Provision of Liquidity through the Primary Credit Facility during the Financial Crisis:

A Structural Analysis

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- Over the course of the recent liquidity crisis, the Federal Reserve made several changes to its primary credit lending facility
  - Narrow the spread between the primary credit rate and the target funds rate (from 100 bp. to 25 bp.)
  - Increase the terms of lending to 90 days

- In this paper, we provide a structural assessment of the effectiveness of these changes
- Our results suggest that most of these changes were highly effective in stabilizing the federal funds market

Artuç and Demiralp (2008)

- Develop a structural model and show that
  - The changes in the discount window facility after 2003 were highly effective:
    - The implicit costs of borrowing declined significantly after 2003
    - The borrowing function is re-established

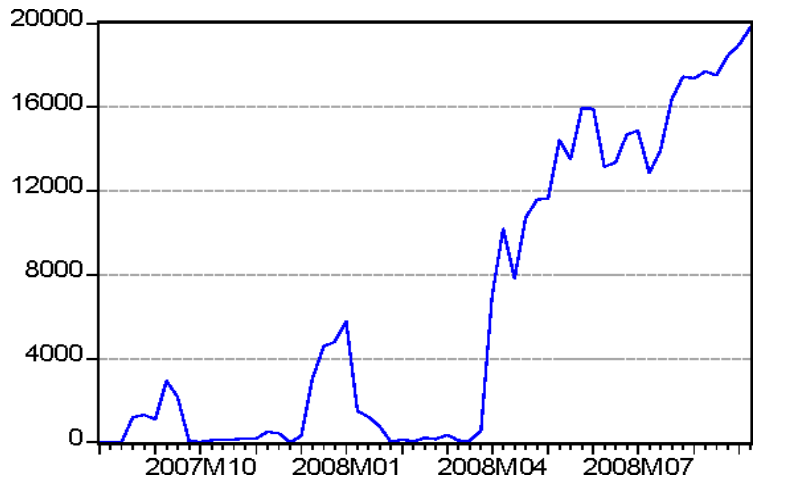
This Paper

- Rely on the model developed by Artuç and Demiralp (2008) as our baseline model
  - Perform out of sample simulations to asses the effects of changes in the primary credit facility since August 2007
- Our results are highly consistent with the predictions in Artuç and Demiralp (2008):
  - The new discount window is functional
  - It plays an essential role in controlling the volatility in the federal funds market

An Overview

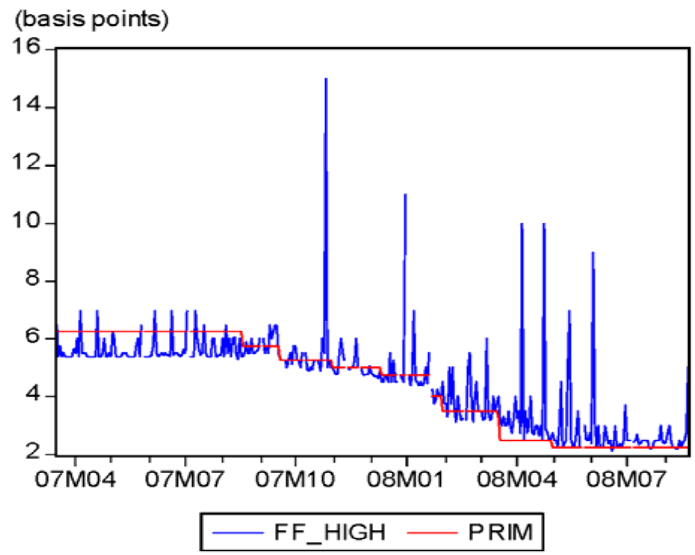
- The steps taken by the Federal Reserve to make discount window credit more accessible lead to an increase in the volume of discount window borrowing

Figure 1: Primary Credit Outstanding (Weekly Average)



- Nevertheless, some trades in the funds market took place at rates above the primary credit rate on occasion

Figure 2: Daily High Funds Rate and the Primary Credit Rate



where FF_HIGH: Daily high funds rate

PRIM: Primary Credit rate

- These findings are consistent with Artuç and Demiralp (2008)
  - The reluctance to borrow from the Federal Reserve has several components:
    - The non-price mechanism (which declined significantly after 2003)
    - Asymmetric information problems associated with discount window borrowing (which may increase at the outbreak of a crisis)
    - Lack of available collateral (at least until September 2008)

The Model

- Bank *i*'s goal is to keep its daily reserves holdings at a level L_1 (L_2 on Settlement Wednesday)
- During the day, there are aggregate (U_t) and individual(V_t^i) shocks to the average level of reserve balances ($\bar{R}$) which sets the balance of bank *i* equal to:

$$R_t^i = \bar{R} + U_t + V_t^i$$

- The individual bank becomes:
  - a lender in the funds market if $R_t^i > L$
  - demands funds if $R_t^i < L$ for $L = L_1, L_2$

- Banks that are short of reserves have two options:
  - borrow ϕ_t dollars from the funds market
    - pay the market rate r_t
  - borrow ϕ_t dollars from the Federal Reserve
    - pay discount rate (or the primary credit rate after 2003), r_f, plus a fixed cost c. Thus, total cost per dollar is

$$r_f + \frac{c}{\phi_t}$$

    - Because of the fixed cost, partial borrowing from the Federal Reserve is not optimal

- Equilibrium funds rate (r_t) is determined when the total supply of funds is equal to the total demand for funds

- We focus on individual trades in the funds market and on days of market tightness because these are the days on which borrowing from the Fed are more likely

- We set the daily high funds rate equal to:

$$r_t^{high} = r_t + \omega_t$$

- If there is a decline in the fixed cost of borrowing after 2003, this implies:
  - A decline in the volatility of the funds rate in the post-2003 period
  - An increase in the sensitivity of Fed borrowing to the funds rate
- This implied change in volatility and the revival of the borrowing function allows us to identify the size of the implicit cost before and after 2003

- In order to control for other factors that may have contributed to the decline in volatility (since 1998), we allow the distributions of U_t and V_t to get wider or narrower in a linear fashion over time:

$$X_U = A + D \times t \qquad X_V = B + E \times t$$

- Consider the following specification for the implicit borrowing cost c:

  c_1, prior to 2003,

  $c_1 + c_2$ after 2003

- The model is estimated via “Indirect Inference”
- We contemplate a simplified borrowing function as part of the auxiliary model:

$$BR_t = \beta_1 + \beta_2 (FFR - FFT)_t + \beta_3 t + \beta_4 t (FFR - FFT)_t + \beta_5 D^{2003} (FFR - FFT)_t + \beta_6 D^{Settl.Wed.} + \varepsilon_t$$

- In addition to the OLS estimates, we use the mean and the variances of borrowing and the spread between the daily high funds rate and the target as part of the auxiliary model

- Comparing the actual vs. simulated data suggests that the model is very successful in describing the data
- Estimation results suggest that the implicit fixed cost of borrowing declines about 90 percent (from 0.054 to 0.007) after the policy change in 2003

Table A1: Indirect Inference and Auxiliary Model Estimations

PANEL 1: AUXILIARY OLS REGRESSION	*Actual Data*		*Simulated Data*	
	Coefficient	Std. Err.	Coefficient	Std. Err.
1. Constant	0.48**	0.07	0.53**	0.04
2. $\tilde{r}_t$	0.26**	0.05	0.35**	0.03
3. $(1/100) \times T$	-0.04**	0.01	-0.05**	0.004
4. $(1/100) \times T \times \tilde{r}_t$	0.06**	0.01	0.05**	0.005
5. $D^{2003} \times \tilde{r}_t$	0.86**	0.22	1.01**	0.10
6. $D^{Sttl.Wed.}$	0.46**	0.11	0.48**	0.07

PANEL 2: MOMENTS	*Actual Data*	*Simulated Data*
1. Mean(ς)	0.46	0.45
2. Mean($\tilde{r}_t$)	0.42	0.37
3. Mean($\tilde{r}_{2t}$)	0.25	0.25
4. Var(ς)	3.01	2.15
5. Var($\tilde{r}_t$)	1.14	1.93
6. Var($\tilde{r}_{2t}$)	0.14	0.08

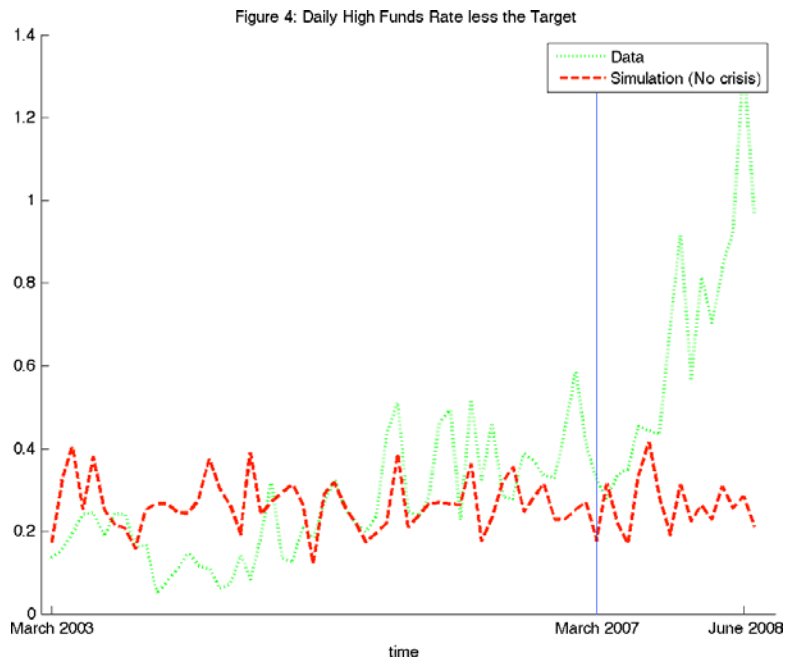
PANEL 3: INDIRECT INFERENCE ESTIMATION	Coefficient	Std. Err.
1. c_1	0.0541**	0.002
2. c_2	-0.0485**	0.004
3. A	0.4257**	0.001
4. B	0.3432**	0.0008
5. D	-0.0010**	0.0005
6. E	0.2001**	0.0007
7. F	0.0421**	0.0004
8. $\overline{R}$	0.8594**	0.0034
9. s	0.0027	0.00001
10. L_2	0.4828	0.0016

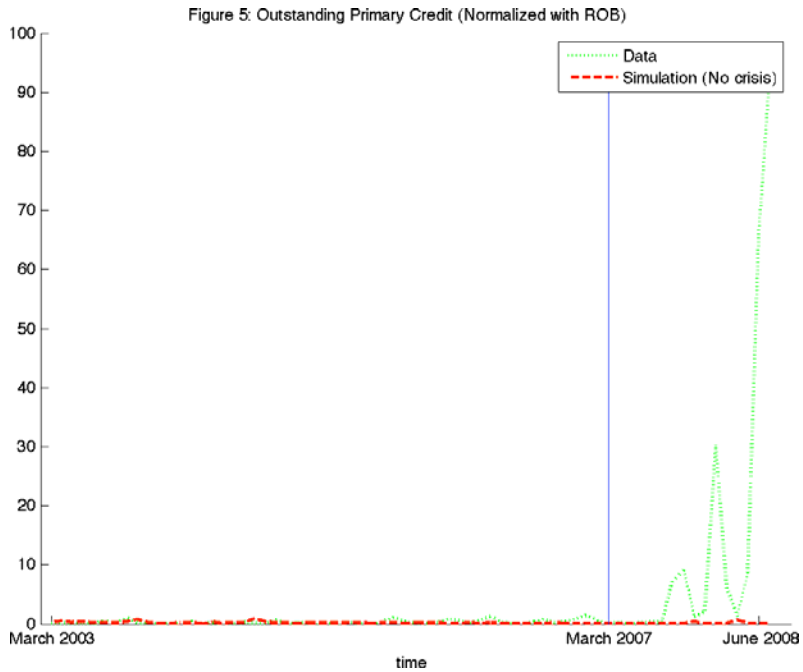
*/** indicates significance at 95 percent and 99 percent level of confidence respectively.

Simulation Analysis

- We use our model to analyze the role of the Federal Reserve's primary credit lending facility in calming money markets in the face of the liquidity crisis

- The estimation period covers June 1998 through March 2007 (daily)
  - Note: The model is estimated for the period prior to the crisis.





- There's a wide discrepeancy between the actual data and model's simulations

- We should incorporate the crisis circumstances into our model before we can conduct any counterfactual experiments about the efficiency of the Federal Reserve's policies

- Make several assumptions to replicate the conditions during the crisis :
  - Double the size of the aggregate shock (to capture the overall increase in liquidity)
  - Reduce the implicit costs of borrowing by one half (to capture the changes in terms of lending)

- The model performs better after these adjustments "Benchmark Model"

Figure 6: Daily High Funds Rate less the Target

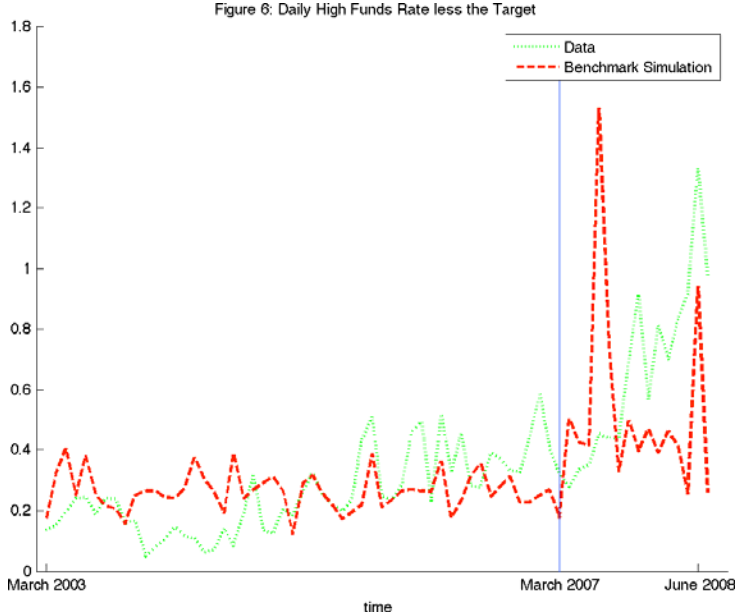
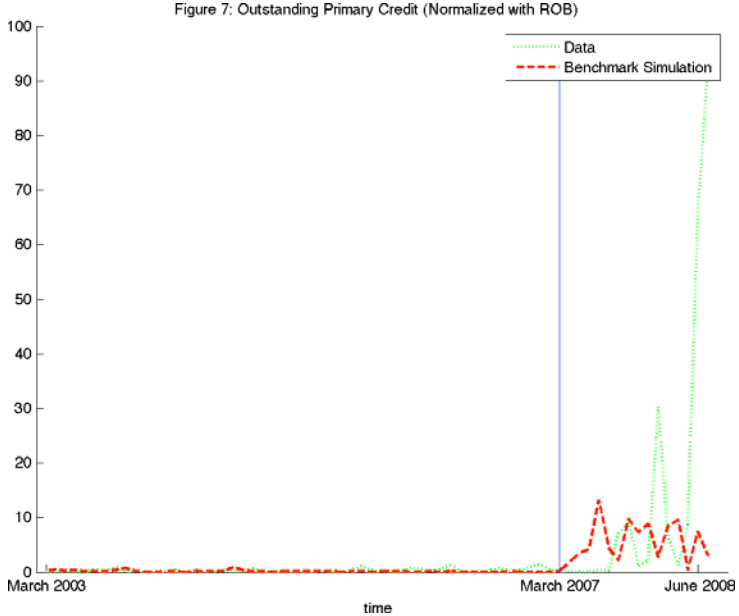
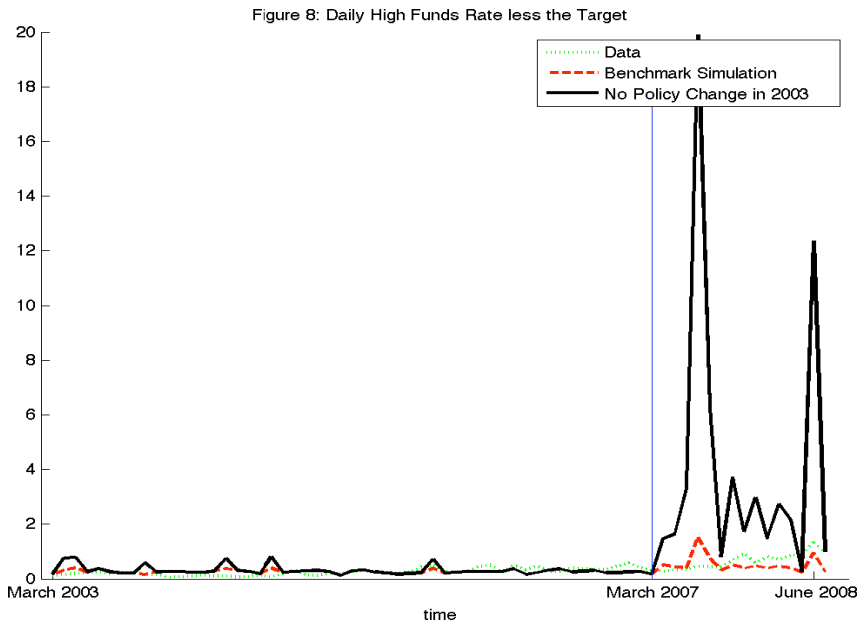


Figure 7: Outstanding Primary Credit (Normalized with ROB)



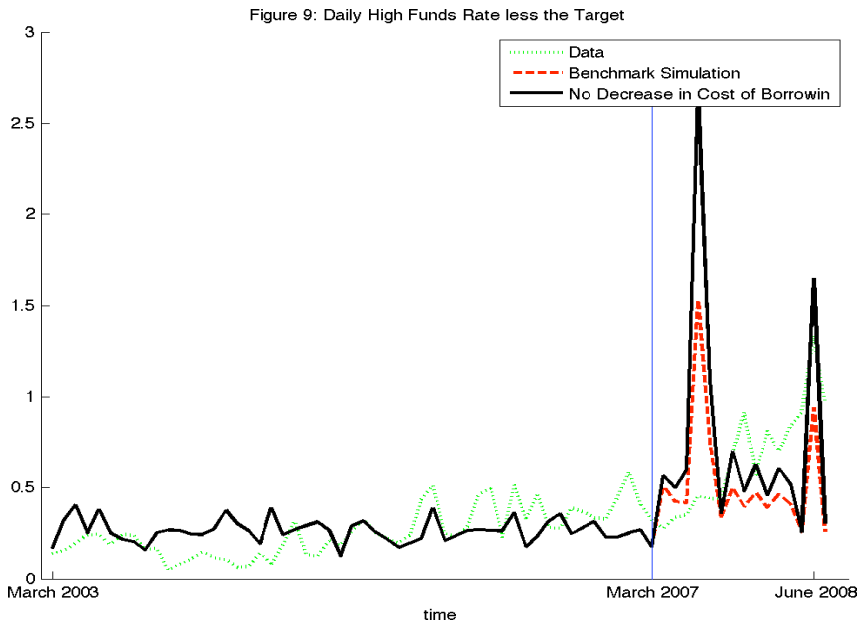
2003 Policy Change

- Had the Fed not changed its lending policy in 2003, what would the picture look like in the funds market today?
- Based on our findings in Artuç and Demiralp (2008), we would expect the volatility in the funds market to worsen significantly in the absence of the new regime because the current practice allows the needy institutions to utilize this service without much hesitation
- Figure 8 confirms our expectations



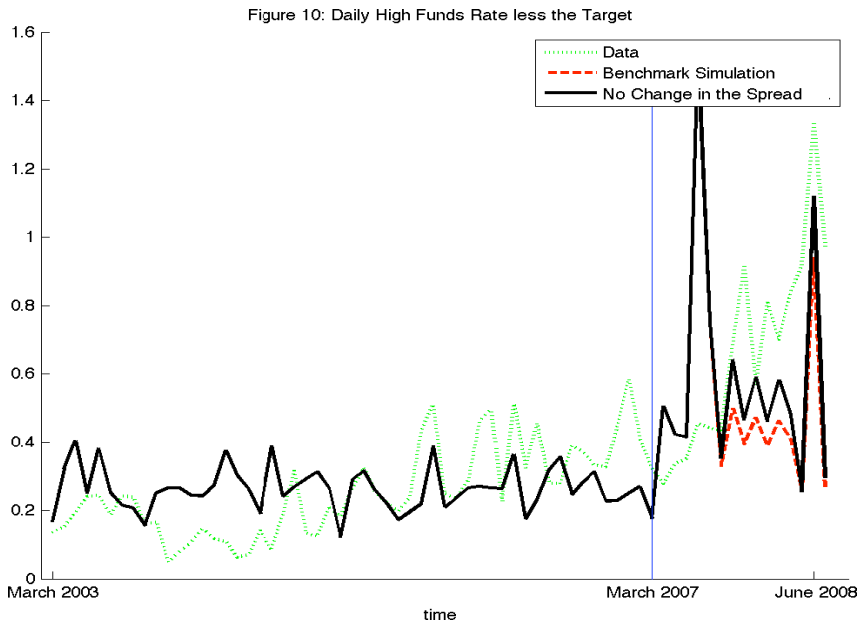
Steps to reduce the implicit costs of borrowing

- In assessing the implications of extended terms of borrowing and a wider set of eligible collateral, we keep the fixed cost of borrowing at its pre-crisis level and simulate the interest rate spread under this scenario



Steps to reduce explicit costs of borrowing

- The Federal Reserve also narrowed the spread between the primary credit rate and the target rate from 100 basis points to 25 basis points over the course of the crisis
- Our earlier findings in Artuç and Demiralp (2008) would suggest that the primary credit rate works as an upper bound in the absence of market stigma and that a decline in this rate should decrease deviations of the funds rate from the target
- Our next simulation (Figure 10) keeps the spread between the primary credit rate and the target unchanged at 100 basis points.



Paying interest on reserves

- In addition to placing a lower bound on the funds rate, interest payments on reserve balances may increase the demand for balances simply because the cost of holding these balances are now lower
- Our last exercise considers the impact of a higher level of balances in controlling the funds rate volatility
- We increase the average normalized reserve balances by 10% in our counterfactual experiment
- Figure 11 shows that the control over interest rates improve while Figure 12 shows that the need for borrowing declines if the average balance holdings increase as predicted under this new regime

Figure 11: Daily High Funds Rate less the Target

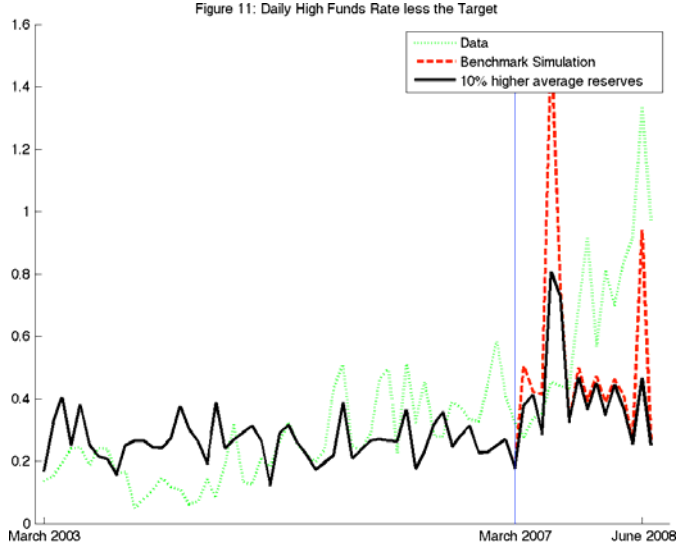
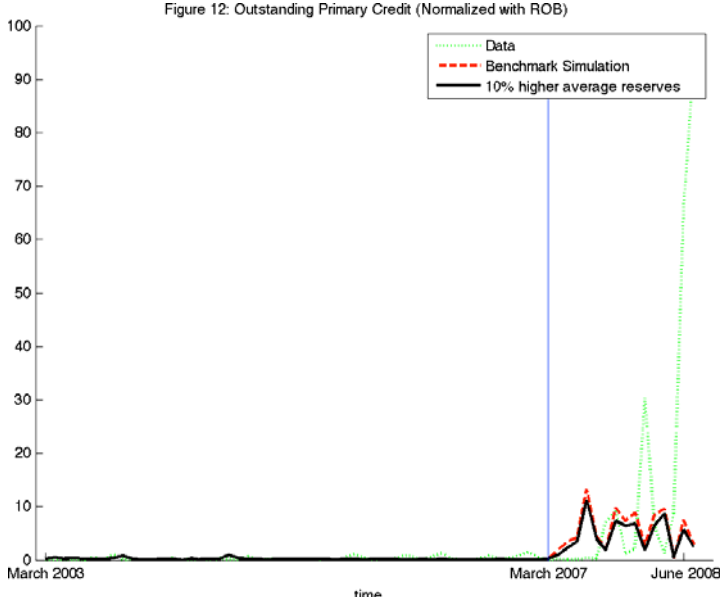


Figure 12: Outstanding Primary Credit (Normalized with ROB)



Conclusions

- The steps taken by the Federal Reserve to mitigate the crisis were highly effective
  - The extensions of the terms of borrowing and the list of eligible collateral were the most effective tools in calming the money market
  - Narrowing of the spread between the primary credit rate and the target was not as effective

Clarifications to some of Discussant's Comments

- Performance of the Model prior to the crisis: Does the model perform badly?
  - The model's simulations should not be confused with "forecasts" and the performance of the model should be evaluated based on Table 1
  - Indeed, Table 1 reflects that the model does a pretty good job in matching the actual data for the auxiliary regression results as well as the moments.

- Auxiliary Regression: Is it too simplistic?
  - We agree that the auxiliary regression is a simplified borrowing function (See Artuç and Demiralp (2008) for a more detailed borrowing function).
  - Nevertheless, for the purposes of estimation, an auxiliary model does not need to be “correct” for Indirect Inference to give consistent results. So long as the selected auxiliary model summarizes the data well, the estimates of the actual model will be consistent and asymptotically normal

- Modeling implicit cost endogenously
  - We are very sympathetic to this comment which may particularly be valid during times of crisis
  - However, modeling the implicit cost of borrowing as a function of the amount of borrowing cannot be identified in our set up
  - We leave this issue as potential future research