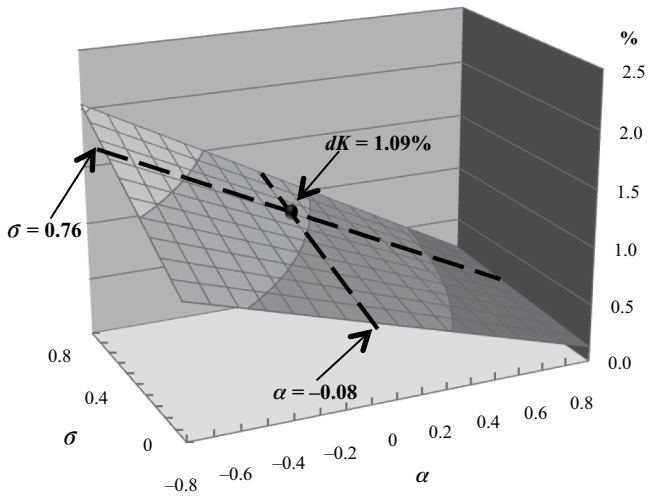
The predicted changes are based on the scale effect described in subsections 2.3 and 2.4. For changes in $ITCR^{E\&S}$ and $ITCR^{R\&D}$, the change in output equals the product of capital's income share (ω^K), the price elasticity of demand for output (η), and the percentage change in the user cost (Table 2, columns 2 and 4, respectively). For a change in *CITR*, the change in output is the sum of the change in output due to changes in $UC^{E\&S}$ ($\omega^{E\&S} \times \eta \times$ entry in Table 2, column 1) and $UC^{R\&D}$ ($\omega^{R\&D} \times \eta \times$ entry in Table 2, column 3). The increase in $ITCR^{E\&S}$ has a substantially larger impact on output than $ITCR^{R\&D}$ because R&D plays a much smaller role in production: R&D's average share of production costs in U.S. manufacturing is lower than E&S's share by a factor of six (i.e., $\omega^{E\&S} = 6 \times \omega^{R\&D}$). The predicted increase in output due to $ITCR^{E\&S}$ is also much larger than the predicted increase due to *CITR* because the latter has a relatively smaller impact on the user cost (Table 2, columns 1 and 3). It is possible that a multiplier effect could make the predicted increases reported in Table 4 smaller or larger, though, as discussed earlier, we suggest caution when inserting multiplier assumptions.

4.2. Sensitivity to Alternative Parameter Values

The simulation results presented in the previous subsection are based on a set of parameters that we believe most accurately characterize relevant structural features of the economy. However, Section 3 highlights that other values of these parameters are also quite plausible. In order to assess the sensitivity of the simulation results to alternative values, we recompute our simulations for California and present the results in three-dimensional figures that plot a wide range of parameter values on two of the axes and the predicted increases in investment or output on the vertical axis. Seven figures are presented, and they parallel the seven columns of results presented in Tables 3 and 4.

Figures 4 to 7 report predicted increases in E&S and R&D investment for alternative values of the elasticity of substitution between capital and other factors of production (σ) and the slope of the tax reaction function (α). Our preferred parameter values are indicated with the dashed black lines in each figure, and their intersection, which indicates our predicted increase in investment given these preferred parameter values (and matches the values in Tables 3 and 4 for California), is shown as a circle. For example, Figure 4 shows the response of E&S investment to a decrease in *CITR*. Here, our preferred parameter values of $\sigma = 0.76$ and $\alpha = -0.08$ yield a predicted increase in investment of 1.09 percent for a one percentage point decrease in *CITR*. Figure 4 allows σ to vary between 0.0 and 1.0 and α between –0.8 and +0.8. The variations in σ have a modest effect on the predicted increase in investment. Holding α fixed at –0.08, the predicted increases in investment rise to 1.22 percent when σ is at its upper bound of 1.0 and fall to 0.69 percent when σ is at its lower bound of 0.0. The latter result represents a situation where the substitution channel is completely inoperative, and the investment increase is solely from the scale channel. More dramatic changes occur with variations in α. The predicted increase in investment from a decrease in *CITR* falls with α. An upper bound value of 0.80 for α represents very competitive responses by neighboring states and severely diminishes the economic incentive and incremental investment from a tax policy change. As α varies from –0.8 to +0.8, the predicted increase in investment falls from 1.83 to 0.20 percent. Similar results presented in Figure 5 hold

FIGURE 4
PREDICTED INCREASE IN E&S INVESTMENT DUE TO 1 PERCENTAGE POINT DROP IN *CITR*
(for various values of tax competition slope (α) and relative user cost elasticity (σ))



Notes: Figures 4 through 10 are three-dimensional surface charts describing the sensitivity of the economic impact (investment or output) of a change in tax policy to variations in selected parameters. For example, in Figure 4, the height of the surface (z axis) indicates the percentage change in a state's investment (*dI/I* (= *dK/K*, per footnote 9)) resulting from a one percentage point reduction in the state's corporate income tax rate *(CITR)*, based on our simulations and data for 2006 for the state of California. The size of the impact, *dI/I*, depends on several variables and parameters. Figure 4 highlights the sensitivity of impact to two key economic parameters: the slope of the *CITR* interstate reaction function (α), which varies along the x axis, and the elasticity of the capital with respect to the relative user cost of capital (σ), which varies along the y axis. Note that the height of the three-dimensional surface shown in the figure varies by state, but the shape of the surface does not change. For instance, while *dI/I* = 1.09% is specific to California, the sensitivities of *dI/I* to α and σ is qualitatively the same for all states.

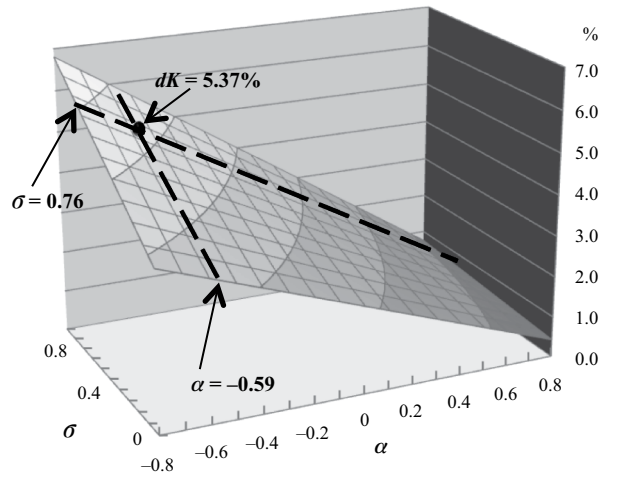
The dashed line at $\alpha = -0.08$ indicates the *CITR* reaction function slope estimated in Chirinko and Wilson (2009a); the dashed line at $\sigma = 0.76$ indicates the relative user cost elasticity estimated in Chirinko and Wilson (2008). The point where these lines intersect, shown as a ball in the chart, therefore reflects our best estimate of exactly how much the capital stock in California would increase if the state were to reduce its corporate income tax rate by one percentage point.

for the predicted increase in investment from an increase in *ITCR*.

Figures 6 and 7 present comparable results for R&D investment. For these R&D figures, we vary σ over a wider range (0.0 to 3.0) than we did for the E&S figures. We do so because our preferred value of 2.5, based on the estimates found in Wilson (2009), are much larger than the range of values typically found for the E&S elasticity of substitution. The sensitivity of the simulation results to α remains. Variations in σ have a more dramatic effect than was evident in Figures 4 and 5, though this is primarily due to the wider range of values for σ in Figures 6 and 7. Owing to R&D's small share of capital income, the scale effect for R&D investment is very small. Thus, as σ approaches 0.0 and the substitution effect is eliminated, the predicted increase in investment also approaches 0.0.

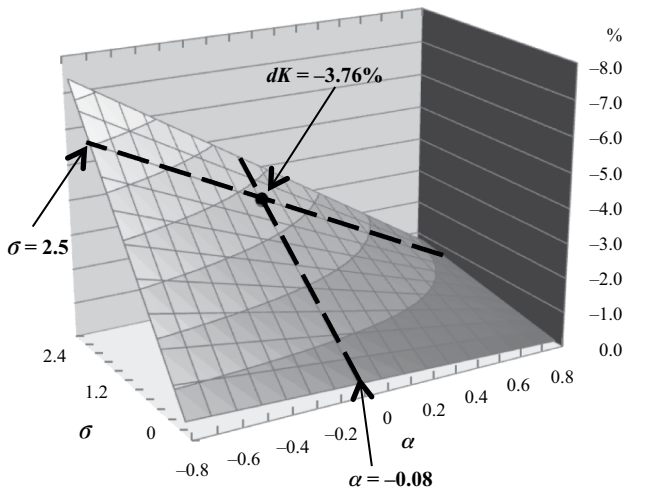
The sensitivity of the predicted increases in output are presented in Figures 8 to 10 for alternative values of α and the price elasticity of demand for output (η), the latter ranging from 0.0 to 5.0. As with the prior figures, the simulation results are very sensitive to α. For example, a one percentage point increase in $ITCR^{E\&S}$ results in a 3.37 percent increase in output for our benchmark parameters. This predicted increase (Figure 9) falls to 2.12 percent and 0.42 percent when α equals 0.00 and 0.80, respectively. Since the scale effect is proportionate to η, this parameter also has substantial influence on the predicted output resulting from changes in each of the three tax variables. In Figure 9, an increase in η from its benchmark value of 3.0 to its upper limit of 5.0 raises the predicted increase in output from 3.37 percent to 5.62 percent.

FIGURE 5
PREDICTED INCREASE IN E&S INVESTMENT
DUE TO 1 PERCENTAGE POINT INCREASE IN $ITCR^{E\&S}$
(for various values of tax competition slope (α)
and relative user cost elasticity (σ))



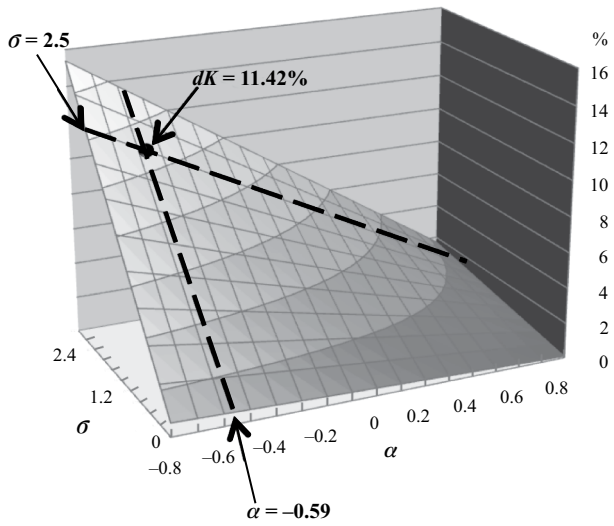
See notes to Figure 4.

FIGURE 6
PREDICTED DECREASE IN R&D INVESTMENT
DUE TO 1 PERCENTAGE POINT DROP IN *CITR*
(for various values of tax competition slope (α)
and relative user cost elasticity (σ))



See notes to Figure 4.

FIGURE 7
PREDICTED INCREASE IN R&D INVESTMENT
DUE TO 1 PERCENTAGE POINT INCREASE IN $ITCR^{R\&D}$
(for various values of tax competition slope (α)
and relative user cost elasticity (σ))



See notes to Figure 4.

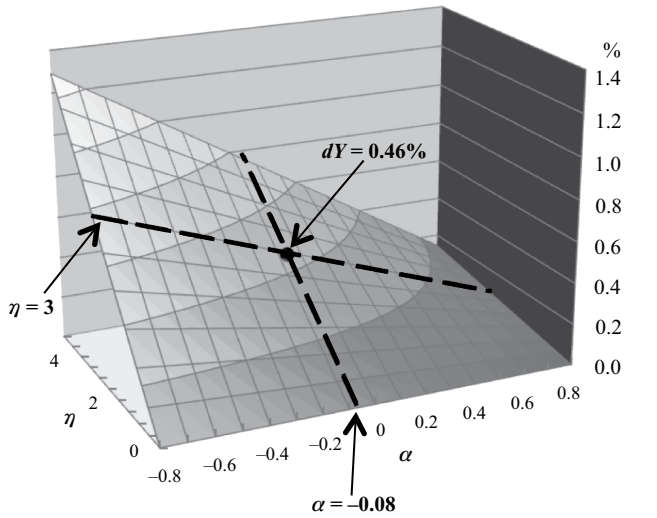
4.3. An Online Applet Allowing Users to Select Their Own Parameter Values

Figures 4 to 10 document the sensitivity of the simulations to the underlying parameter values. In order to allow users flexibility in tailoring the simulations to their own views on the appropriate parameter values best describing the firms operating in their states, we have created an applet that allows choices for the following parameters: σ, α, η, Λ, $\omega^{E\&S}$, and $\omega^{R\&D}$. The applet also allows users to choose the size of the increase or decrease in any one of the three tax policies. This could be quite valuable for policymakers or analysts debating the merits of a particular tax policy change under legislative consideration. Table 1 suggests what we believe is a plausible range of values, though any values can be employed in the user-directed simulations. The applet can be accessed at http://www.frbsf.org/csip/taxapp.php.

5. Summary

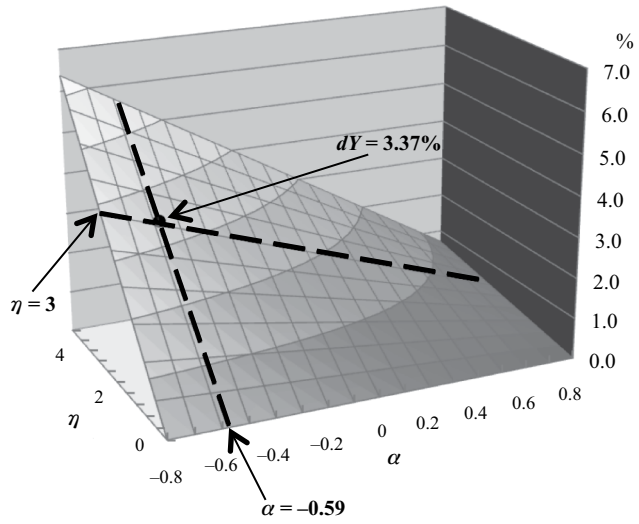
This article has developed a framework for quantifying the impacts of state business tax policies. We examine three tax instruments: the corporate income tax, the investment tax credit on equipment and structures, and the investment tax credit on research and development. The links among tax policies, investment, and output depend on a set of channels determined by economic theory and a set of parameters whose values are drawn from empirical research. We have provided illustrative calculations based on our preferred parameter values. Recognizing the differences that exist about the values of key parameters, we discuss how the predicted economic effects of these tax policy changes vary depending on the choice of these parameters. In addition, we have developed and made available online a simple web tool that al-

FIGURE 8
PREDICTED INCREASE IN OUTPUT DUE TO 1 PERCENTAGE POINT DROP IN *CITR*
(for various values of tax competition slope (α) and elasticity of demand (η))



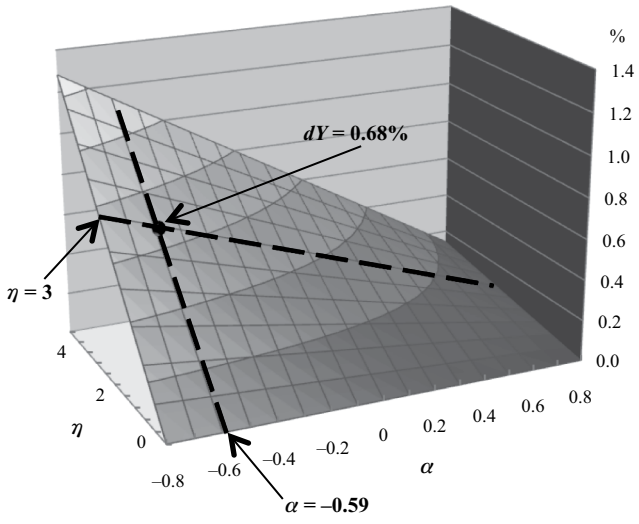
See notes to Figure 4.

FIGURE 9
PREDICTED INCREASE IN OUTPUT DUE TO 1 PERCENTAGE POINT INCREASE IN $ITCR^{E\&S}$
(for various values of tax competition slope (α) and elasticity of demand (η))



See notes to Figure 4.

FIGURE 10
PREDICTED INCREASE IN OUTPUT DUE TO 1 PERCENTAGE POINT INCREASE IN $ITCR^{R\&D}$
(for various values of tax competition slope (α) and elasticity of demand (η))



See notes to Figure 4.

lows users to insert their own preferred parameter values and simulate the economic effects for the state and tax policy of their choosing.

Three caveats should be kept in mind with our simulations. A comprehensive evaluation of a proposed tax policy requires several pieces of information. The simulation results presented in this article provide information on one important benefit. Additional information is required concerning the revenues that are decreased initially due to the tax incentives and increased eventually due to higher levels of economic activity. Moreover, second-round effects need to be considered. For example, generous investment incentives may require state governments to lower expenditures on government services or may induce firms to lower employment. That these effects are *second* does not necessarily imply that they are *secondary*. Nonetheless, our simulation results provide a valuable input to the complex process of policy evaluation.

A second caveat is that we have restricted ourselves to a limited number of fiscal options. Apart from the three state business taxes considered in this article, state policymakers have many other revenue options, such as sales taxes and user fees, as well as expenditure reductions. Job tax credits are an additional policy option that have been adopted by approximately half of states sometime during this decade. Given the sharp decrease in employment during the recent recession and the anemic pace at which jobs are recovering, job tax credits have received more attention as a policy tool. The framework developed in this article can be extended to consider the effects of job credits and other policies on employment.

Finally, since our simulations are at the state level, these results may not inform national policy. The calculations reported in this article only pertain to each state's investment and output from a change in its tax policy. Given the mobility of capital across and tax competition among states, a tax policy that looks highly desirable from the perspective of a single state may be much less desirable nationally. Increases in investment and output may be at the expense of other states. From a national perspective, state tax initiatives may well be a zero-sum game.[15] Simulating the impacts of a given state's policy on the behavior of other states and on national investment and output as a whole is beyond the scope of this article and our existing work, but it is a topic for future research.

15. In our analysis of equipment and structure capital formation, we could not reject the hypothesis that state business tax policy is a zero-sum game (Chirinko and Wilson 2008). Wilson (2009) finds a similar result for research and development.

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WP 2009-01

Sources of the Great Moderation: Shocks, Friction, or Monetary Policy?

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Daniel Waggoner, *FRB Atlanta*
Tao Zha, *FRB Atlanta*

We study the sources of the Great Moderation by estimating a variety of medium-scale DSGE models that incorporate regime switches in shock variances and in the inflation target. The best-fit model, the one with two regimes in shock variances, gives quantitatively different dynamics in comparison with the benchmark constant-parameter model. Our estimates show that three kinds of shocks accounted for most of the Great Moderation and business-cycle fluctuations: capital depreciation shocks, neutral technology shocks, and wage markup shocks. In contrast to the existing literature, we find that changes in the inflation target or shocks in the investment-specific technology played little role in macroeconomic volatility. Moreover, our estimates indicate much less nominal rigidities than those suggested in the literature.

WP 2009-02

EAD Calibration for Corporate Credit Lines

Gabriel Jiménez, *Banco de España*
Jose A. Lopez, *FRB San Francisco*
Jesús Saurina, *Banco de España*

Managing the credit risk inherent to a corporate credit line is similar to that of a term loan, but with one key difference. For both instruments, the bank should know the borrower's probability of default and the facility's loss given default. However, since a credit line allows the borrowers to draw down the committed funds according to their own needs, the bank must also have a measure of the line's exposure at default (EAD). Our study, which is based on a census of all corporate lending within Spain over the last 20 years, provides the most comprehensive overview of corporate credit line use and EAD calculations to date. Our analysis shows that defaulting firms have significantly higher credit line usage rates and EAD values up to five years prior to their actual default. Furthermore, we find that there are important variations in EAD values due to credit line size, collateralization, and maturity. While our results are derived from data for a single country, they should provide useful benchmarks for further academic, business, and policy research into this underdeveloped area of credit risk management.

WP 2009-03

CONDI: A Cost-Of-Nominal-Distortions Index

Stefano Eusepi, *FRB New York*
Bart Hobijn, *FRB San Francisco*
Andrea Tambalotti, *FRB New York*

We construct a price index with weights on the prices of different personal consumption expenditure goods chosen to minimize the welfare costs of nominal distortions: a cost-of-nominal-distortions index (CONDI). We compute these weights in a multisector New Keynesian model with time-dependent price setting, calibrated using U.S. data on the dispersion of price stickiness and labor shares across sectors. We find that the CONDI weights mostly depend on price stickiness and are less affected by the dispersion in labor shares. Moreover, CONDI stabilization leads to negligible welfare losses compared to the optimal policy and is better approximated by core rather than headline inflation targeting. An even better approximation of the CONDI can be obtained with an adjusted core index that covers total expenditures excluding autos, clothing, energy, and food at home, but that includes food away from home.

WP 2009-04
Unemployment Dynamics in the OECD

Michael Elsby, *University of Michigan*
Bart Hobijn, *FRB San Francisco*
Aysegül Sahin, *FRB New York*

We provide a set of comparable estimates for the rates of inflow to and outflow from unemployment for 14 OECD economies using publicly available data. We then devise a method to decompose changes in unemployment into contributions accounted for by changes in inflow and outflow rates for cases where unemployment deviates from its flow steady state, as it does in many countries. Our decomposition reveals that fluctuations in both inflow and outflow rates contribute substantially to unemployment variation within countries. For Anglo-Saxon economies, we find approximately a 20:80 inflow/outflow split to unemployment variation, while for continental European and Nordic countries, we observe much closer to a 50:50 split. Using the estimated flow rates, we compute gross worker flows into and out of unemployment. In all economies we observe that increases in inflows lead increases in unemployment, whereas outflows lag a ramp-up in unemployment.

WP 2009-05
What Do We Know and Not Know about Potential Output?

Susanto Basu, *Boston College*
John Fernald, *FRB San Francisco*

Potential output is an important concept in economics. Policymakers often use a one-sector neoclassical model to think about long-run growth and often assume that potential output is a smooth series in the short run—approximated by a medium- or long-run estimate. But in both the short and long run, the one-sector model falls short empirically, reflecting the importance of rapid technical change in producing investment goods; and few, if any, modern macroeconomic models would imply that, at business cycle frequencies, potential output is a smooth series. Discussing these points allows us to discuss a range of other issues that are less well understood and where further research could be valuable.

WP 2009-06
The Olympic Effect

Andrew K. Rose, *University of California, Berkeley*
Mark M. Spiegel, *FRB San Francisco*

Economists are skeptical about the economic benefits of hosting "mega-events" such as the Olympic Games or the World Cup, since such activities have considerable cost and seem to yield few tangible benefits. These doubts are rarely shared by policymakers and the population, who are typically quite enthusiastic about such spectacles. In this paper, we reconcile these positions by examining the economic impact of hosting mega-events like the Olympics; we focus on trade. Using a variety of trade models, we show that hosting a mega-event like the Olympics has a positive impact on national exports. This effect is statistically robust, permanent, and large; trade is around 30 percent higher for countries that have hosted the Olympics. Interestingly however, we also find that unsuccessful bids to host the Olympics have a similar positive impact on exports. We conclude that the Olympic effect on trade is attributable to the signal a country sends when bidding to host the games, rather than the act of actually holding a mega-event. We develop a political economy model that formalizes this idea and derives the conditions under which a signal like this is used by countries wishing to liberalize.

WP 2009-07
Beyond Kuznets: Persistent Regional Inequality in China

Christopher Candelaria, *FRB San Francisco*
Mary Daly, *FRB San Francisco*
Galina Hale, *FRB San Francisco*

Regional inequality in China appears to be persistent and even growing in the past two decades. We study potential offsetting factors and interprovincial migration to shed light on the sources of this persistence. We find that some of the inequality could be attributed to differences in quality of labor, industry composition, and geographical location of provinces. We also demonstrate that interprovincial migration, while driven in part by wage differences across provinces, does not offset these differences. Finally, we find that interprovincial redistribution did not help offset regional inequality during our sample period.

WP 2009-08

The Effect of an Employer Health Insurance Mandate on Health Insurance Coverage and the Demand for Labor: Evidence from Hawaii

Thomas Buchmueller, *University of Michigan*
John DiNardo, *University of Michigan*
Robert G. Valletta, *FRB San Francisco*

Over the past few decades, policymakers have considered employer mandates as a strategy for stemming the tide of declining health insurance coverage. In this paper we examine the long-term effects of the only employer health insurance mandate that has ever been enforced in the United States, Hawaii's Prepaid Health Care Act, using a standard supply-demand framework and Current Population Survey data covering the years 1979 to 2005. During this period, the coverage gap between Hawaii and other states increased, as did real health insurance costs, implying a rising burden of the mandate on Hawaii's employers. We use a variant of the traditional permutation (placebo) test across all states to examine the magnitude and statistical properties of these growing coverage differences and their impacts on labor market outcomes, conditional on an extensive set of covariates. As expected, the coverage gap is larger for workers who tend to have low rates of coverage in the voluntary market (primarily those with lower skills). We also find that relative wages fell in Hawaii over time, but the estimates are statistically insignificant. By contrast, a parallel analysis of workers employed fewer than 20 hours per week indicates that the law significantly increased employers' reliance on such workers in order to reduce the burden of the mandate. We find no evidence suggesting that the law reduced employment probabilities.

WP 2009-09

The International Dimension of Productivity and Demand Shocks in the U.S. Economy

Giancarlo Corsetti, *European University Institute*
Luca Dedola, *European Central Bank*
Sylvain Leduc, *FRB San Francisco*

Identifying productivity and real demand shocks in the United States with sign restrictions based on standard theory, we provide evidence on real and financial channels of their international propagation. Productivity gains in U.S. manufacturing have substantial macroeconomic effects, raising U.S. consumption, investment, and the terms of trade, relative to the rest of the world while lowering U.S. net exports. Significant international financial adjustment occurs via a rise in the global value of the U.S. stock market, portfolio shifts in U.S. foreign assets and liabilities, and especially real dollar appreciation. Positive demand shocks to U.S. manufacturing also lead to real appreciation and raise investment but have otherwise limited effects on trade flows. This evidence suggests a fundamental role of cross-country endogenous demand and wealth movements in shaping international macroeconomic interdependence.

WP 2009-10

Survey Measures of Expected Inflation and the Inflation Process

Bharat Trehan, *FRB San Francisco*

This paper uses data from surveys of expected inflation to learn how the expectations formation processes of households and professionals have changed following a change in the inflation process in the early part of this decade. Households do not appear to have recognized the change in the process and are placing substantially more weight than appears warranted on recent inflation data when forming expectations about inflation over the next year. Professional forecasters do appear to have changed how they predict inflation in recent years in a way that appears consistent, at first, with the finding that the "core" inflation process has not changed as much as the "headline" inflation process has. But the professionals appear to be placing too much weight on lagged core inflation data, and over recent sample periods professional forecasts of headline CPI inflation are noticeably worse than the alternatives. Some other evidence is consistent with the hypothesis that they are now focusing on the core CPI.

WP 2009-11

The Paradox of Declining Female Happiness

Betsey Stevenson, *University of Pennsylvania*
Justin Wolfers, *University of Pennsylvania*

By many objective measures, the lives of women in the United States have improved over the past 35 years, yet we show that measures of subjective well-being indicate that women's happiness has declined both absolutely and relative to men. The paradox of women's declining relative well-being is found across various data sets and measures of subjective well-being and is pervasive across demographic groups and industrialized countries. Relative declines in

female happiness have eroded a gender gap in happiness in which women in the 1970s typically reported higher subjective well-being than did men. These declines have continued and a new gender gap is emerging—one with higher subjective well-being for men.

WP 2009-12

The Welfare Consequences of Monetary Policy

Federico Ravenna, *University of California, Santa Cruz*
Carl E. Walsh, *University of California, Santa Cruz*

We explore the distortions in business cycle models arising from inefficiencies in price setting and in the search process matching firms to unemployed workers, and the implications of these distortions for monetary policy. To this end, we characterize the tax instruments that would implement the first-best equilibrium allocations and then examine the trade-offs faced by monetary policy when these tax instruments are unavailable. Our findings are that the welfare cost of search inefficiency can be large, but the incentive for policy to deviate from the inefficient flexible-price allocation is in general small. Sizable welfare gains are available if the steady state of the economy is inefficient, and these gains do not depend on the existence of an inefficient dispersion of wages. Finally, the gains from deviating from price stability are larger in economies with more volatile labor flows, as in the United States.

WP 2009-13

Do Central Bank Liquidity Facilities Affect Interbank Lending Rates?

Jens H.E. Christensen, *FRB San Francisco*
Jose A. Lopez, *FRB San Francisco*
Glenn D. Rudebusch, *FRB San Francisco*

In response to the global financial crisis that started in August 2007, central banks provided extraordinary amounts of liquidity to the financial system. To investigate the effect of central bank liquidity facilities on term interbank lending rates, we estimate a six-factor arbitrage-free model of U.S. Treasury yields, financial corporate bond yields, and term interbank rates. This model can account for fluctuations in the term structure of credit risk and liquidity risk. A significant shift in model estimates after the announcement of the liquidity facilities suggests that these central bank actions did help lower the liquidity premium in term interbank rates.

WP 2009-14

Foreign Entry into Underwriting Services: Evidence from Japan's "Big Bang" Deregulation

Jose A. Lopez, *FRB San Francisco*
Mark M. Spiegel, *FRB San Francisco*

We examine the impact of foreign underwriting activity on bond markets using issue-level data in the Japanese "samurai" and euro-yen bond markets. Firms choosing Japanese underwriters tend to be Japanese, riskier, and smaller. We find that Japanese underwriting fees, while higher overall on average, are actually lower after conditioning for issuer characteristics. Moreover, firms tend to sort properly in their choice of underwriter, in the sense that a switch in underwriter nationality would be predicted to result in an increase in underwriting fees. Finally, we conduct a matching exercise to examine the 1995 liberalization of foreign access to the samurai bond market, using yen-denominated issues in the euro-yen market as a control. Foreign entry led to a statistically and economically significant decrease in underwriting fees in the samurai bond market, as spreads fell by an average of 23 basis points. Overall, our results suggest that the market for underwriting services is partially segmented by nationality, as issuers appear to have preferred habitats, but entry increases market competition.

WP 2009-15

Welfare-Based Optimal Monetary Policy with Unemployment and Sticky Prices: A Linear-Quadratic Framework

Federico Ravenna, *University of California, Santa Cruz*
Carl E. Walsh, *University of California, Santa Cruz*

In this paper, we derive a linear-quadratic model for monetary policy analysis that is consistent with sticky prices and search and matching frictions in the labor market. We show that the second-order approximation to the welfare of the representative agent depends on inflation and "gaps" that involve current and lagged unemployment. Our approximation makes explicit how the costs of fluctuations are generated by the presence of search frictions. These costs are distinct from the costs associated with relative price dispersion and fluctuations in consumption that appear in standard New Keynesian models. We use the model to analyze optimal monetary policy under commitment and discretion and to show that the structural characteristics of the labor market have important implications for optimal policy.

WP 2009-16
Monetary Policy Response to Oil Price Shocks

Jean-Marc Natal, *Swiss National Bank*

How should monetary authorities react to an oil price shock? The New Keynesian literature has concluded that ensuring complete price stability is the optimal thing to do. In contrast, this paper argues that a meaningful trade-off between stabilizing inflation and the welfare-relevant output gap arises in a distorted economy once one recognizes (i) that oil (energy) cannot be easily substituted by other factors in the short run, (ii) that there is no fiscal transfer available to policymakers to neutralize the steady-state distortion due to monopolistic competition, and (iii) that increases in oil prices also directly affect consumption by raising the price of fuel, heating oil, and other energy sources. While the first two conditions are necessary to introduce a microfounded monetary policy trade-off, the third one makes it quantitatively significant. The optimal precommitment monetary policy relies on unobservables and is therefore hard to implement. To address this concern, I derive a simple interest rate feedback rule that mimics the optimal plan in all relevant dimensions but that depends only on observables, namely core inflation, oil price inflation, and the growth rate of output.

WP 2009-17
Cross-Country Causes and Consequences of the 2008 Crisis: Early Warning

Andrew K. Rose, *University of California, Berkeley*
Mark M. Spiegel, *FRB San Francisco*

This paper models the causes of the 2008 financial crisis together with its manifestations, using a Multiple Indicator Multiple Cause (MIMIC) model. Our analysis is conducted on a cross-section of 107 countries; we focus on national causes and consequences of the crisis, ignoring cross-country "contagion" effects. Our model of the incidence of the crisis combines 2008 changes in real GDP, the stock market, country credit ratings, and the exchange rate. We explore the linkages between these manifestations of the crisis and a number of its possible causes from 2006 and earlier. We include over 60 potential causes of the crisis, covering such categories as: financial system policies and conditions, asset price appreciation in real estate and equity markets, international imbalances and foreign reserve adequacy, macroeconomic policies, and institutional and geographic features. Despite the fact that we use a wide number of possible causes in a flexible statistical framework, we are unable to link most of the commonly cited causes of the crisis to its incidence across countries. This negative finding in the cross-section makes us skeptical of the accuracy of "early warning" systems of potential crises, which must also predict their timing.

WP 2009-18
Cross-Country Causes and Consequences of the 2008 Crisis: International Linkages and American Exposure

Andrew K. Rose, *University of California, Berkeley*
Mark M. Spiegel, *FRB San Francisco*

This paper models the causes of the 2008 financial crisis together with its manifestations, using a Multiple Indicator Multiple Cause (MIMIC) model. Our analysis is conducted on a cross-section of 85 countries; we focus on international linkages that may have allowed the crisis to spread across countries. Our model of the cross-country incidence of the crisis combines 2008 changes in real GDP, the stock market, country credit ratings, and the exchange rate. We explore the linkages between these manifestations of the crisis and a number of its possible causes from 2006 and earlier. The causes we consider are both national (such as equity market run-ups that preceded the crisis) and, critically, international financial and real linkages between countries and the epicenter of the crisis. We consider the United States to be the most natural origin of the 2008 crisis, though we also consider six alternative sources of the crisis. A country holding American securities that deteriorate in value is exposed to an American crisis through a financial channel. Similarly, a country which exports to the United States is exposed to an American downturn through a real channel. Despite the fact that we use a wide number of possible causes in a flexible statistical framework, we are unable to find strong evidence that international linkages can be clearly associated with the incidence of the crisis. In particular, countries heavily exposed to either American assets or trade seem to behave little differently than other countries; if anything, countries seem to have benefited slightly from American exposure.

WP 2009-19
Household Inflation Experiences in the U.S.: A Comprehensive Approach

Bart Hobijn, *FRB San Francisco*
Kristin Mayer, *Princeton University*
Carter Stennis, *FRB New York*
Giorgio Topa, *FRB New York*

We present new measures of household-specific inflation experiences based on comprehensive information from the Consumer Expenditure Survey (CEX). We match households in the Interview and the Diary Surveys from the CEX to produce both complete and detailed pictures of household expenditures. The resulting household inflation measures are based on a more accurate and detailed description of household expenditures than those previously available. We find that our household-based inflation measures track aggregate measures such as the CPI-U quite well and that the addition of Diary Survey data induces small but significant differences in the measurement of household inflation. The distribution of inflation experiences across households exhibits a large amount of dispersion over the entire sample period. In addition, we uncover a significantly negative relationship between mean inflation and inflation inequality across households.

WP 2009-20
Mortgage Default and Mortgage Valuation

John Krainer, *FRB San Francisco*
Stephen LeRoy, *University of California, Santa Barbara*
Munpyung O, *University of California, Santa Barbara*

We study optimal exercise by mortgage borrowers of the option to default. Also, we use an equilibrium valuation model incorporating default to show how mortgage yields and lender recovery rates on defaulted mortgages depend on initial loan-to-value ratios when borrowers default optimally. The analysis treats both the frictionless case and the case in which borrowers and/or lenders incur deadweight costs upon default. The model is calibrated using data on California mortgages. We find that the model's principal testable implication for default and mortgage pricing—that default rates and yield spreads will be higher for high loan-to-value mortgages—is borne out empirically.

WP 2009-21
A State Level Database for the Manufacturing Sector: Construction and Sources

Robert Chirinko, *Emory University*
Daniel J. Wilson, *FRB San Francisco*

This document describes the construction of and data sources for a state-level panel data set measuring output and factor use for the manufacturing sector. These data are a subset of a larger, comprehensive data set that we currently are constructing and hope to post on the FRBSF website in the near future. The comprehensive data set will cover the U.S. manufacturing sector and may be thought of as a state-level analog to other widely used productivity data sets such as the industry-level NBER Productivity Database or Dale Jorgenson's "KLEM" database or the country-level Penn World Tables, but with an added emphasis on adjusting prices for taxes. The selected variables currently available for public use are nominal and real gross output, nominal and real investment, and real capital stock. The data cover all 50 states and the period 1963 to 2006.

WP 2009-22
Mortgage Loan Securitization and Relative Loan Performance

John Krainer, *FRB San Francisco*
Elizabeth Laderman, *FRB San Francisco*

We compare the ex ante observable risk characteristics and the default rates of securitized mortgage loans and mortgage loans retained by the original lender. We find that privately securitized loans tend to be riskier and to default at a faster rate than loans securitized with the GSEs and lender-retained loans. However, the differences in default rates across investor types are of secondary importance for explaining mortgage defaults compared to more conventional predictors, such as original loan-to-value ratios and the path for house prices. Privately securitized home mortages have conditionally higher expected returns than retained loans, suggesting the presence of risk factors that are unobservable but nonetheless at least partially acknowledged by the market.

WP 2009-23
Heeding Daedalus: Optimal Inflation and the Zero Lower Bound

John C. Williams, *FRB San Francisco*

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See p. 53 for the abstract of this paper.

WP 2009-24
The Role of Capital Service-Life in a Model with Heterogeneous Labor and Vintage Capital

Milton Marquis, *Florida State University*
Wuttipan Tantivongy, *Florida State University*
Bharat Trehan, *FRB San Francisco*

We examine how the economy responds to both disembodied and embodied technology shocks in a model with vintage capital. We focus on what happens when there is a change in the number of vintages of capital that are in use at any one time and on what happens when there is a change in the persistence of the shocks hitting the economy. The data suggest that these kinds of changes took place in the U.S. economy in the 1990s, when the pace of embodied technical progress appears to have accelerated. We find that embodied technology shocks lead to greater variability (of output, investment, and labor allocations) than disembodied shocks of the same size. On the other hand, a decrease in the number of vintages in use at any time (such as is likely to occur when the pace of technical progress accelerates) tends to reduce the volatility of output and also to differentiate the initial response of the economy to the two shocks.

WP 2009-25
A Theory of Banks, Bonds, and the Distribution of Firm Size

Katheryn Russ, *University of California, Davis*
Diego Valderrama, *FRB San Francisco*

We draw on stylized facts from the finance literature to build a model where altering the relative costs of bank and bond financing changes the entire distribution of firm size, with implications for the aggregate capital stock, output, and welfare. Reducing transactions costs in the bond market increases the output and profits of midsize firms at the expense of both the largest and smallest firms. In contrast, reducing the frictions involved in bank lending promotes the expansion of the smallest firms while all other firms shrink, even as it increases the profitability of both small and midsize firms. Although both policies increase aggregate output and welfare, they have opposite effects on the extensive margin of production—promoting bond issuance causes exit while cheaper bank credit induces entry. When reducing transactions costs in one market, the resulting increase in output and welfare are largest when transactions costs in the other market are very high.

WP 2009-26
Risk Aversion, the Labor Margin, and Asset Pricing in DSGE Models

Eric Swanson, *FRB San Francisc*o

In dynamic stochastic general equilibrium (DSGE) models, the household's labor margin as well as consumption margin affects Arrow-Pratt risk aversion. This paper derives simple, closed-form expressions for risk aversion that take into account the household's labor margin. Ignoring the labor margin can lead to wildly inaccurate measures of the household's true attitudes toward risk. I show that risk premia on assets computed using the stochastic discount factor are proportional to Arrow-Pratt risk aversion, so that measuring risk aversion correctly is crucial for understanding asset prices. Closed-form expressions for risk aversion in DSGE models with generalized recursive preferences and internal and external habits are also derived.

WP 2009-27
Financial Choice in a Non-Ricardian Model of Trade

Katheryn Russ, *University of California, Davis*
Diego Valderrama, *FRB San Francisco*

We join the new trade theory with a model of choice between bank and bond financing to show the differential effects of financial policy on the distribution of firm size, welfare, aggregate output, gains from trade, and the real exchange rate in a small open economy. Increasing bank efficiency and reducing bond transaction costs both increase welfare but have opposite effects on the extensive margin of trade, aggregate exports, and the real exchange rate. Increasing the degree of trade openness increases firms' relative demand

for bond versus bank financing. We identify a financial switching channel for gains from trade where increasing access to export markets allows firms to overcome high fixed costs of bond issuance to secure a lower marginal cost of capital.

WP 2009-28

Do Credit Constraints Amplify Macroeconomic Fluctuations?

Zheng Liu, *FRB San Francisco*
Pengfei Wang, *Hong Kong University of Science and Technology*
Tao Zha, *FRB Atlanta*

Previous studies on financial frictions have been unable to establish the empirical significance of credit constraints in macroeconomic fluctuations. This paper argues that the muted impact of credit constraints stems from the absence of a mechanism to explain the observed persistent comovements between housing prices and business investment. We develop such a mechanism by incorporating two key features into a DSGE model: we identify shocks that shift the demand for collateral assets and we allow productive agents to be credit constrained. A combination of these two features enables our model to successfully generate an empirically important mechanism that amplifies and propagates macroeconomic fluctuations through credit constraints.

WP 2009-29

Can Lower Tax Rates Be Bought? Business Rent-Seeking and Tax Competition among U.S. States

Robert Chirinko, *University of Chicago, Illinois*
Daniel Wilson, *FRB San Francisco*

The standard model of strategic tax competition—the noncooperative tax-setting behavior of jurisdictions competing for a mobile capital tax base—assumes that government policymakers are perfectly benevolent, acting solely to maximize the utility of the representative resident in their jurisdiction. We depart from this assumption by allowing for the possibility that policymakers, given the political and electoral environments in which they operate, also may be influenced by the rent-seeking (lobbying) behavior of businesses. Firms recognize the factors affecting policymakers' welfare and may make campaign contributions to influence tax policy. These changes to the standard strategic tax competition model imply that business contributions affect not only the levels of equilibrium tax rates but also the slope of the tax reaction function between jurisdictions. Thus, business campaign contributions may affect tax competition and enhance or retard the mobility of capital across jurisdictions. Based on a panel of 48 U.S. states and unique data on business campaign contributions, our empirical work uncovers four key results. First, we document a significant direct effect of business contributions on tax policy. Second, the economic value of a $1 business campaign contribution in terms of lower state corporate taxes is nearly $4. Third, the slope of the reaction function between tax policy in a given state and the tax policies of its competitive states is negative. Fourth, we highlight the sensitivity of the empirical results to state effects.

Abstracts of Articles Accepted in Journals, Books, and Conference Volumes*

An Arbitrage-Free Generalized Nelson-Siegel Term Structure Model

Jens H.E. Christensen and **Glenn D. Rudebusch**, with Francis X. Diebold, *University of Pennsylvania*

Published in *The Econometrics Journal* 12(3, November), pp. 33–64.

The Svensson generalization of the popular Nelson-Siegel term structure model is widely used by practitioners and central banks. Unfortunately, like the original Nelson-Siegel specification, this generalization, in its dynamic form, does not enforce arbitrage-free consistency over time. Indeed, we show that the factor loadings of the Svensson generalization cannot be obtained in a standard finance arbitrage-free affine term structure representation. Therefore, we introduce a closely related generalized Nelson-Siegel model on which the no-arbitrage condition can be imposed. We estimate this new arbitrage-free generalized Nelson-Siegel model and demonstrate its tractability and good in-sample fit.

Happiness, Unhappiness, and Suicide: An Empirical Assessment

Mary C. Daly
Daniel J. Wilson

Published in *Journal of the European Economic Association* 7(2–3, April 2009), pp. 539–549.

The use of subjective well-being (SWB) data for investigating the nature of individual preferences has increased tremendously in recent years. There has been much debate about the cross-sectional and time-series patterns found in these data, particularly with respect to the relationship between SWB and relative status. Part of this debate concerns how well SWB data measure true utility or preferences. In a recent paper, Daly, Wilson, and Johnson (2007) propose using data on suicide as a revealed preference (outcome-based) measure of well-being and find strong evidence that reference-group income negatively affects suicide risk. In this paper, we compare and contrast the empirical patterns of SWB and suicide data. We find that the two have very little in common in aggregate data (time series and cross-sectional), but have a strikingly strong relationship in terms of their determinants in individual-level, multivariate regressions. This latter result cross-validates suicide and SWB micro data as useful and complementary indicators of latent utility.

Consumption-Habits in a New Keynesian Business Cycle Model

Richard Dennis

Published in *Journal of Money, Credit, and Banking* 41(5, August 2009), pp. 1015–1030.

Consumption-habits have become an integral component in New Keynesian models. However, consumption-habits can be modeled in a host of different ways and this diversity is reflected in the literature. I examine whether different approaches to modeling consumption-habits have important implications for business cycle behavior. Using a standard New Keynesian business cycle model, I show that, to a first-order log approximation, the consumption Euler equation associated with the additive functional form for habit formation encompasses the multiplicative function form. Empirically, I show that whether consumption-habits are internal or external has little effect on the model's business cycle characteristics.

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*The abstracts are arranged alphabetically by FRB San Francisco authors, whose names are in boldface.

Methods for Robust Control

Richard Dennis, with
Kai Leitemo,
Norwegian School of Management
Ulf Söderström, *Bocconi University*

Published in *Journal of Economic Dynamics and Control*. 33(8, August 2009), pp. 1604–1616.

Robust control allows policymakers to formulate policies that guard against model misspecification. The principal tools used to solve robust control problems are state-space methods (see Hansen and Sargent 2008 and Giordani and Soderlind 2004). In this paper we show that the structural-form methods developed by Dennis (2007) to solve control problems with rational expectations can also be applied to robust control problems, with the advantage that they bypass the task, often onerous, of having to express the reference model in state-space form. In addition, we show how to implement two different timing assumptions with distinct implications for the robust policy and the economy. We apply our methods to a New Keynesian dynamic stochastic general equilibrium model and find that robustness has important effects on policy and the economy.

A General-Equilibrium Asset-Pricing Approach to the Measurement of Nominal and Real Bank Output

John Fernald, with
Susanto Basu, *Boston College*
J. Christina Wang, *FRB Boston*

Published in *Price Index Concepts and Measurement* 70, eds. E. Diewert, J. Greenlees, and C. Hulten. Chicago: University of Chicago Press for NBER, 2010.

This paper addresses the proper measurement of financial service output that is not priced explicitly. It shows how to impute nominal service output from financial intermediaries' interest income and how to construct price indices for those financial services. We present an optimizing model with financial intermediaries that provide financial services to resolve asymmetric information between borrowers and lenders. We embed these intermediaries in a dynamic stochastic general equilibrium model where assets are priced competitively according to their systematic risk, as in the standard consumption-capital-asset-pricing model. In this environment, we show that it is critical to take risk into account in order to measure financial output accurately. We also show that even using a risk-adjusted reference rate does not solve all the problems associated with measuring nominal financial service output. Our model allows us to address important outstanding questions in output and productivity measurement for financial firms, such as: (1) What are the correct "reference rates" one should use in calculating bank output? (2) If reference rates need to take account of risk, does this mean that they must be ex ante rates of return? (3) What is the right price deflator for the output of financial firms? Is it just the general price index? (4) When—if ever—should we count capital gains of financial firms as part of financial service output?

Sovereign Wealth Funds, Governance, and Reserve Accumulation

Reuven Glick, with
Joshua Aizenman,
University of California, Santa Cruz

Published at *VoxEU.org*, January 16, 2009.
http://www.voxeu.org/
index.php?q=node/2799

This column provides evidence that there is a great deal of difference between the governance standards of the economies in which sovereign wealth funds have been established and the standards of the industrial economies in which they are seeking to invest. It also discusses how the expansion of asset holdings of sovereign wealth funds may reduce official reserve holdings.

Sovereign Wealth Funds: Stylized Facts about Their Determinants and Governance

Reuven Glick, with
Joshua Aizenman,
University of California, Santa Cruz

Published in *International Finance* 12(3, Winter 2009), pp. 351–386.

Concerns about the implications of foreign investments by sovereign wealth funds (SWFs) stem in large part from apprehensions about the objectives and governance quality of these institutions. This paper contributes to a better understanding of the stylized facts of sovereign wealth funds by providing statistical analysis of a range of characteristics of SWFs, including the motivation for their establishment as well as their size, governance, and effect on reserve management behavior. Specifically, it estimates what factors foster the establishment of SWFs as well as affect their size. It also investigates the extent to which the governance and transparency of individual SWFs correlate with domestic and global governance practices. Lastly, it analyzes how asset accumulation by SWFs may affect central bank holdings of official reserves.

Sterilization, Monetary Policy, and Global Financial Integration

Reuven Glick, with
Joshua Aizenman,
University of California, Santa Cruz

Published in *Review of International Economics* 17(4, September 2009), pp. 777–801.

This paper investigates the changing pattern and efficacy of sterilization within emerging market countries as they liberalize markets and integrate with the world economy. We estimate the marginal propensity to sterilize foreign asset accumulation associated with net balance of payments inflows, across countries, and over time. We find that the extent of sterilization of foreign reserve inflows has risen in recent years to varying degrees in Asia as well as in Latin America, consistent with greater concerns about the potential inflationary impact of reserve inflows. We also find that sterilization depends on the composition of balance of payments inflows.

Endogenous Tradability and Some Macroeconomic Implications

Reuven Glick, with
Paul Bergin,
University of California, Davis

Published in
Journal of Monetary Economics
56(8, November 2009), pp. 1086–1095.

While nontraded goods play an important role in many open economy macroeconomic models, these models have difficulty explaining the low volatility in the relative price of nontraded goods. In contrast to macroeconomic convention, this paper argues that the share of nontraded goods is endogenous, a time-varying product of macroeconomic shocks and trade costs that are heterogeneous across goods. A simple open economy model demonstrates that trade cost heterogeneity and a time-varying margin of tradedness dramatically reduces the volatility of nontraded prices. This also reduces the ability of real exchange rate adjustments to dampen current account imbalances.

Navigating the Trilemma: Capital Flows and Monetary Policy in China

Reuven Glick, with
Michael Hutchison,
University of California, Santa Cruz

Published in *Journal of Asian Economics*
20(3, May 2009), pp. 205–224.

In recent years China has faced an increasing trilemma—how to pursue an independent domestic monetary policy and limit exchange rate flexibility, while at the same time facing large and growing international capital flows. This paper analyzes the impact of the trilemma on China's monetary policy as the country liberalizes its goods and financial markets and integrates with the world economy. It shows how China has sought to insulate its reserve money from the effects of balance of payments inflows by sterilizing through the issuance of central bank liabilities. However, we report empirical results indicating that sterilization dropped precipitously in 2006 in the face of the ongoing massive buildup of international reserves, leading to a surge in reserve money growth. We estimate a vector error correction model linking the surge in China's reserve money to broad money, real GDP, and the price level. We use this model to explore the inflationary implications of different policy scenarios. Under a scenario of continued rapid reserve money growth (consistent with limited sterilization of foreign exchange reserve accumulation) and strong economic growth, the model predicts a rapid increase in inflation. A model simulation using an extension of the framework that incorporates recent increases in bank reserve requirements also implies a rapid rise in inflation. By contrast, model simulations incorporating a sharp slowdown in economic growth such as that seen in late 2008 and 2009 lead to less inflation pressure even with a substantial buildup in international reserves.

Collateral Damage: Trade Disruption and the Economic Impact of War

Reuven Glick, with
Alan M. Taylor,
University of California, Davis

Published in *The Review of Economics and Statistics* 92(1, February 2010), pp. 102–127.

Conventional wisdom in economic history suggests that conflict between countries can be enormously disruptive of economic activity, especially international trade. We study the effects of war on bilateral trade with available data extending back to 1870. Using the gravity model, we estimate the contemporaneous and lagged effects of wars on the trade of belligerent nations and neutrals, controlling for other determinants of trade, as well as the possible effects of reverse causality. We find large and persistent impacts of wars on trade, national income, and global economic welfare. We also conduct a general equilibrium comparative statics exercise that indicates costs associated with lost trade might be at least as large as the conventionally measured direct costs of war, such as lost human capital, as illustrated by case studies of World Wars I and II.

Currency Crises and Foreign Credit in Emerging Markets: Credit Crunch or Demand Effect?

Galina Hale, with
Carlos Arteta, *Federal Reserve Board*

Published in *European Economic Review* 53(7, October 2009), pp. 758–774.

Currency crises of the past decade highlighted the importance of balance sheet effects of currency crises. In credit-constrained markets, such effects may lead to further declines in credit. Controlling for a host of fundamentals, we find a systematic decline in foreign credit to emerging market private firms of about 25 percent in the first year following currency crises, which we define as large changes in the real value of the currency. This decline is especially large in the first five months, lessens in the second year and disappears entirely by the third year. We identify the effects of currency crises on the demand and supply of credit and find that the decline in the supply of credit is persistent and contributes to about 8 percent decline in credit for the first two years, while the 35 percent decline in demand lasts only five months.

Foreign Direct Investment and Incentives to Innovate and Imitate

Galina Hale, with
Irene Brambilla,
Universidad de San Andrés
Cheryl Long, *Colgate University*

Published in *Scandinavian Journal of Economics* 111(4, December 2009), pp. 835–861.

We propose a new channel of foreign direct investment (FDI) spillovers on domestic firms, which operates through imitation of original products. Domestic heterogeneous firms may not introduce any new products, introduce a new product line (innovate), or develop a variety that is a close substitute to an existing product line (imitate). The presence of foreign firms generates incentives for imitation because they introduce original products that are vertically differentiated from domestic products. Using firm-level panel data for China, we find that increased FDI presence in a given industry leads to more imitation, but not necessarily more innovation, by domestic firms.

Does Creditor Protection Mitigate the Likelihood of Financial Crises and Their Effect on the Stock Market?

Galina Hale, with
Assaf Razin, *Cornell University*

Published at *VoxEU.org*, August 8, 2009.
http://voxeu.org/index.php?q=node/3856

Finding reliable indicators that predict the likelihood and severity of crises across countries has been a frustrating quest for economists. This column suggests that countries with better creditor protection suffer less when a crisis hits.

Do Banks Price Their Informational Monopoly?

Galina Hale, with
João Santos, *FRB New York*

Published in *Journal of Financial Economics* 93(2, August 2009), pp. 185–206.

Modern corporate finance theory argues that, although bank monitoring is beneficial to borrowers, it also allows banks to use the information they gain through monitoring to "hold up" borrowers for higher interest rates. In this paper, we seek empirical evidence for this information hold-up cost. Since new information about a firm's creditworthiness is revealed at the time of its first issue in the public bond market, it follows that after firms undertake their bond IPO, banks with an exploitable information advantage will be forced to adjust their loan interest rates downwards, particularly for firms that are revealed to be safe. We test this hypothesis by comparing banks' loan pricing policies before and after borrowers gain access to the public bond market. To isolate the information hold-up cost we further compare the change in the loan policies between borrowers that already had a credit rating at the time of their bond IPO and borrowers that get their first credit rating at that time. Our findings show that firms are able to borrow at lower interest rates after their bond IPO and that these savings are larger for safer firms. We also find that, among safe firms, those that get their first credit rating at the time of their bond IPO benefit from larger interest rate savings than those that already had a credit rating. These findings provide support for the hypothesis that banks price their informational monopoly. Finally, we find that while entering the public bond market may reduce these informational rents, it is also costly to firms because they have to pay higher underwriting costs on their IPO bond.

An Exploration of Technology Diffusion

Bart Hobijn, with
Diego Comin, *Harvard Business School*

Forthcoming in
American Economic Review.

We develop and estimate a model where technology diffusion depends on the level of productivity embodied in capital and where this is, in turn, determined by two key mechanisms: the rate at which the quality embodied in new technology vintages increases (embodiment) and the gains from varieties induced by the introduction of new vintages (variety). In our model, these two effects are related to technology adoption decisions taken at two different levels. The capital goods suppliers' decisions of when to adopt a given vintage determines the embodiment margin. The workers' decisions of which of the adopted vintages to use in production determines the variety margin. Estimation of our model for a sample of 19 technologies, 21 countries, and the period 1870–1998 reveals that embodied productivity growth is large for many of the technologies in our sample. On average, increases in the variety of vintages available is a more important source of growth than the increases in the embodiment margin. There is, however, substantial heterogeneity

across technologies. Where adoption lags matter, they are largely determined by a lack of educational attainment and lack of trade openness.

Unemployment in the Current Crisis

Bart Hobijn, with
Michael Elsby, *University of Michigan*
Aysegül Sahin, *FRB New York*

Published at *VOXEU.org*,
February 14, 2009.
http://www.voxeu.org/
index.php?q=node/3071

Unemployment is rising—job losses are up 30 percent in the U.S. and 50 percent in the U.K. since 2007. How bad will it get? This column uses data on unemployment inflows and duration to predict labor market trends. A conservative estimate says that unemployment will reach at least 5 percent in Britain and 13.5 percent in Spain.

Job-Finding and Separation Rates in the OECD

Bart Hobijn, with
Aysegül Sahin, *FRB New York*

Published in *Economics Letters*
104(3, September 2009), pp. 107–111.

We provide a set of comparable estimates of average monthly job-finding and separation rates for over 20 OECD countries that can be used for the cross-country analysis of labor markets.

Do Alternative Measures of GDP Affect Its Interpretation?

Bart Hobijn, with
Charles Steindel, *FRB New York*

Published in *Current Issues in Economics and Finance* 15(7, November 2009).

Gross domestic product's high correlation with unemployment and inflation makes it a key measure of the U.S. economy. Yet the somewhat arbitrary nature of the GDP construction process complicates interpretation and measurement of the indicator. A study of an alternative measure of GDP designed to address the published series' limitations finds that the adjusted measure differs in its representation of the long-term trend—but not the short-term fluctuations—of GDP. The published series' relevance as an indicator is therefore robust to some of the arbitrariness of its construction.

Estimating Static Models of Strategic Interactions

John Krainer, with
Patrick Bajari, *University of Michigan*
Han Hong, *Duke University*
Denis Nekipelov, *Duke University*

Forthcoming in *Journal of Business and Economic Statistics.*

We study the estimation of static games of incomplete information with multiple equilibria. A static game is a generalization of a discrete choice model, such as a multinomial logit or probit, which allows the actions of a group of agents to be interdependent. While the estimator we study is quite flexible, we demonstrate that in most cases it can be easily implemented using standard statistical packages such as STATA. We also propose an algorithm for simulating the model which finds all equilibria to the game. As an application of our estimator, we study recommendations for high technology stocks between 1998 and 2003. We find that strategic motives, typically ignored in the empirical literature, appear to be an important consideration in the recommendations submitted by equity analysts.

Financial Contracting and the Choice Between Private Placement and Publicly Offered Bonds

Simon Kwan, with
Willard Carleton, *University of Arizona*

Forthcoming in
Journal of Money, Credit, and Banking.

The financial contracting in private placement bonds and publicly offered bonds are different. Our data show that private placement bonds are more likely to have restrictive covenants than public bonds. Private placement bonds are also more likely to be issued by smaller and riskier firms. For investment-grade firms that issue bonds in both markets, our analysis shows that firms select the bond type to minimize financing costs. We find significant differences in the pricing of private placement and publicly offered bonds, and some of these differences appear to be related to the different institutional features between the two markets.

CRA Lending during the Subprime Meltdown

Elizabeth Laderman, with
Carolina Reid, *FRB San Francisco*

Published in *Revisiting the CRA: Perspectives on the Future of the Community Reinvestment Act*,
London: Routledge, 2009, pp. 115–133.

In this study, we use a unique data set that joins lender and origination information from the Home Mortgage Disclosure Act reports with data on loan performance from Lender Processing Services, Inc. Applied Analytics. We thus have access to information on borrower characteristics, loan characteristics, institutional characteristics, and loan performance. We use these data to examine several interrelated questions: What is the neighborhood distribution of loans made by independent mortgage companies versus those made by institutions regulated under the CRA? After controlling for borrower credit risk, is there a difference in the foreclosure rates for loans made by independent mortgage companies versus those made by institutions regulated under the CRA? How do other factors—such as loan terms and loan source—influence the likelihood of foreclosure? How do these factors differ in low- and moderate-income neighborhoods compared with the factors in middle- and upper-income neighborhoods?

Rational and Near-Rational Bubbles without Drift

Kevin J. Lansing

Forthcoming in *The Economic Journal*.

This paper derives a general class of intrinsic rational bubble solutions in a Lucas-type asset pricing model. I show that the rational bubble component of the price-dividend ratio can evolve as a geometric random walk without drift, such that the mean of the bubble growth rate is zero. Driftless bubbles are part of a continuum of equilibrium solutions that satisfy a period-by-period no-arbitrage condition. I also derive a near-rational solution in which the agent's forecast rule is underparameterized. The near-rational solution generates intermittent bubbles and other behavior that is quantitatively similar to that observed in long-run U.S. stock market data.

Speculative Bubbles and Overreaction to Technological Innovation

Kevin J. Lansing

Published in *Journal of Financial Transformation* 26 (June 2009), pp. 51–54.

"Nowhere does history indulge in repetitions so often or so uniformly as in Wall Street," observed legendary speculator Jesse Livermore. History tells us that periods of major technological innovation are typically accompanied by speculative bubbles as economic agents overreact to genuine advancements in productivity. Excessive run-ups in asset prices can have important consequences for the economy as firms and investors respond to the price signals, resulting in capital misallocation. On the one hand, speculation can magnify the volatility of economic and financial variables, thus harming the welfare of those who are averse to uncertainty and fluctuations. But on the other hand, speculation can increase investment in risky ventures, thus yielding benefits to a society that suffers from an underinvestment problem.

Time-Varying U.S. Inflation Dynamics and the New Keynesian Phillips Curve

Kevin J. Lansing

Published in *Review of Economic Dynamics* 12(2, April 2009), pp. 304–326.

This paper introduces a form of boundedly rational inflation expectations in the New Keynesian Phillips curve. The representative agent is assumed to behave as an econometrician, employing a time series model for inflation that allows for both permanent and temporary shocks. The near-unity coefficient on expected inflation in the Phillips curve causes the agent's perception of a unit root in inflation to become close to self-fulfilling. In a "consistent expectations equilibrium," the value of the Kalman gain parameter in the agent's forecast rule is pinned down using the observed autocorrelation of inflation changes. The forecast errors observed by the agent are close to white noise, making it difficult for the agent to detect a misspecification of the forecast rule. I show that this simple model of inflation expectations can generate time-varying persistence and volatility that is broadly similar to that observed in long-run U.S. data. Model-based values for expected inflation track well with movements in survey-based measures of U.S. expected inflation. In numerical simulations, the model can generate pronounced low-frequency swings in the level of inflation that are driven solely by expectational feedback, not by changes in monetary policy.

Capital-Labor Substitution and Equilibrium Indeterminacy

Kevin J. Lansing, with
Jang-Ting Guo,
University of California, Riverside

Published in *Journal of Economic Dynamics and Control* 33 (December 2009), pp. 1991–2000.

This paper examines the quantitative relationship between the elasticity of capital–labor substitution in production and the conditions needed for equilibrium indeterminacy (and belief-driven fluctuations) in a one-sector growth model. With variable capital utilization, the substitution elasticity has little quantitative impact on the minimum degree of increasing returns needed for indeterminacy. However, when capital utilization is constant, a below-unity substitution elasticity sharply raises the minimum degree of increasing returns because it imposes a higher effective adjustment cost on labor hours. Overall, our results show that empirically plausible departures from the Cobb-Douglas production specification can make indeterminacy more difficult to achieve.

The Role of China in Asia: Engine, Conduit, or Steamroller?

Sylvain Leduc, with
Jane T. Haltmaier, *Federal Reserve Board*
Shaghil Ahmed, *Federal Reserve Board*
Brahima Coulibaly, *Federal Reserve Board*
Ross Knippenberg, *Federal Reserve Board*
Mario Marazzi, *Federal Reserve Board*
Beth Anne Wilson, *Federal Reserve Board*

Forthcoming in *The Future of Asian Trade and Growth: Economic Development with the Emergence of China*, ed. Linda Yueh. London: Routledge.

This paper assesses China's role in Asia as an independent engine of growth, as a conduit of demand from the industrial countries, and as a competitor for export markets. We provide both macroeconomic and microeconomic evidence. The macroeconomic analysis focuses on the impact of U.S. and Chinese demand on the output of the Asian economies by estimating growth comovements and VARs. The results suggest an increasing role of China as an independent source of growth. The microeconomic analysis decomposes trade into basic products, parts and components, and finished goods. We find a large role for parts and components trade consistent with China playing an important and increasing role as a conduit. We also estimate some regressions that show that China's increasing presence in export markets has had a negative effect on exports of some products for some other Asian economies, but not for other products, including those of the important electronic high-technology industry.

The Adjustment of Global External Balances: Does Partial Exchange Rate Pass-Through to Trade Prices Matter?

Sylvain Leduc, with
Christopher Gust, *Federal Reserve Board*
Nathan Sheets, *Federal Reserve Board*

Published in *Journal of International Economics*
79(2, November 2009), pp. 173–185.

This paper assesses whether partial exchange rate pass-through to trade prices has important implications for the prospective adjustment of global external imbalances. To address this question, we develop and estimate an open-economy DSGE model in which pass-through is incomplete due to the presence of local currency pricing, distribution services, and a variable demand elasticity that leads to fluctuations in optimal markups. We find that the overall magnitude of trade adjustment is similar in a low and high pass-through environment with more adjustment in a low pass-through world occurring through movements in the terms of trade rather than real trade flows and through a larger response of the exchange rate.

Trade Integration, Competition, and the Decline in Exchange Rate Pass-Through

Sylvain Leduc, with
Christopher Gust, *Federal Reserve Board*
Robert Vigfusson, *Federal Reserve Board*

Forthcoming in
Journal of Monetary Economics.

Over the past 20 years, U.S. import prices have become less responsive to the exchange rate. We propose that a significant portion of this decline is a result of increased trade integration. To illustrate this effect, we develop an open economy dynamic general equilibrium model in which trade occurs along both the intensive and extensive margins. The key element we introduce into this environment is strategic complementarity in price setting. As a result, a firm's pricing decision depends on the prices set by its competitors. This feature implies that a foreign exporter finds it optimal to vary its markup in response to shocks that change the exchange rate, insulating import prices from exchange rate movements. With increased trade integration, exporters have become more responsive to the prices of their competitors, and this change in pricing behavior accounts for a significant portion of the observed decline in the sensitivity of U.S. import prices to the exchange rate.

Learning, Adaptive Expectations, and Technology Shocks

Zheng Liu, with
Kevin X.D. Huang, *Vanderbilt Universit*y
Tao Zha, *FRB Atlanta*

Published in *The Economic Journal*
119(536, March 2009), pp. 377–405.

This study explores the macroeconomic implications of adaptive expectations in a standard growth model. We show that the self-confirming equilibrium under adaptive expectations is the same as the steady-state rational expectations equilibrium for all admissible parameter values, but that dynamics around the steady state are substantially different between the two equilibria. The differences are driven mainly by the dampened wealth effect and the strengthened intertemporal substitution effect, not by escapes emphasized by Williams (2003). Consequently, adaptive expectations can be an important source of frictions that amplify and propagate technology shocks and seem promising for generating plausible labor market dynamics.

Asymmetric Expectation Effects of Regime Shifts in Monetary Policy

Zheng Liu, with
Daniel Waggoner, *FRB Atlanta*
Tao Zha, *FRB Atlanta*

Published in *Review of Economic Dynamics* 12(2, April 2009), pp. 284–303.

This paper addresses two substantive issues: (1) Does the magnitude of the expectation effect of regime switching in monetary policy depend on a particular policy regime? (2) Under which regime is the expectation effect quantitatively important? Using two canonical dynamic stochastic general equilibrium models, we show that there exists asymmetry in the expectation effect across regimes. The expectation effect under the dovish policy regime is quantitatively more important than that under the hawkish regime. These results suggest that the possibility of regime shifts in monetary policy can have important effects on rational agents' expectation formation and on equilibrium dynamics. They offer a theoretical explanation for the empirical possibility that a policy shift from the dovish regime to the hawkish regime may not be the main source of substantial reductions in the volatilities of inflation and output.

Empirical Analysis of the Average Asset Correlation for Real Estate Investment Trusts

Jose A. Lopez

Published in *Quantitative Finance* 9(2, May 2009), pp. 217–229.

The credit risk capital requirements within the current Basel II Accord are based on the asymptotic single risk factor (ASRF) approach. The asset correlation parameter, defined as an obligor's sensitivity to the ASRF, is a key driver within this approach, and its average values for different types of obligors are to be set by regulators. Specifically, for commercial real estate (CRE) lending, the average asset correlations are to be determined using formulas for either income-producing real estate or high-volatility commercial real estate. In this paper, the value of this parameter was empirically examined using portfolios of U.S. publicly traded real estate investment trusts as a proxy for CRE lending more generally. CRE lending as a whole was found to have the same calibrated average asset correlation as corporate lending, providing support for the recent U.S. regulatory decision to treat these two lending categories similarly for regulatory capital purposes. However, the calibrated values for CRE categories, such as multifamily residential or office lending, varied in important ways. The comparison of calibrated and regulatory values of the average asset correlations for these categories suggests that the current regulatory formulas generate parameter values that may be too high in most cases.

Empirical Analysis of Corporate Credit Lines

Jose A. Lopez, with
Gabriel Jiménez, *Banco de España*
Jesús Saurina, *Banco de España*

Published in *Review of Financial Studies* 22(12, December 2009), pp. 5069–5098

Since bank credit lines are a major source of corporate funding, we examine the determinants of their usage with a comprehensive database of Spanish corporate credit lines. A line's default status is a key factor driving its usage, which increases as firm financial conditions worsen. Firms with prior defaults access their credit lines less, suggesting that bank monitoring influences firms' usage decisions. Line usage has an aging effect that causes it to decrease by roughly 10 percent per year of its life. Lender characteristics, such as the length of a firm's banking relationships, as well as macroeconomic conditions, affect usage decisions.

Foreign Bank Lending and Bond Underwriting in Japan during the Lost Decade

Jose A. Lopez
Mark M. Spiegel

Published in *China and Asia: Economic and Financial Interactions*, proceedings of the 2006 Asian Pacific Economic Association Conference, eds. Yin-Wong Cheung and Kar-Yiu Wong. London: Routledge, 2009.

We examine foreign intermediation activity in Japan during the so-called "lost decade" of the 1990s, contrasting the behavior of lending by foreign commercial banks and underwriting activity by foreign investment banks over that period. Foreign bank lending is shown to be sensitive to domestic Japanese conditions, particularly Japanese interest rates, more so than their domestic Japanese bank counterparts. During the 1990s, foreign bank lending in Japan fell, both in overall numbers and as a share of total lending. However, there was marked growth in foreign underwriting activity in the international yen-denominated bond sector. A key factor in the disparity between these activities is their different clientele: While foreign banks in Japan lent primarily to domestic borrowers, international yen-denominated bond issuers were primarily foreign entities with yen funding needs or opportunities for profitable swaps. Indeed, low interest rates that discouraged lending activity in Japan by foreign banks directly encouraged foreign underwriting activity tied to the so-called "carry trades." Regulatory reforms, particularly the "big bang" reforms of the 1990s, also play a large role in the growth of foreign underwriting activity over our sample period.

Forecasting Recessions: The Puzzle of the Enduring Power of the Yield Curve

Glenn D. Rudebusch
John C. Williams

Published in *Journal of Business and Economic Statistics* 27(4, October 2009), pp. 492–503.

We show that professional forecasters have essentially no ability to predict future recessions a few quarters ahead. This is particularly puzzling because, for at least the past two decades, researchers have provided much evidence that the yield curve, specifically the spread between long- and short-term interest rates, does contain useful information at that forecast horizon for predicting aggregate economic activity and, especially, for signaling future recessions. We document this puzzle and suggest that forecasters have generally placed too little weight on yield curve information when projecting declines in the aggregate economy.

Financial Globalization and Monetary Policy Discipline: A Survey with New Evidence from Financial Remoteness

Mark M. Spiegel

Published in *IMF Staff Papers* 56 (February 2009), pp. 198–221.

The literature appears to have reached a consensus that financial globalization has had a "disciplining effect" on monetary policy, as it has reduced the returns from—and hence the temptation for—using monetary policy to stabilize output. As a result, monetary policy over recent years has placed more emphasis on stabilizing inflation, resulting in reduced inflation and greater output stability. However, this consensus has not been accompanied by convincing empirical evidence that such a relationship exists. One reason is likely to be that de facto measures of financial globalization are endogenous, and that instruments for financial globalization are elusive. In this paper, I introduce a new instrument, financial remoteness, as a plausibly exogenous instrument for financial openness. I examine the relationship between financial globalization and median inflation levels over an 11-year cross-section from 1994 through 2004, as well as a panel of 5-year median inflation levels between 1980 and 2004. The results confirm a negative relationship between median inflation and financial globalization in the base specification, but this relationship is sensitive to the inclusion of conditioning variables or country fixed effects, precluding any strong inferences.

Monetary and Financial Integration: Evidence from the EMU

Mark M. Spiegel

Published in *Journal of the Japanese and International Economies* 23(2, June 2009), pp. 114–130.

This paper examines the impact of European Monetary Union (EMU) accession on bilateral Portuguese international borrowing patterns. Using a difference-in-differences methodology, I demonstrate that Portugal's accession to the EMU was accompanied by a change in its borrowing pattern in favor of borrowing from its EMU partner nations. This extends the evidence in the literature that overall international borrowing is facilitated by the creation of a monetary union and raises the issue of financial diversion. The results are shown to survive a wide variety of robustness checks and are corroborated by preliminary evidence concerning Greece's accession to EMU in 2001.

Monetary and Financial Integration in the EMU: Push or Pull?

Mark M. Spiegel

Published in *Review of International Economics* 17(4, September 2009), pp. 751–776.

A number of studies have recently noted that monetary integration in the European Monetary Union (EMU) has been accompanied by increased financial integration. This paper examines the channels through which monetary union increased financial integration, using international panel data on bilateral international commercial bank claims from 1998 to 2006. I decompose the relative increase in bilateral commercial bank claims among union members following monetary integration into three possible channels: a "borrower effect," as a country's EMU membership may leave its borrowers more creditworthy in the eyes of foreign lenders; a "creditor effect," as membership in a monetary union may increase the attractiveness of a nation's commercial banks as intermediaries, perhaps through increased scale economies enjoyed by commercial banks themselves or through an improved regulatory environment after the advent of monetary union; and a "pairwise effect," as joint membership in a monetary union increases the quality of intermediation between borrowers and creditors when both are in the same union. This pairwise effect could be attributed to mitigated currency risk stemming from monetary integration, but may also indicate that monetary union integration increases borrowing capacity. I decompose the data into a series of difference-in-differences specifications to isolate these three channels and find that the pairwise effect is the primary source of increased financial integration. This result is robust to a number of sensitivity exercises used to address concerns frequently associated with difference-in-differences specifications, such as serial correlation and issues associated with the timing of the intervention.

Takeoffs

Mark M. Spiegel, with
Joshua Aizenman,
University of California, Santa Cruz

Forthcoming in
Review of Development Economics.

This paper identifies factors associated with takeoff—a sustained period of high growth following a period of stagnation. We examine a panel of 241 "stagnation episodes" from 146 countries, 54 percent of these episodes are followed by takeoffs. Countries that experience takeoffs average 2.3 percent annual growth following their stagnation episodes, while those that do not average 0 percent growth; 46 percent of the takeoffs are "sustained," i.e., lasting eight years or longer. Using probit estimation, we find that de jure trade openness is positively and significantly associated with takeoffs. A one standard deviation increase in de jure trade openness is associated with a 55 percent increase in the probability of a takeoff in our default specification. We also find evidence that capital account openness encourages takeoff responses, although this channel is less robust. Measures of de facto trade openness, as well as a variety of other potential conditioning variables, are found to be poor predictors of takeoffs. We also examine the determinants of nations achieving sustained takeoffs. While we fail to find a significant role for openness in determining whether or not takeoffs are sustained, we do find a role for output composition: Takeoffs in countries with more commodity-intensive output bundles are less likely to be sustained, while takeoffs in countries that are more service-intensive are more likely to be sustained. This suggests that adverse terms of trade shocks prevalent among commodity exports may play a role in ending long-term high growth episodes.

Moderate Inflation and the Deflation-Depression Link

Mark M. Spiegel, with
Jess Benhabib, *New York University*

Published in *Journal of Money, Credit, and Banking* 41(4, June 2009), pp. 787–798.

In a recent paper, Atkeson and Kehoe (2004) demonstrated the lack of a robust empirical relationship between inflation and growth for a cross-section of countries with 19th and 20th century data, concluding that the historical evidence only provides weak support for the contention that deflation episodes are harmful to economic growth. In this paper, we revisit this relationship by allowing for inflation and growth to have a nonlinear specification dependent on inflation levels. In particular, we allow for the possibility that high inflation is negatively correlated with growth, while a positive relationship exists over the range of negative-to-moderate inflation. Our results confirm a positive relationship between inflation and growth at moderate inflation levels, and support the contention that the relationship between inflation and growth is nonlinear over the entire sample range.

International Financial Remoteness and Macroeconomic Volatility

Mark M. Spiegel, with
Andrew Rose,
University of California, Berkeley

Published in *Journal of Development Economics* 89(2, July 2009), pp. 250–257.

This paper shows that proximity to major international financial centers seems to reduce business cycle volatility. In particular, we show that countries that are further from major locations of international financial activity systematically experience more volatile growth rates in both output and consumption, even after accounting for domestic financial depth, political institutions, and other controls. Our results are relatively robust in the sense that more financially remote countries are more volatile, though the results are not always statistically significant. The comparative strength of this finding is in contrast to the more ambiguous evidence found in the literature.

Non-Economic Engagement and International Exchange: The Case of Environmental Treaties

Mark M. Spiegel, with
Andrew Rose,
University of California, Berkeley

Published in *Journal of Money, Credit, and Banking* 41(2-3, March 2009), pp. 337–363.

We examine the role of non-economic partnerships in promoting international economic exchange. Since farsighted countries are more willing to join costly international partnerships such as environmental treaties, environmental engagement tends to encourage international lending. Countries with such non-economic partnerships also find it easier to engage in economic exchanges since they face the possibility that debt default might also spill over to hinder their non-economic relationships. We present a theoretical model of these ideas, and then verify their empirical importance using a bilateral cross-section of data on international crossholdings of assets and environmental treaties. Our results support the notion that international environmental cooperation facilitates economic exchange.

Convergence and Anchoring of Yield Curves in the Euro Area

Eric T. Swanson, with
Michael Ehrmann,
European Central Bank
Marcel Fratzscher,
European Central Bank
Refet Gürkaynak, *Bilkent University*

Forthcoming in *Review of Economics and Statistics.*

We study the convergence of European bond markets and the anchoring of inflation expectations in the euro area using high-frequency bond yield data for France, Germany, Italy, and Spain, some smaller euro area countries, and a control group comprising the U.K., Denmark, and Sweden. We find that European Economic and Monetary Union (EMU) has led to substantial convergence in euro area sovereign bond markets in terms of interest rate levels, unconditional daily fluctuations, and conditional responses to major macroeconomic announcements. Our findings also suggest a substantial increase in the anchoring of long-term inflation expectations since EMU, particularly for Italy and Spain, which have seen their long-term interest rates become much lower, much less volatile, and much better anchored in response to news. Finally, we present evidence that the elimination of exchange rate risk and the adoption of a common monetary policy were the primary drivers of bond market convergence in the euro area, as opposed to fiscal policy restraint and the loose exchange rate peg of the 1990s.

Does Inflation Targeting Help Anchor Long-Run Inflation Expectations? Evidence from Long-Term Bond Yields in the U.S., U.K., and Sweden

Eric T. Swanson, with
Refet Gürkaynak, *Bilkent University*
Andrew T. Levin, *Federal Reserve Board*

Forthcoming in *Journal of the European Economic Association.*

We investigate the extent to which inflation expectations have been more firmly anchored in the United Kingdom—a country with an explicit inflation target—than in the United States—a country with no such target—using the difference between far-ahead forward rates on nominal and inflation-indexed bonds as a measure of compensation for expected inflation and inflation risk at long horizons. We show that far-ahead forward inflation compensation in the U.S. exhibits substantial volatility, especially at low frequencies, and displays a highly significant degree of sensitivity to economic news. Similar patterns are evident in the U.K. prior to 1997, when the Bank of England was not independent, but have been strikingly absent since the Bank of England gained independence in 1997. Our findings are further supported by comparisons of dispersion in longer-run inflation expectations of professional forecasters and by evidence from Sweden, another inflation targeting country with a relatively long history of inflation-indexed bonds. Our results support the view that an explicit and credible inflation target helps to anchor the private sector's views regarding the distribution of long-run inflation outcomes.

Gender, Monetary Policy, and Employment: The Case of Nine OECD Countries

Yelena Takhtamanova, with
Eva Sierminska, *Luxembourg Income Study and DIW Berlin*

Published in *Feminist Economics* 15(3, July 2009), pp. 323–353.

In many countries, low and stable inflation is the focus of monetary policy. Recent empirical evidence from developing countries indicates, however, that the costs of reducing inflation are disproportionately borne by women. This paper seeks to determine whether a similar pattern is evident in nine Organisation for Economic Co-operation and Development (OECD) countries, using quarterly data for 1980–2004. The study examines economywide and sectoral employment effects by gender by utilizing two methodologies: single equation regression and vector autoregression analysis. Results indicate that the link between monetary policy instruments (short-term interest rates) and employment in the industrial countries under investigation is weak and does not vary by gender.

Relative Productivity Growth and the Secular "Decline" of U.S. Manufacturing

Bharat Trehan, with
Milton Marquis, *Florida State University*

Published in *The Quarterly Review of Economics and Finance* 50(1, February 2010), pp. 67–74.

There has been considerable debate about the causes of the "decline" of U.S. manufacturing over the postwar period. We show that the behavior of employment, prices, and output in manufacturing relative to services over this period can be explained by a two-sector growth model in which productivity shocks are the only driving forces. Household preferences turn out to play a key role in our model. The data are consistent with a specification where households are unwilling to substitute goods for services (the estimated elasticity of substitution is statistically indistinguishable from zero), so the economy adjusts to differential productivity growth entirely by reallocating labor across sectors.

Climate Change and Housing Prices: Hedonic Estimates for Ski Resorts in Western North America

Robert G. Valletta, with
Van Butsic, *University of Wisconsin*
Ellen Hanak,
Public Policy Institute of California

Forthcoming in *Land Economics*.

We apply a hedonic framework to estimate and simulate the impact of global warming on real estate prices near ski resorts in the western United States and Canada. Using data on housing values for selected U.S. Census tracts and individual home sales in four locations, combined with detailed weather data and characteristics of nearby ski resorts, we find precise and consistent estimates of positive snowfall effects on housing values. Simulations based on these estimates reveal substantial heterogeneity in the likely impact of climate change across regions, including large reductions in home prices near resorts where snow reliability already is low.

Heeding Daedalus: Optimal Inflation and the Zero Lower Bound

John C. Williams

Published in *Brookings Papers on Economic Activity*
2009(2, fall), pp. 1–37.

This paper reexamines the implications of the zero lower bound on interest rates for monetary policy and the optimal choice of steady-state inflation in light of the experience of the recent global recession. There are two main findings. First, the zero lower bound did not materially contribute to the sharp declines in output in the United States and many other economies through the end of 2008, but it is a significant factor slowing recovery. Model simulations imply that an additional 4 percentage points of rate cuts would have kept the unemployment rate from rising as much as it has and would bring the unemployment and inflation rates more quickly to steady-state values, but the zero bound precludes these actions. This inability to lower interest rates comes at the cost of $1.8 trillion of foregone output over four years. Second, if recent events are a harbinger of a significantly more adverse macroeconomic climate than experienced over the preceding two decades, then a 2 percent steady-state inflation rate may provide an inadequate buffer to keep the zero bound from having noticeable deleterious effects on the macroeconomy, assuming the central bank follows the standard Taylor rule. In such an adverse environment, stronger systematic countercyclical fiscal policy and/or alternative monetary policy strategies can mitigate the harmful effects of the zero bound with a 2 percent inflation target. However, even with such policies, an inflation target of 1 percent or lower could entail significant costs in terms of macroeconomic volatility.

Welfare-Maximizing Monetary Policy under Parameter Uncertainty

John C. Williams, with
Rochelle Edge, *Federal Reserve Board*
Thomas Laubach, *Federal Reserve Board*

Published in *Journal of Applied Econometrics*
25(1, January 2010), pp. 129–143.

This paper examines welfare-maximizing monetary policy in an estimated micro-founded general equilibrium model of the U.S. economy where the policymaker faces uncertainty about model parameters. Uncertainty about parameters describing preferences and technology implies uncertainty about the model's dynamics, utility-based welfare criterion, and the "natural" rates of output and interest that would prevail absent nominal rigidities. We estimate the degree of uncertainty regarding natural rates due to parameter uncertainty. We find that optimal Taylor rules under parameter uncertainty respond less to the output gap and more to price inflation than would be optimal absent parameter uncertainty. We also show that policy rules that focus solely on stabilizing wages and prices yield welfare outcomes very close to the first-best.

Imperfect Knowledge and the Pitfalls of Optimal Control Monetary Policy

John C. Williams, with
Athanasios Orphanides,
Central Bank of Cyprus

Published in *Central Banking, Analysis and Economic Policies: Monetary Policy Under Uncertainty and Learning*, eds. K. Schmidt-Hebbel and C. Walsh, Central Bank of Chile, 2009, pp. 115–144.

This paper examines the robustness characteristics of optimal control policies derived under the assumption of rational expectations to alternative models of expectations formation and uncertainty about the natural rates of interest and unemployment. We assume that agents have imperfect knowledge about the precise structure of the economy and form expectations using a forecasting model that they continuously update based on incoming data. We also allow for central bank uncertainty regarding the natural rates of interest and unemployment. We find that the optimal control policy derived under the assumption of perfect knowledge about the structure of the economy can perform poorly when knowledge is imperfect. These problems are exacerbated by natural rate uncertainty, even when the central bank's estimates of natural rates are efficient. We show that the optimal control approach can be made more robust to the presence of imperfect knowledge by deemphasizing the stabilization of real economic activity and interest rates relative to inflation in the central bank loss function. That is, robustness to the presence of imperfect knowledge about the economy provides an incentive to employ a "conservative" central banker. We then examine two types of simple monetary policy rules from the literature that have been found to be robust to model misspecification in other contexts. We find that these policies are robust to the alternative models of learning that we study and natural rate uncertainty and outperform the optimal control policy and generally perform as well as the robust optimal control policy that places less weight on stabilizing economic activity and interest rates.

A Black Swan in the Money Market

John C. Williams, with
John Taylor, *Stanford University*

Published in *American Economic Journal: Macroeconomics* 1(1, January 2009), pp. 58–83.

The recent financial crisis saw a dramatic and persistent jump in interest rate spreads between overnight federal funds and longer-term interbank loans. The Fed took several actions to reduce these spreads, including the creation of the Term Auction Facility (TAF). The effectiveness of these policies depends on the cause of the increased spreads such as counterparty risk, liquidity, or other factors. Using a no-arbitrage pricing framework and various measures of risk, we find robust evidence that increased counterparty risk contributed to the rise in spreads but do not find robust evidence that the TAF had a significant effect on spreads.

Beggar Thy Neighbor? The In-State, Out-of-State, and Aggregate Effects of R&D Tax Credits

Daniel J. Wilson

Published in *Review of Economics and Statistics* 91(2, May 2009), pp. 431–436.

The proliferation of research and development (R&D) tax incentives among U.S. states in recent decades raises two important questions: (1) Are these tax incentives effective in achieving their stated objective, to increase R&D spending within the state? (2) To the extent the incentives do increase R&D within the state, how much of this increase is due to drawing R&D away from other states? In short, this paper answers (1) "yes" and (2) "nearly all," with the implication that the net national effect of R&D tax incentives on R&D spending is near zero. The paper addresses these questions by exploiting the cross-sectional and time-series variation in R&D tax credits, and in turn the user cost of R&D, among U.S. states from 1981–2004 to estimate an augmented version of the standard R&D factor demand model. I estimate an in-state user cost elasticity around –2.5 (in the long-run), consistent with previous studies of the R&D cost elasticity. However, the R&D elasticity with respect to costs in neighboring states, which has not previously been investigated, is estimated to be around +2.5, suggesting a zero-sum game among states and raising concerns about the efficiency of state R&D credits from the standpoint of national social welfare.

IT and Beyond: The Contribution of Heterogeneous Capital to Productivity

Daniel J. Wilson

Published in *Journal of Business and Economic Statistics* 27(1, January 2009), pp. 52–70.

This article explores the relationship between capital composition and productivity using a unique, detailed data set on firm investment in the United States in the late 1990s. I develop a methodology for estimating the separate effects of multiple capital types in a production function framework. I back out the implied marginal products of each capital type and compare these with rental price data. I find that although most capital types earned normal returns, information and communications technology capital goods had marginal products substantially above their rental prices. The article also provides evidence of complementarities and substitutabilities among capital types and between capital types and labor.

Conferences

Federal Reserve "Day Ahead" Conference on Financial Markets

Macroeconomic Models for Monetary Policy

Asia and the Global Financial Crisis

The U.S. and World Economic Geography Before and After the Downturn

Symposium: The Outlook for Consumption

Symposium: Happiness and the Economy

The San Francisco Fed's Research Department organized four conferences and two symposiums in 2009.

The San Francisco Fed hosted the "Day Ahead" conference, a one-day finance-oriented conference that brings together economists from around the Federal Reserve System to present and discuss research related to financial institutions and markets.

The Department's annual macroeconomic conference, "Macroeconomic Models for Monetary Policy," addressed how policymakers could improve the models they use for economic forecast and analysis. Papers presented at the conference focused on five important questions: Why do many prices respond slowly to economic events? What makes wages sluggish and at what point do firms lay off workers? How do households and firms form expectations about the future? How do financial market frictions affect the decisions of households, firms, and the central bank? and What is the best way to measure potential output?

"Asia and the Global Financial Crisis," the first Asia Economic Policy Conference of the Federal Reserve Bank of San Francisco's Center for Pacific Basin Studies, examined the impact of the crisis on Asian nations and the responses of policymakers. Although nations in the region were deeply affected, they generally recovered more quickly and vigorously than other industrial and emerging markets thanks to strong economic fundamentals and reforms enacted following financial crises in the 1990s.

"The U.S. and World Economic Geography Before and After the Downturn" examined how the crisis has changed residential and development environments in many parts of the world. For example, the crisis has reduced home ownership and created pressure to increase neighborhood density in the United States. And, at least temporarily, it slowed migration in China to export-oriented urban areas.

The CSIP symposium "The Outlook for Consumption" featured presentations and a panel discussion about the effects of the economic downturn on U.S. consumption, including future consumer behavior regarding housing, saving, wealth, and credit. The CSIP symposium on "Happiness and the Economy" was cohosted with University of Southern California and the University of Warwick. Presentations focused on the measurement of happiness and well-being and the factors that affect both of these variables in developing and developed nations.

(continued on next page)

These conferences bring professional economists from the Federal Reserve System and from research institutions together with policymakers from the United States and abroad. Many of the papers presented are "works in progress" and they represent the latest research on policy-related issues.

Attendance at all of the conferences is by invitation only. In addition, the papers are chosen from submissions by a select group of noted researchers.

In this section are the conference agendas as well as summaries of some of the conferences that appeared in our *FRBSF Economic Letter*.

Federal Reserve "Day Ahead" Conference on Financial Markets

Federal Reserve Bank of San Francisco
January 2, 2009

Sponsored by the Federal Reserve Bank of San Francisco

Links to some papers presented at this conference can be found at
http://www.frbsf.org/economics/conferences/0901/agenda.pdf

Session 1: Expectations, Market Returns, and Market Risks

Chair: Brian Madigan, *Federal Reserve Board*

Expectations of Risk and Return among Household Investors: Are Their Sharpe Ratios Countercyclical?

Gene Amromin, *FRB Chicago*
Steven A. Sharpe, *Federal Reserve Board*

A Black Swan in the Money Market

John B. Taylor, *Stanford University*
John C. Williams, *FRB San Francisco*

Inflation and the Stock Market: Understanding the "Fed Model"

Geert Bekaert, *Columbia University*
Eric Engstrom, *Federal Reserve Board*

Inflation Expectations and Risk in an Arbitrage-Free Model of Nominal and Real Bond Yields

Jens H. E. Christensen, *FRB San Francisco*
Jose Lopez, *FRB San Francisco*
Glenn Rudebusch, *FRB San Francisco*

Session 1 Discussants:
Tobias Adrian, *FRB New York*
Andrew Levin, *Federal Reserve Board*
Kevin Lansing, *FRB San Francisco*
Mark Jensen, *FRB Atlanta*

Session 2: Liquidity Shocks and Asset Prices

Chair: Bill Dudley, *FRB New York*

The Anatomy of a Financial Crisis: The Evolution of Panic-Driven Runs in the Asset-Backed Commercial Paper Market

Daniel Covitz, *Federal Reserve Board*
Nellie Liang, *Federal Reserve Board*
Gustavo Suarez, *Federal Reserve Board*

The Impact of Creditor Protection on Stock Prices in the Presence of Credit Crunches

Galina Hale, *FRB San Francisco*
Assaf Razin, *Tel Aviv University and Cornell University*
Hui Tong, *International Monetary Fund*

Liquidity Crisis, Runs, and Security Design: Lessons from the Collapse of the Auction Rate Municipal Bond Market

Song Han, *Federal Reserve Board*
Dan Li, *Federal Reserve Board*

Session 2 Discussants:
Peter Lupoff, *Millennium Management and IAFE*
Rochelle Edge, *Federal Reserve Board*
Til Schuermann, *FRB New York*

Session 3: Regulation of Financial Institutions

Chair: Fred Furlong, *FRB San Francisco*

Stress Testing Banking Book Positions under Basel II

Paul Kupiec, *Federal Deposit Insurance Corporation*

Financial Innovation and Corporate Default Rates

Samuel Maurer, *FRB New York*
Hoai-Luu Nguyen, *FRB New York*
Asani Sarkar, *FRB New York*
Chenyang Wei, *FRB New York*

Escape from New York: The Market Impact of Loosening Disclosure Requirements

Nuno Fernandes, *IMD*
Ugur Lel, *Federal Reserve Board*
Darius Miller, *Southern Methodist University*

A Model of CMBS Spreads

Joseph Nichols, *Federal Reserve Board*
Amy Cunningham, *Federal Reserve Board*

Session 3 Discussants:
Matt Pritsker, *Federal Reserve Board*
William Keeton, *FRB Kansas City*
Paula Tkac, *FRB Atlanta*
Mario Ugoletti, *U.S. Department of the Treasury*

Session 4: Subprime Mortgage Crisis

Chair: Harvey Rosenblum, *FRB Dallas*

Understanding the Subprime Mortgage Crisis

Yuliya Demyanyk, *FRB St. Louis*
Otto Van Hemert, *New York University*

The Subprime Mortgage Crisis: Irrational Exuberance or Rational Error?

Nikola Kojucharov, *Federal Reserve Board*
Clyde F. Martin, *Texas Tech University*
Robert F. Martin, *Federal Reserve Board*
Lili Xu, *Texas Tech University*

Vintage and Credit Rating: What Matters in the ABX Data during the Credit Crunch?

Mardi Dungey, *University of Cambridge*
Jerry Dwyer, *FRB Atlanta*
Tom Flavin, *National University of Ireland Maynooth*

Foreclosures in Ohio: Does Lender Type Matter?

O. Emre Ergungor, *FRB Cleveland*

Session 4 Discussants:
Andreas Lehnert, *Federal Reserve Board*
Kris Gerardi, *FRB Atlanta*
Shane Sherlund, *Federal Reserve Board*
Bob Avery, *Federal Reserve Board*

Macroeconomic Models for Monetary Policy

Federal Reserve Bank of San Francisco
March 6, 2009

Sponsored by the Federal Reserve Bank of San Francisco

Links to papers presented at this conference can be found on the website
http://www.frbsf.org/economics/conferences/0903/index.html

Keynote Speaker

Eric Rosengren, *FRB Boston*

Reset Price Inflation and the Impact of Monetary Policy Shocks

Mark Bils, *University of Rochester*
Peter Klenow, *Stanford University*
Benjamin Malin, *Federal Reserve Board*

Discussants: Virgiliu Midrigan, *New York University*
Ricardo Reis, *Columbia University*

Estimating a Medium-Scale DSGE Model with Expectations Based on Small Forecasting Models

Sergey Slobodyan, *Charles University CERGE and Czech Economics Institute*
Raf Wouters, *National Bank of Belgium*

Discussants: Marco Del Negro, *FRB New York*
George Evans, *University of Oregon*

A Monetary Business Cycle Model with Labor Market Frictions

Lawrence Christiano, *Northwestern University*
Mathias Trabandt, *European Central Bank and Sveriges Riksbank*
Karl Walentin, *Sveriges Riksbank*

Discussants: Shin-Ichi Nishiyama, *Bank of Canada*
Simon Gilchrist, *Boston University*

Optimal Monetary Policy in a Model of the Credit Channel

Fiorella De Fiore, *European Central Bank*
Oreste Tristani, *European Central Bank*

Discussants: Vasco Cúrdia, *FRB New York*
Tao Zha, *FRB Atlanta*

Potential and Natural Output

Alejandro Justiniano, *FRB Chicago*
Giorgio Primiceri, *Northwestern University*

Discussants: John Leahy, *New York University*
Carl Walsh, *University of California, Santa Cruz*

Asia and the Global Financial Crisis
Asia Economic Policy Conference

October 19–20, 2009

Sponsored by the Federal Reserve Bank of San Francisco

Links to papers presented at this conference can be found at
http://www.frbsf.org/economics/conferences/aepc/2009/agenda.php

Speakers

Asia and the Global Financial Crisis — Ben Bernanke, *Federal Reserve Board of Governors*

Reforming the Global Financial Architecture — Sir Andrew Crockett, *JPMorgan Chase International*

Asia, the Financial Crisis, and Global Economic Governance — John Lipsky, *International Monetary Fund*

Papers

The Impact of the Financial Crisis on Emerging Asia
Morris Goldstein, *Peterson Institute for International Economics*
Daniel Xie, *Peterson Institute for International Economics*

Discussant: Michael Mussa, *Peterson Institute for International Economics*

Lessons from Asian Financial Experience
Anne Krueger, *Johns Hopkins University*

Discussant: Andrew Sheng, *China Banking Regulatory Commission*

Global Imbalances and the Financial Crisis: Products of Common Causes
Maurice Obstfeld, *University of California, Berkeley*
Kenneth Rogoff, *Harvard University*

Discussants: Ricardo Caballero, *Massachusetts Institute of Technology*
Jacob Frenkel, *Group of Thirty*

Fire, Flood, and Lifeboats: Policy Responses to the Global Crisis of 2007–09
Takatoshi Ito, *University of Tokyo*

Discussant: Frederic Mishkin, *Columbia Business School*

Panel Discussion: Experiences with the Crisis
Moderator: Kevin Warsh, *Federal Reserve Board of Governors*
Panelists: Heng Swee Keat, *Monetary Authority of Singapore*
Kyungsoo Kim, *Bank of Korea*
Takafumi Sato, *Financial Services Agency, Japan*

The Financial Crisis and Global Policy Reforms
Barry Eichengreen, *University of California, Berkeley*

Discussant: Anil Kashyap, *University of Chicago Booth School of Business*

The U.S. and World Economic Geography Before and After the Downturn

Federal Reserve Bank of San Francisco
November 18, 2009

Sponsored by the Federal Reserve Bank of San Francisco's Center for the Study of Innovation and Productivity

Green Hype? Green Cities, Green Buildings — John Quigley, *University of California, Berkeley*

Cities and the Housing Debacle — Jan Brueckner, *University of California, Irvine*

Lessons from Across the Pond: U.K. Urban Policy and the Downturn — Henry Overman, *London School of Economics*

The Geography of Development in Emerging Market Countries: The Case of China — Vernon Henderson, *Brown University*

Symposium: The Outlook for Consumption

Federal Reserve Bank of San Francisco
May 22, 2009

Sponsored by the Federal Reserve Bank of San Francisco's Center for the Study of Innovation and Productivity

Links to some papers presented at this symposium can be found at http://www.frbsf.org/csip/research/symposium200905.pdf

The American Consumer: Reforming or Just Resting?	Chris Carroll, *Johns Hopkins University* Jiri Slacalek, *European Central Bank*
House Price Shocks, Earning Shocks and Aggregate Consumption: Aggregating Individual Life Cycle Profiles	Orazio Attanasio, *University College London*
Housing and Consumption	Erik Hurst, *University of Chicago*
Panel Discussion	Moderator: John C. Williams, *FRB San Francisco* Charles Yuji Horioka, *Osaka University* Karen Dynan, *Federal Reserve Board* Robert Hall, *Stanford University*

Symposium: Happiness and the Economy

Federal Reserve Bank of San Francisco
September 11, 2009

Cosponsored by the Federal Reserve Bank of San Francisco's Center for the Study of Innovation and Productivity, University of Warwick, and University of Southern California

Methodology and New Approaches

Chair: Andrew Oswald, *University of Warwick*
Panelists: Nicholas Christakis, *Harvard University*
Mary Daly, *FRB San Francisco*
Michael McBride, *University of California, Irvine*

Utility Theory and Choice

Chair: Erzo Luttmer, *Harvard University*
Panelists: Miles Kimball, *University of Michigan*
Dan Benjamin, *Cornell University*
Eugenio Proto, *University of Warwick*

Global Issues and International Data

Chair: Ada Ferrer-i-Carbonell, *Institute for Economic Analysis, Barcelona*
Panelists: Carol Graham, *University of Maryland and Brookings*
John Knight, *University of Oxford*
Anke Plagnol, *University of Cambridge*

Adaptation and Comparisons

Chair: Andrew Clark, *Paris School of Economics*
Panelists: Richard Easterlin, *University of Southern California*
Arie Kapteyn, *RAND Corporation*
Mariano Rojas, *FLASCO and UPAEP*

Economic and Societal Problems

Chair: Claudia Senik, *Paris School of Economics*
Panelists: Nattavudh Powdthavee, *University of York*
Liliana Winkelmann, *University of Zurich*
Alois Stutzer, *University of Basel*

Closing Remarks

Chair: Richard Easterlin, *University of Southern California*
Panelists: Robert Willis, *University of Michigan*
Mary Daly, *FRB San Francisco*
Thomas Deleire, *University of Wisconsin, Madison*

Macroeconomic Models for Monetary Policy: Conference Summary

Reprinted from *FRBSF Economic Letter* 2009-23, July 20, 2009.

This *Economic Letter* summarizes papers presented at the conference "Macroeconomic Models for Monetary Policy" held March 6, 2009, at the Federal Reserve Bank of San Francisco.

The current financial crisis underscores the need for better macroeconomic models to help central banks forecast the economy and analyze the effects of monetary and fiscal policy. The "Macroeconomic Models for Monetary Policy" conference held March 6, 2009, at the Federal Reserve Bank of San Francisco brought together leading researchers from academia and central banks to discuss ways of improving macroeconomic models for monetary policy. Papers presented at the conference focused on five important questions: Why do many prices respond slowly to economic events? What makes wages sluggish and at what point do firms lay off workers? How do households and firms form expectations about the future? How do financial market frictions affect the decisions of households, firms, and the central bank? What is the best way to measure potential output?

What makes prices slow to adjust?

Some prices—such as those for gasoline, airfare, and fresh produce—change very frequently. But prices for about 70 percent of goods and services in the United States change much less often, only about once every six to twelve months. The speed of price adjustment matters for monetary policy because, if all prices in the economy always changed instantaneously, monetary policy would have little effect on the economy other than to cause prices to change. This is the classic argument that "money is a veil"—if the central bank were to double the quantity of money in circulation and the monetary doubling were perfectly anticipated by everyone in the economy and all prices were perfectly flexible, then the only effect of the central bank's action would be that all prices in the economy would double. On the other hand, if prices respond slowly—for example, because it is costly for firms to change them or because prices are set in contracts that last for several months—then changes in the quantity of money or the federal funds rate can have significant effects not only on prices, but also on production and sales.

Bils, Klenow, and Malin use data on thousands of individual price quotes from the consumer price index to create a new measure of price changes, which they call "reset price inflation." For any product, the "reset price" is defined as the price the seller would like to be in effect today. Reset price inflation—the average percent change in reset prices—is less persistent than observed inflation because in the latter price changes don't occur instantly, but rather are spread out over several months. Reset price inflation thus provides us with an additional perspective on how prices in a macroeconomic model behave and how that behavior compares to the data.

Bils, Klenow, and Malin estimate the reset price for every product in every month using price changes of comparable products to infer what every other product's reset price would have been if that product had also experienced a price change. The method is like using comparable sales to estimate the price of a home. The authors compare their constructed measure of reset price inflation to the prediction of a number of different models of price rigidity. They find that reset price inflation is most consistent with models in which firms can change prices whenever they want, subject to a cost—which may be due to printing new menus or catalogs, losing some percentage of repeat customers, or other factors—rather than models in which prices are set for fixed periods, such as a year. The lack of persistence in reset price inflation in the late 1980s and 1990s also suggests that monetary policy reacted strongly to movements in inflation throughout that period. The authors note that these conclusions are still tentative and many puzzles remain regarding the behavior of reset price inflation.

What makes labor markets sluggish?

It takes time to find a job or fill a vacancy. When compatible workers and firms do meet, terms of employment such as wages, hours, and benefits are often subject to negotiation. When economic conditions deteriorate, firms typically lay off a fraction of their employees rather than spread wage cuts across their entire workforce. What are the economic causes and consequences of these labor market frictions?

Traditional macroeconomic models invoke union-type wage contracts as the primary source of labor market frictions. But as the extent of unionization in the United States has declined to less than 15 percent of the labor force, explanations based solely on union contracts have become less persuasive. Christiano, Trabandt, and Walentin consider alternative labor market frictions in an otherwise standard

macroeconomic model and find that the traditional union-type model of wage contracting is hard to beat. One reason might be that there are implicit rather than explicit wage contracts between workers and firms that mimic formal union agreements. However, the authors also find that they can match U.S. GDP and inflation data just as well using a more decentralized model in which workers and firms search for each other, bargain over wages once matches are found, and continue employment until either the worker leaves for personal reasons or the firm fires the worker due to deteriorating business conditions. The advantage of the authors' more decentralized model is that it more accurately describes worker flows into and out of employment than a union-type wage contracting model, in which workers are never truly considered unemployed but, in effect, relax at home until the union calls them back to work. Thus, the authors' decentralized labor market model can potentially make better predictions about the effectiveness of such government policies as unemployment benefits and job training programs in helping unemployed workers find suitable jobs.

How are expectations formed?

Decisions by households and firms today are closely tied to their views about the future. As a result, understanding how households and firms form expectations is crucial for understanding how they make decisions regarding consumption, investment, and employment today.

A common assumption in macroeconomics is that households and firms have "rational expectations"—that is, they form expectations about the future in a mathematically optimal way, taking into account all of the equations that describe the economy and all of the information in the economy. While this assumption provides a useful and mathematically tractable benchmark, it probably overstates the knowledge and mathematical acumen possessed by actual households and firms. Slobodyan and Wouters modify an otherwise typical macroeconomic model to allow households and firms to form expectations using small, simple forecasting models. Agents in the authors' model are not naive, but rather update their forecasting models continuously and favor alternative models based on how their forecasts have performed over time.

Slobodyan and Wouters show that models that allow expectations to be formed this way fit many aspects of the data much better than do models in which expectations are formed with perfect rationality. For example, prices and wages in the authors' model respond sluggishly to surprise changes in policy because they assume it takes households and firms some time to learn what the effects of those policies will be. Also, inflation expectations and inflation persistence in the United States have both gradually declined since the 1970s, which is much easier to explain using the authors' dynamic model of expectations than with a model assuming perfectly rational expectations.

Financial market frictions

A striking feature of the current economic crisis is the dramatic effect financial market disruptions have had on the real economy. Yet standard macroeconomic models assume that financial markets are frictionless, always matching buyers and sellers at prices that perfectly equate risk-adjusted returns across all types of securities. Bankruptcy and default are typically nonexistent in these models.

De Fiore and Tristani begin to address these shortcomings by incorporating credit market frictions into an otherwise standard macroeconomic model. In the authors' model, banks lend to firms, but there is some probability that any given firm will be unable to repay a loan and default. When firms default, the bankruptcy process imposes costs on the bank and to society. Banks cover the expected losses from default by diversifying, lending to large numbers of firms at an interest rate above the federal funds rate.

De Fiore and Tristani use their model to analyze the mathematically optimal monetary policy in the presence of financial frictions and default. They show that it is optimal for monetary policy to ease very aggressively in response to an adverse financial market shock, a finding that stands in sharp contrast to the popular Taylor rule, which would set short-term interest rates based on how far output diverges from potential output and inflation diverges from the central bank's target for inflation and would prescribe only a mild response to financial disruption.

Potential output

One of the central concepts in macroeconomics is potential output, the level of a country's GDP that would occur if that country were not in an unusually expansionary or recessionary period. When output is above potential, then the "output gap" is positive, the economy is in a boom, and it is generally optimal for monetary policy to be tighter than normal. When output is below potential, the output gap is negative, the economy is in a slump, and it is usually optimal for monetary policy to be easier than normal.

The standard method of measuring potential output is to draw a smooth trend line (or a smooth curve) through the history of U.S. data. However, that approach is problematic in a macroeconomic model, because such models are independent of any single country's data and should be applicable to many different national economies. Moreover, the trend-line approach is unsatisfying because one can imagine that a persistent boom or slump might inappropriately affect the

estimated trend. A model-based definition of potential output avoids these problems and has other applications, such as simulating how the output gap and monetary policy would evolve under alternative forecast scenarios.

Justiniano and Primiceri assess different measures of potential output in a state-of-the-art macroeconomic model. They show under what conditions the model can produce an output gap estimate that closely matches the traditional, trend-based measure for the United States. The authors' model generalizes the traditional measure of the output gap to the case of a macroeconomic model, which makes the definition easy to apply to any country or any forecast scenario. Moreover, their approach is well adapted to the case of a long boom or slump, and allows potential output to change rapidly if fundamental economic conditions change suddenly, something that a slowly evolving trend does not allow. The authors conclude with an exercise that investigates the extent to which U.S. business cycles have been amplified by imperfect competition in product and labor markets and find that this amplification has been substantial.

Eric Swanson
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Conference papers

Links to papers presented at the conference are available at http://www.frbsf.org/economics/conferences/0903/index.html

Bils, Mark, Peter Klenow, and Benjamin Malin. "Reset Price Inflation and the Impact of Monetary Policy Shocks."

Christiano, Lawrence, Mathias Trabandt, and Karl Walentin. "A Monetary Business Cycle Model with Labor Market Frictions."

De Fiore, Fiorella, and Oreste Tristani. "Optimal Monetary Policy in a Model of the Credit Channel."

Justiniano, Alejandro, and Giorgio Primiceri. "Potential and Natural Output."

Slobodyan, Sergey, and Raf Wouters. "Estimating a Medium-Scale DSGE Model with Expectations Based on Small Forecasting Models."

Asia and the Global Financial Crisis: Conference Summary

Reprinted from *FRBSF Economic Letter* 2010-08, March 15, 2010.

This *Economic Letter* summarizes papers presented at "Asia and the Global Financial Crisis," the first Asia Economic Policy Conference of the Federal Reserve Bank of San Francisco's Center for Pacific Basin Studies, held October 19–20, 2009, in Santa Barbara, California.

"Asia and the Global Financial Crisis" brought together experts from around the world to discuss the transmission of the crisis to Asia and the responses of economic policymakers and regulators.

In opening remarks, Federal Reserve Chairman Ben Bernanke noted that, in the aftermath of the financial crisis of the late 1990s, many emerging market economies in Asia and elsewhere took advantage of improved global conditions to strengthen their economic and financial fundamentals. They bolstered fiscal and foreign debt positions, accumulated foreign exchange reserves, and reformed their banking sectors. When financial turmoil erupted in the summer of 2007, Asian economies were well positioned to avoid its worst effects. In particular, most financial institutions in the region were not heavily exposed to distressed markets for structured credit products and other asset-backed securities.

Still, Asian nations were affected in late 2007 and 2008 when economies weakened in the United States and other industrial countries. The global financial crisis intensified dramatically when Lehman Brothers failed in September 2008. As investor appetite for risk declined, capital flows shifted away from countries that were viewed as more vulnerable. Moreover, financial institutions withdrew money from risky assets in both advanced and emerging markets. The Federal Reserve established liquidity swap lines with central banks in Asia and other regions to help alleviate dollar funding pressures.

In Bernanke's view, emerging Asia's sound macroeconomic and financial fundamentals provided room for maneuver in carrying out countercyclical monetary and fiscal policy, in contrast with earlier crises or compared with options available to other emerging market countries. In particular, China implemented a sizable fiscal program, supplemented by accommodative monetary and bank lending policies. Bernanke attributed Asia's relatively rapid recovery in large part to such domestic demand-boosting policies, which provided a substitute for exports to trading partners outside the region.

Day 1: National experiences of the crisis

First-day presentations reviewed national experiences of the crisis. Morris Goldstein and Daniel Xie identified several characteristics that affected the depth of the downturn among Asian countries. China and India experienced relatively small growth slowdowns, but the economies of Hong Kong, Korea, Singapore, and Taiwan contracted sharply, on par with the recessions they experienced during the financial crisis of 1997–98.

Declining demand for imports among advanced economies transmitted the crisis to export-reliant Asian countries. And, compared with most other emerging market regions, emerging Asia was more sensitive to falling U.S. equity and bond prices. On the other hand, emerging Asia benefited because it had not increased its exposure to banks in the advanced countries in the decade preceding the crisis. Developing Asian countries also relied more than other emerging market regions on foreign direct investment inflows. And Asian economies were not heavily exposed to U.S. subprime loans. Goldstein and Xie also argued that Asian countries largely avoided the combustible mix of large currency depreciations and adverse mismatches in the currency denominations of assets and liabilities. Recent experience in emerging Europe underscores the risk when currency and maturity mismatches are not controlled.

Anne Krueger drew out several lessons from the experiences of Japan and Korea during the 1997–98 financial crisis. First, policymakers must choose an exchange rate regime compatible with monetary and fiscal policy. Unless policymakers are willing to subordinate monetary and fiscal policy to the demands of a fixed exchange rate regime, a flexible exchange rate is preferable. Secondly, mismatches between banking assets and liabilities must be avoided. When their currency denominations differ, unhedged positions are vulnerable to exchange rate movements. Thirdly, short-term debt should not exceed foreign exchange reserves.

Krueger noted that delays in addressing financial problems are costly. The extent to which authorities implement policies forcefully and quickly is an important determinant of the speed of recovery. Krueger emphasized that authorities must recapitalize financial institutions and see to it that nonperforming loans are addressed. Fiscal stimulus can boost growth in the short term, as it did in Japan in 1996.

But this is likely to be temporary and full recovery unsustainable as long as the financial system remains impaired. Secondly, official credibility and transparency are crucial. Uncertainty about the health of financial institutions can prolong and deepen crises.

Maurice Obstfeld and Kenneth Rogoff argued that, although global imbalances in trade and capital flows didn't cause the crisis, they were generated by some of the same underlying factors and they amplified its magnitude. Excessively stimulatory U.S. monetary policy combined with low global interest rates, credit market distortions, and problematic financial innovations led to a housing bubble. At the same time, exchange rate, and other economic policies of emerging market countries such as China helped the United States borrow cheaply abroad to finance its bubble. To limit future global imbalances, Obstfeld and Rogoff suggested policies to improve domestic financial market efficiency in less-developed economies, where structural shortcomings tend to boost corporate and household saving rates. They also proposed stronger global financial market regulation, including more extensive international cooperation.

In a keynote address, Andrew Crockett argued that the crisis showed that market failures are more widespread and problematic than previously believed. In the future, the global financial system is likely to continue to be market driven, but regulation will play a more substantial role. Crockett foresaw a fragmented institutional structure, with various international regulatory bodies playing roles alongside established international financial institutions, such as the International Monetary Fund. Asian countries are likely to have a larger voice, consistent with their growing economic clout.

Day 2: Policy responses to the crisis

In day two of the conference, presentations concentrated on policy responses to the crisis. Takatoshi Ito focused on the U.S. Treasury Department's liquidity provision programs and the Federal Reserve's monetary easing campaign, drawing comparisons with the actions of the Japanese Ministry of Finance and the Bank of Japan during that country's 1997 financial crisis. Japan's crisis started with the Lehman Brothers-like failure of Hokkaido Takushoku Bank. It was also marked by the Bank of Japan's "quantitative easing" monetary policy after interest rates reached the zero bound, similar to the Federal Reserve's balance sheet expansion in 2008 and 2009.

Ito argued that the March 2008 forced sale of Bear Stearns led investors to believe that other troubled financial institutions would also get assistance, magnifying the shock when Lehman Brothers was allowed to go under. The near failure of Bear Stearns indicated that the crisis had become severe enough to threaten the global financial system. In the immediate aftermath of the Lehman failure, U.S. authorities squandered an opportunity to impose a tough financial recovery program, which would have kept taxpayer losses smaller, according to Ito. He concluded that policy actions taken during the crisis appeared to have prevented the worst outcomes, but financial conditions would have improved more rapidly if U.S. regulators had shut down troubled institutions early in the crisis.

In a panel of Asian policymakers, Heng Swee Keat, Managing Director of the Monetary Authority of Singapore, noted that the global financial crisis showed Asia's "deep integration" with the rest of the world, putting to rest the theory that nations in the region had decoupled from the global economy. Asian nations experienced a severe collapse in trade, with exports within Asia plummeting even more than the decline in regional exports to the United States and Western Europe. However, Asian monetary and financial systems proved resilient, thanks partly to reforms enacted following the 1997–98 financial crisis, including regulations encouraging Asian investors to avoid currency mismatch exposure.

Kyungsoo Kim, Deputy Governor of the Bank of Korea, said his country experienced substantial capital outflows at the beginning of the crisis that resulted in downward exchange rate pressure. Korean authorities took steps to ensure the liquidity of domestic financial markets, including the establishment of a $30 billion swap arrangement with the Federal Reserve. Kim highlighted the difficulties associated with procyclical capital inflows in small, open economies, arguing that the crisis showed that capital flows need to be managed to avoid excessive swings in credit conditions.

Takafumi Sato, former Commissioner of Japan's Financial Services Agency, compared the effects of the recent crisis on Japan with the impact of that country's financial troubles of the 1990s. The recent crisis was less damaging to Japanese financial markets because the problems originated outside Japan. Japanese banks were generally less exposed to securitized assets than their U.S. and European counterparts. In addition, reforms undertaken by Japan in response to the previous crisis allowed for a quick response this time. Nevertheless, the Japanese financial system was not immune to this crisis, particularly after Japanese exports plummeted. Regulators took steps to maintain the functioning of financial markets by, for example, authorizing government and central bank purchases of commercial paper, and implementing other liquidity provisions.

Following the panel, Barry Eichengreen outlined global policy reforms that should be implemented in light of the crisis. Eichengreen cited two primary causes of the crisis: excessive deregulation and global imbalances that fueled an unsustainable U.S. credit boom. Financial institutions had incentives that prompted them to take on ever greater levels of risk. Moreover, lenders made inadequate efforts to evalu-

ate asset risk because they followed an originate-to-distribute business model that left them with little exposure. Meanwhile, rating agencies lacked the capacity to value complex instruments and faced conflicts of interest in doing so. Eichengreen's policy prescriptions included regulations requiring reduced leverage, incorporation of off-balance-sheet items into financial assessments, creation of resolution mechanisms for nondepository institutions, and enhancement of regulatory agency resources.

Eichengreen concluded that monetary policy makers should pay attention to global imbalances, even when inflation is absent. In countries that borrow in their own currency, policymakers should address fiscal policy procyclicality. Reserve accumulation should be less aggressive because building such surpluses requires global imbalances. Finally, Eichengreen argued that relative prices need to be adjusted to deal with changes in patterns of demand. This can happen either through exchange rate adjustment or inflation, although adjustment is likely to be less disruptive.

In a closing address, International Monetary Fund Deputy Managing Director John Lipsky noted that the global economy remained in an exceptionally vulnerable state, despite signs of recovery. Ensuring continued growth requires broad international collaboration. He criticized the notion that Asian nations had decoupled from the global economy, pointing out that growth appeared to be most robust in those countries that were most integrated with the rest of the world. Overall, recovery in Asian nations reflected quick and forceful policy responses, which were aided by strong economic fundamentals. Lipsky stressed that policy support should be maintained until incipient recoveries become more durable.

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Conference papers

Links to conference papers are available at
http://www.frbsf.org/economics/conferences/aepc/2009/agenda.php

Eichengreen, Barry. "The Financial Crisis and Global Policy Reforms."

Goldstein, Morris, and Daniel Xie. "The Impact of the Financial Crisis on Emerging Asia."

Ito, Takatoshi. "Fire, Flood, and Lifeboats: Policy Responses to the Global Crisis of 2007–09."

Krueger, Anne. "Lessons from Asian Financial Experience."

Obstfeld, Maurice, and Kenneth Rogoff. "Global Imbalances and the Financial Crisis: Products of Common Causes."

The U.S. and World Economic Geography Before and After the Downturn

Reprinted from *FRBSF Economic Letter* (forthcoming).

This *Economic Letter* summarizes the sessions of the Center for the Study of Innovation and Productivity conference, "The U.S. and World Economic Geography Before and After the Downturn," held at the Federal Reserve Bank of San Francisco November 18, 2009.

At the conference, four leading experts on economic geography and urban economics gave talks spanning a wide set of economic geography topics that are relevant in the aftermath of the recent economic crisis. These included the outlook for urban structure in the United States in the wake of the housing downturn, urban policy changes in the United Kingdom, how the geography of China's economic development may have been affected by the global downturn, and the widespread trend toward "green" construction in the face of global warming.

Cities and the housing crisis

Most analysts point to the dramatic correction in house prices starting in 2006 as the catalyst for the wider financial and economic crises we are only now digging out of. Jan Brueckner of the University of California, Irvine, an expert in urban and real estate economics, looked at what the housing correction means for the future of residential investment, home ownership, and broad trends in economic geography. He focused on possible short- to long-run ramifications of the housing "debacle" on the economic geography of the United States. In particular, he considered the potential effects of the crisis on the location and quantity of residential investment, the social capital of neighborhood life, and intranational migration patterns.

Brueckner speculated that the large fall in house prices may have caused households to rethink the riskiness of homeownership as an investment. The increase in the perceived risk of owning a home could lead to a permanently lower rate of homeownership, as well as a shift in preferences toward smaller, less expensive houses. These effects, in turn, could have an impact on the geography of the nation's housing sector. In particular, shifts toward renting instead of owning and toward smaller homes for those who do own could lead to denser, more compact cities and slow or reverse urban sprawl.

Although some would welcome a reduction in urban sprawl, the social capital of existing neighborhoods—i.e., the value generated by social networks and relationships formed within a community—could be a casualty of the housing crash, according to Brueckner. The enormous loss of housing equity across the nation is forcing many people to uproot themselves and their families, severing bonds with their communities. Secondly, a decline in homeownership rates implies fewer households are firmly planted in their communities. A large volume of social science literature documents that, compared with nonowners, homeowners are more likely to invest in the social capital of the community by voting, participating in community organizations, maintaining their property, becoming active in local schools, and similar acts of social solidarity. To the extent that renters replace owners, the production of social capital could fall.

Potential shifts toward owning smaller homes or renting, however, are likely to be longer-term trends. In the short run, the decline in housing equity may "lock in" households. That is, many households may be unable to move because the market value of their house is below what they owe on their mortgage. Alternatively, their equity may be too small to afford a down payment on a new house, especially given higher down payment requirements these days. This lock-in and a subsequent drop in intranational migration could hamper the job-matching process, whereby job seekers in depressed areas move to areas where job openings are more abundant. Such job matching is an important dynamic helping to pull economies out of recession.

Lessons from across the pond

Of course, the United States was not alone in experiencing a housing crash that triggered financial and economic crises. Along with other countries, the United Kingdom suffered in many of the same ways. Henry Overman of the London School of Economics discussed how the economic downturn has varied geographically within Britain and how this has affected urban policy. Overman pointed out that, early in the recession, many observers assumed that London and the south of England would suffer disproportionately due to the importance of the financial sector in that region. However, it turned out that the manufacturing-intensive north saw the largest dropoff in economic activity.

Local governments in the hardest-hit areas have responded in different ways, according to Overman. Some have sought

to help small businesses obtain loans. Others have increased grants and incentives targeted at such activities as research and development. Still others have tried to create jobs and attract future businesses by initiating large infrastructure projects. Overman argued that local government stimulus is likely to be less effective than national monetary and fiscal support for several reasons: Local policy often is slow-moving. It can end up siphoning off economic activity from surrounding areas. And "leakage" can occur when local government spending goes to out-of-the-area recipients. He recommended that local governments instead focus on helping individuals and families weather the downturn by providing advice and small-scale housing assistance. He also encouraged cities to reconsider restrictive land use policies which have contributed to the tremendous volatility that has characterized British residential and commercial real estate prices in recent decades.

The current downturn has increased calls for national government policies aimed at closing the gaps between rich and poor areas of Great Britain. Overman argued that, in the past, many such policies have been ineffective or have actually worsened such gaps. Policies should instead focus on aiding poor people rather than poor areas, which would allow market forces to determine the most efficient geographic distribution of economic activity, he concluded.

China and the geography of economic development

The rapid economic growth in China and other emerging markets has led to enormous geographic reallocations of population and production. J. Vernon Henderson of Brown University documented the major shifts in urbanization in China over past three decades, especially the mass migration from rural areas to cities. Despite the vast movement of population, China by many measures remains too rural. For example, based on GDP per capita and the cross-country relationship between per capita GDP and the urban share of the population, China should have a 55 percent urban share instead of its actual 46 percent share. Moreover, Henderson's research has shown that China's urban population is less urban than urban populations in other countries. The majority of China's population living in cities with over 100,000 people lives in small cities of less than one million people. Less than 4 percent live in megacities of more than 12 million. In the rest of the world, a little over a third of the urban population lives in small cities and nearly 10 percent live in megacities. Henderson estimated that China's output per worker would increase significantly if the urban population were concentrated in larger cities.

One reason why China has not urbanized more quickly is that intranational migration is severely restricted by the government, Henderson noted. These restrictions prevent rural people from permanently relocating to the cities where jobs are more abundant. Nonetheless, an enormous number of migrants appear to have moved despite the restrictions. The global downturn weakened China's export sector and may have stemmed the tide of urban migration. But China's exports have rebounded and this has led to a revival of labor demand in Chinese cities, spurring renewed migration from rural areas, Henderson concluded.

Going green while in the red

One longer-run trend affecting economic geography in the U.S. and globally is climate change. The recent recession probably had little impact on the underlying warming trend, but recessions often push businesses and households to redouble their efforts to control costs. Faced with the prospects of rising temperatures, commercial and residential property owners in many regions may have accelerated a trend already under way toward making homes and buildings more "green" or energy-efficient. John Quigley of the University of California, Berkeley, examined the extent to which the greening of buildings is being capitalized in rents and sale prices.

Quigley noted that commercial buildings account for a large share of energy costs in the United States and that energy expenditures represent a significant part of the total occupancy costs of buildings. Increasing public pressure on commercial property owners to help reduce energy consumption and carbon emissions has accelerated a trend toward building and marketing so-called "green" buildings. Property owners and developers value a green rating from such certification programs as EnergyStar and LEED. They say they may be able to command higher rents, stemming in part from the ability of tenants to market themselves as environmentally sensitive. They may also get higher sale prices because green buildings have lower energy and maintenance costs.

Quigley and fellow researchers have attempted to estimate what rental and sales-price premiums green-rated buildings get. They compared prices of green buildings with other comparable structures located nearby in cities across the United States. They found that, all else equal, green buildings fetch 2 to 3 percent higher rents and 16 to 17 percent higher prices than similar nongreen buildings. Quigley concluded that these premiums primarily reflect real energy cost savings and are not due merely to the cachet of the green label.

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Conference presentations

Links to presentations are available at
http://www.frbsf.org/csip/index.php.

Brueckner, Jan. "Cities and the Housing Debacle."

Henderson, Vernon. "The Geography of Development in Emerging Market Countries: The Case of China"

Overman, Henry. "Lessons from Across the Pond: U.K. Urban Policy and the Downturn."

Quigley, John. "Green Hype? Green Cities, Green Buildings."

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09-01-02 U.S. Monetary Policy Objectives in the Short and Long Run / *Janet Yellen*

09-03 The Tech Pulse Index: Recent Trends in Tech-Sector Activity / *Bart Hobijn*

09-04 Behavior of Libor in the Current Financial Crisis / *Simon Kwan*

09-05 Labor Supply Responses to Changes in Wealth and Credit / *Mary Daly, Bart Hobijn, and Joyce Kwok*

09-06 House Prices and Bank Loan Performance / *John Krainer*

09-07 Out-of-Market Small Business Loans / *Elizabeth Laderman*

09-08 Tax Credits for Job Creation and Retention: What Can We Learn from the States? / *Daniel Wilson and Charles Notzon*

09-09 How Will a Credit Crunch Affect Small Business Finance? / *Gregory Udell*

09-10 2008 Annual Pacific Basin Conference: Summary / *Reuven Glick*

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09-13 Interprovincial Inequality in China / *Christopher Candelaria, Mary Daly, and Galina Hale*

09-14 Are Fiscal Stimulus Funds Going to the "Right" States? / *Daniel Wilson*

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09-16 U.S. Household Deleveraging and Future Consumption Growth / *Reuven Glick and Kevin J. Lansing*

09-17 The Fed's Monetary Policy Response to the Current Crisis / *Glenn Rudebusch*

09-18 Jobless Recovery Redux? / *Mary Daly, Bart Hobijn, and Joyce Kwok*

09-19 How Big Is the Output Gap? / *Justin Weidner and John Williams*

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