Online Appendix for A Model of Monetary Policy Shocks for Financial Crises and Normal Conditions[*]

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[*]The views expressed herein are solely those of the authors and do not necessarily reflect the views of the Federal Reserve Bank of Kansas City or the Federal Reserve System.

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A ONLINE APPENDIX FOR DSGE MODEL

This section describes the DSGE model used in the paper in detail. Our approach to modeling the household's portfolio of monetary assets follows closely from Belongia and Ireland (2014). The production side of the economy is a standard New-Keynesian model.

A.1 The Household

The representative household enters any period $t = 0, 1, 2, ...$ with a portfolio consisting of maturing bonds B_{t-1} and monetary assets totaling A_{t-1}. The household faces a sequence of budget constraints in any given period. In the first sub-period the household buys and sells bonds, receives real wages W_t for hours worked H_t during the period, is paid dividends F_t from intermediate goods firms, purchases consumption goods C_t, pays lump-sum taxes T_t, and allocates its monetary assets A_{t-1}/Π_t net of central bank transfers τ_t between currency N_t and deposits D_t. Any loans L_t needed to finance these transactions are made at this time. This is summarized in the constraint below:

$$N_t + D_t = \frac{A_{t-1}}{\Pi_t} + \frac{B_{t-1}}{\Pi_t} - \frac{B_t}{R_t} + W_t H_t + F_t - C_t - T_t + L_t + \tau_t, \tag{A.1}$$

where $\Pi_t = P_t/P_{t-1}$. In the second sub-period, the household receives deposits with interest $R_t^D D_t$ and receives any residual assets of the bank F_t^b. The household then combines this income with currency to repay loans with interest $R_t^L L_t$. Any remaining funds are carried over into the next period in the form of monetary assets A_t, as summarized below:

$$A_t = N_t + F_t^b + R_t^D D_t - R_t^L L_t. \tag{A.2}$$

The household seeks to maximize their lifetime utility, discounted at rate β, subject to these constraints. The period flow utility of the household takes the following form:

$$U_t = \left[ln(C_t - hY_{t-1}) - \xi H_t - H_t^s\right].$$

The household receives utility from consumption relative to last periods aggregate demand (i.e. the household has external habits) and disutility from working and shopping. Time spent shopping increases with aggregate demand Y_t (i.e. long lines) but is reduced with higher liquidity services. Therefore the time spent shopping takes the following form:

$$H_t^s = \frac{1}{\chi}\left(\frac{Y_t}{M_t}\right)^{\chi}. \tag{A.3}$$

The monetary aggregate, M_t, which enters the shopping-time function takes a rather general CES form:

$$M_t = \left[\nu^{\frac{1}{\omega}}(N_t)^{\frac{\omega-1}{\omega}} + (1-\nu)^{\frac{1}{\omega}}(D_t)^{\frac{\omega-1}{\omega}}\right]^{\frac{\omega}{\omega-1}}, \tag{A.4}$$

where ν calibrates the relative expenditure shares on currency and deposits and ω calibrates the elasticity of substitution between the two monetary assets. Given these parameters, χ is left free to calibrate the interest semi-elasticity of money demand.

The representative household faces the problem of maximizing its lifetime utility subject to its budget constraints. Letting $\mathcal{C}_t = [C_t, H_t, M_t, N_t, D_t, L_t, B_t, A_t]$ denote the vector of choice variables, the household's problem can be recursively defined using Bellman's method:

$$\begin{aligned} V_t\Big(B_{t-1}, A_{t-1}\Big) &= \max_{\mathcal{C}_t} \Bigg\{ \left[ln(C_t - hY_{t-1}) - \xi H_t - \frac{1}{\chi}\left(\frac{Y_t}{M_t}\right)^{\chi}\right] \\ &-\lambda_t^1\left(N_t + D_t - \frac{A_{t-1}}{\Pi_t} - \frac{B_{t-1}}{\Pi_t} + \frac{B_t}{R_t} - W_t H_t - F_t + C_t + T_t - L_t - \tau_t\right) \\ &-\lambda_t^2\left(M_t - \left[\nu^{\frac{1}{\omega}}(N_t)^{\frac{\omega-1}{\omega}} + (1-\nu)^{\frac{1}{\omega}}(D_t)^{\frac{\omega-1}{\omega}}\right]^{\frac{\omega}{\omega-1}}\right) \\ &-\lambda_t^3\Big(A_t - N_t - F_t^b - R_t^D D_t + R_t^L L_t\Big) + \beta \mathbb{E}_t\Big[V_{t+1}\Big(B_t, A_t\Big)\Big]\Bigg\}. \end{aligned}$$

The first order necessary conditions can be expressed by the following equations:

$$\frac{1}{(C_t - hY_{t-1})} = \beta \mathbb{E}_t\left[\frac{1}{(C_{t+1} - hY_t)}\frac{R_t}{\Pi_{t+1}}\right] \tag{A.5}$$

$$W_t = \xi(C_t - hY_{t-1}) \tag{A.6}$$

$$\frac{C_t - hY_{t-1}}{M_t} = \frac{\lambda_t^2}{\lambda_t^1}\left(\frac{Y_t}{M_t}\right)^{-\chi} \tag{A.7}$$

$$N_t = \nu M_t \left[\frac{\lambda_t^2/\lambda_t^1}{(R_t - 1)/R_t}\right]^{\omega} \tag{A.8}$$

$$D_t = (1-\nu) M_t \left[\frac{\lambda_t^2/\lambda_t^1}{(R_t - R_t^D)/R_t}\right]^{\omega} \tag{A.9}$$

$$M_t = \left[\nu^{\frac{1}{\omega}}(N_t)^{\frac{\omega-1}{\omega}} + (1-\nu)^{\frac{1}{\omega}}(D_t)^{\frac{\omega-1}{\omega}}\right]^{\frac{\omega}{\omega-1}}. \tag{A.10}$$

A.2 The Goods Producing Sector

The goods producing sector features a final goods firm and an intermediate goods firm. There is a unit measure of intermediate goods producing firms indexed by $i \in [0,1]$ who produce a differentiated product. The final goods firm produces Y_t combining inputs $Y_{i,t}$

using the production technology:

$$Y_t = \left[\int_0^1 Y_{i,t}^{\frac{\theta-1}{\theta}} di \right]^{\frac{\theta}{\theta-1}},$$

in which $\theta > 1$ governs the elasticity of substitution between inputs. The final goods producing firm sells its product in a perfectly competitive market, hence solving the profit maximization problem:

$$\max_{Y_{i,t} \in [0,1]} P_t Y_t - \int_0^1 P_{i,t} Y_{i,t} di,$$

subject to the above constant returns to scale technology. The resulting first order condition defines the demand curve for each intermediate goods producing firm's product:

$$Y_{i,t} = \left(\frac{P_{i,t}}{P_t} \right)^{-\theta} Y_t. \tag{A.11}$$

Given the downward sloping demand for its product in (A.11), the intermediate goods producing firm has the ability to set the price of its product above marginal cost. To permit aggregation and allow for the consideration of a representative firm, we assume all such firms have the same constant returns to scale technology:

$$Y_{i,t} = H_{i,t}. \tag{A.12}$$

The term $H_{i,t}$ in the production function denotes the level of employment chosen by the intermediate goods firm. Given the linear production function, the intermediate goods producing firm's real marginal cost takes the same functional form:

$$MC_t = (1 - \mathcal{S}) W_t.$$

A production subsidy, $\mathcal{S}$, is introduced to make the steady state price of goods equal to the marginal cost of production.

The price setting ability of each firm is constrained as in Calvo (1983). In this staggered price-setting framework, the price level P_t is determined in each period as a weighted average of the fraction of firms $1 - \alpha$ that are able to re-optimize their price and the fraction α that leave their prices unchanged. Therefore, each firm maximizes the present value of its current and future discounted profits, taking into account the probability that the firm will not be able to re-optimize:

$$\max_{P^*_{i,t}} \mathbb{E}_t \sum_{j=0}^{\infty} (\beta\alpha)^j \frac{\lambda^1_{t+j}}{\lambda^1_t} \left[\Pi_{t+j-1,t-1} P^*_{i,t} Y_{i,t+j} - MC_{t+j} P_{t+j} Y_{i,t+j}\right]$$

subject to

$$Y_{i,t+j} = \left(\Pi_{t+j-1,t-1} \frac{P^*_{i,t}}{P_{t+j}}\right)^{-\theta} Y_{t+j},$$

where $\Pi_{t+j-1,t-1} \equiv P_{t+j-1}/P_{t-1}$ captures the indexation of prices to lagged inflation. The firm's first order condition is given by:

$$\mathbb{E}_t \sum_{j=0}^{\infty} (\beta\alpha)^j \frac{\lambda^1_{t+j}}{\lambda^1_t} Y_{i,t+j} \left(\Pi_{t+j-1,t-1} \frac{P^*_{i,t}}{P_{t-1}} - \Pi_{t+j,t-1} \frac{\theta}{\theta - 1} MC_{t+j}\right) = 0. \tag{A.13}$$

Finally, in equilibrium, the aggregate price dynamics are determined by the following price aggregate:

$$\Pi_t^{1-\theta} = \alpha \Pi_{t-1}^{1-\theta} + (1-\alpha)(\Pi^*_t)^{1-\theta}, \tag{A.14}$$

where $\Pi^*_t = P^*_t/P_{t-1}$ and P^*_t is the optimal price firms choose who re-optimize in period t.

A.3 The Financial Firm

The financial firm performs the intermediation process of accepting household's deposits and making loans. The financial firm must satisfy the accounting identity which specifies assets (loans to firms plus reserves) equal liabilities (deposits):

$$L_t + rrD_t = D_t. \tag{A.15}$$

Although changes in banking regulation have effectively eliminated reserve requirements, banks may often choose to hold reserves in lieu of making loans. Therefore, instead of assuming the central bank controls the reserve ratio rr, we assume it is exogenously fixed and represents the average ratio of deposits banks hold for regulatory and liquidity purposes.

The financial firm chooses L_t and D_t in order to maximize period profits:

$$\max_{L_t, D_t} R^L_t L_t - R^D_t D_t - L_t + D_t - xL_t,$$

subject to the balance sheet constraint (A.15). The term xL_t denotes the real resource costs banks bear in making loans. We assume for simplicity that these resources are not destroyed in the loan production process, but instead are rented and remitted back to the household as dividends F_t^b. Since the loan and deposits markets are perfectly competitive, substituting the balance-sheet constraint into the profit function and imposing zero profits results in the loan-deposit spread:

$$R_t^L - R_t^D = (R_t^L - 1)rr + x(1 - rr). \tag{A.16}$$

This expression describes the loan deposit spread as a weighted average of the (opportunity) cost of accepting one unit of deposits. The fraction rr are held as reserves which bears the foregone revenue of making loans while the remaining fraction $(1-rr)$ are loaned out which bears the real resource cost of making a new loan.

A.4 Equilibrium And The Output Gap

Here we define the equilibrium conditions which close the model. Equilibrium in the final goods market requires that the accounting identity

$$Y_t = C_t \tag{A.17}$$

holds. Equilibrium in the money market and bond market requires that at all times: $A_t = A_{t-1}/\Pi_t + \tau_t$ and $B_t = B_{t-1} = 0$ respectively. Market clearing in the labor market requires that labor supply equals labor demand:

$$H_t = \int_0^1 H_{i,t} di = \int_0^1 Y_{i,t} di = \int_0^1 \left(\frac{P_{i,t}}{P_t}\right)^{-\theta} di Y_t$$

where the second equality uses the firm's production function (A.12) and the third equality uses the demand for the intermediate goods product (A.11). Therefore, aggregate output is related to price dispersion and aggregate labor supply by:

$$Y_t = \left[\int_0^1 \left(\frac{P_{i,t}}{P_t}\right)^{-\theta} di\right]^{-1} H_t. \tag{A.18}$$

The production subsidy $(1-\mathcal{S})$ to the intermediate goods producers is set so that in steady state the subsidy offsets the steady state markup of the monopolistically competitive firm implying $1-\mathcal{S} = (\theta-1)/\theta$. Finally, the government funds this subsidy with lump-sum taxes from the household implying the following government budget constraint:

$$T_t = \mathcal{S} W_t H_t. \tag{A.19}$$

A.5 Monetary Aggregates

In addition to the monetary aggregate M_t, three other monetary aggregates are defined in the DSGE model. Since we consider policy rules that stabilize the inflation rate, the price level will inherit a unit root. Therefore, we define all three aggregates in terms of their nominal growth rates. The first aggregate we define is the monetary base, which we denote by $M_t^{\mathcal{B}}$:

$$\mu_t^{\mathcal{B}} = ln\left(\frac{M_t^{\mathcal{B}}}{M_{t-1}^{\mathcal{B}}}\Pi_t\right) = ln\left(\frac{N_t + rrD_t}{N_{t-1} + rrD_{t-1}}\right) + ln(\Pi_t), \tag{A.20}$$

so that $M_t^{\mathcal{B}}$ is equal to the sum of currency and reserves. The second aggregate is a weighted nonparametric Divisia aggregate $M_t^{\mathcal{W}}$ used to approximate the parametric aggregate M_t as defined by Barnett (1980):

$$\mu_t^{\mathcal{W}} = ln\left(\frac{M_t^{\mathcal{W}}}{M_{t-1}^{\mathcal{W}}}\Pi_t\right) = \frac{S_t^N + S_{t-1}^N}{2} ln\left(\frac{N_t}{N_{t-1}}\right) + \frac{S_t^D + S_{t-1}^D}{2} ln\left(\frac{D_t}{D_{t-1}}\right) + ln(\Pi_t), \tag{A.21}$$

where $S_t^N = (R_t - 1)N_t/((R_t - 1)N_t + (R_t - R_t^D)D_t)$ is the share of total implicit spending on monetary assets allocated to currency and $S_t^D = 1 - S_t^N$ is the complimentary share spent on deposits. The third aggregate is an unweighted aggregate $M_t^{\mathcal{U}}$ used to approximate the parametric aggregate M_t:

$$\mu_t^{\mathcal{U}} = ln\left(\frac{M_t^{\mathcal{U}}}{M_{t-1}^{\mathcal{U}}}\Pi_t\right) = ln\left(\frac{N_t + D_t}{N_{t-1} + D_{t-1}}\right) + ln(\Pi_t). \tag{A.22}$$

A.6 The Non-Linear Model

$$\frac{1}{C_t - hY_{t-1}} = \beta \mathbb{E}_t \left[\frac{1}{C_{t+1} - hY_t} \frac{R_t}{\Pi_{t+1}} \right] \tag{A.23}$$

$$W_t = \xi (C_t - hY_{t-1}) \tag{A.24}$$

$$M_t = Y_t^{\frac{\chi}{1+\chi}} (C_t - hY_{t-1})^{\frac{1}{1+\chi}} \left(\frac{\lambda_t^2}{\lambda_t^1} \right)^{-\frac{1}{1+\chi}} \tag{A.25}$$

$$N_t = \nu M_t \left[\frac{\lambda_t^2 / \lambda_t^1}{(R_t - 1)/R_t} \right]^{\omega} \tag{A.26}$$

$$D_t = (1-\nu) M_t \left[\frac{\lambda_t^2 / \lambda_t^1}{(R_t - R_t^D)/R_t} \right]^{\omega} \tag{A.27}$$

$$M_t = \left[\nu^{\frac{1}{\omega}} (N_t)^{\frac{\omega-1}{\omega}} + (1-\nu)^{\frac{1}{\omega}} (D_t)^{\frac{\omega-1}{\omega}} \right]^{\frac{\omega}{\omega-1}} \tag{A.28}$$

$$Y_t = \left[\int_0^1 \left(\frac{P_{i,t}}{P_t} \right)^{-\theta} di \right]^{-1} H_t \tag{A.29}$$

$$0 = \mathbb{E}_t \sum_{j=0}^{\infty} (\beta\alpha)^j \frac{\lambda_{t+j}^1}{\lambda_t^1} Y_{i,t+j} \left(\Pi_{t+j-1,t-1} \Pi_t^* - \Pi_{t+j,t-1} \frac{\theta}{\theta - 1} MC_{t+j} \right) \tag{A.30}$$

$$\Pi_t^{1-\theta} = \alpha \Pi_{t-1}^{1-\theta} + (1-\alpha)(\Pi_t^*)^{1-\theta} \tag{A.31}$$

$$MC_t = \frac{\theta - 1}{\theta} W_t \tag{A.32}$$

$$R_t - R_t^D = (R_t - 1) rr + x(1 - rr) \tag{A.33}$$

$$Y_t = C_t \tag{A.34}$$

$$\mu_t^{\mathcal{B}} = ln \left(\frac{N_t + rrD_t}{N_{t-1} + rrD_{t-1}} \right) + ln(\Pi_t) \tag{A.35}$$

$$\mu_t^{\mathcal{W}} = \frac{S_t^N + S_{t-1}^N}{2} ln \left(\frac{N_t}{N_{t-1}} \right) + \frac{S_t^D + S_{t-1}^D}{2} ln \left(\frac{D_t}{D_{t-1}} \right) + ln(\Pi_t) \tag{A.36}$$

$$S_t^N = \frac{(R_t - 1) N_t}{(R_t - 1) N_t + (R_t - R_t^D) D_t} \tag{A.37}$$

$$S_t^D = \frac{(R_t - R_t^D) D_t}{(R_t - 1) N_t + (R_t - R_t^D) D_t} \tag{A.38}$$

$$\mu_t^{\mathcal{U}} = ln \left(\frac{N_t + D_t}{N_{t-1} + D_{t-1}} \right) + ln(\Pi_t) \tag{A.39}$$

A.7 The Log-Linear Model

In this section we provide a linear representation of the model by taking a first order Taylor expansion of the relevant equations around the steady state. Lower case variables denote log deviations from the steady-state: $g_t = ln(G_t) - ln(G)$, where G is the steady state value of G_t.

The Euler equation can be derived from combining (A.23) and (A.34):

$$y_t = \frac{1}{1+h}\mathbb{E}_t y_{t+1} + \frac{h}{1+h}y_{t-1} - \frac{1-h}{1+h}(r_t - \mathbb{E}_t\pi_{t+1}). \tag{A.40}$$

The money demand equation can be derived in two steps. First, we combine (A.26), (A.27) and (A.28) to show that:

$$\lambda_t^2/\lambda_t^1 = \left[\nu\left(\frac{R_t-1}{R_t}\right)^{1-\omega} + (1-\nu)\left(\frac{R_t-R_t^D}{R_t}\right)^{1-\omega}\right]^{\frac{1}{1-\omega}}.$$

Then we use this expression for λ_t^2/λ_t^1 in (A.25) along with equations (A.33) and (A.34) to arrive at the following log-linear expression for real money balances:

$$m_t = \frac{1+\chi(1-h)}{(1+\chi)(1-h)}y_t - \frac{h}{(1+\chi)(1-h)}y_{t-1} - \eta r_t, \tag{A.41}$$

so that in equation (2) in the main text, $\eta = \frac{1}{R}\left(\frac{\nu((R-1)/R)^{-\omega}+(1-\nu)((R-R^D)/R)^{-\omega}(rr-x(1-rr))}{\nu((R-1)/R)^{1-\omega}+(1-\nu)((R-R^D)/R)^{1-\omega}}\right)\frac{1}{1+\chi}$.

The Phillips Curve can be derived in two steps. First, log-linearizing (A.30):

$$\begin{aligned}\pi_t^* - \pi_{t-1} &= (1-\beta\alpha)\mathbb{E}_t\sum_{j=0}^{\infty}(\beta\alpha)^j(mc_{t+j} + \pi_{t+j,t-1} - \pi_{t+j-1,t-1}) - \pi_{t-1}\\ &= (1-\beta\alpha)\mathbb{E}_t\sum_{j=0}^{\infty}(\beta\alpha)^j(mc_{t+j} + \sum_{k=0}^{j}\pi_{t+j} - \sum_{k=0}^{j}\pi_{t+j-1})\\ &= \beta\alpha\mathbb{E}_t(\pi_{t+1}^* - \pi_t) + (1-\beta\alpha)mc_t + (\pi_t - \pi_{t-1}).\end{aligned}$$

The first relationship linearizes the firm pricing decision. The second equality uses $\pi_{t-1} = (1-\beta\alpha)\sum_{j=0}^{\infty}(\beta\alpha)^j\pi_{t-1}$ and the third equality rewrites the infinite sum recursively. Next, linearize (A.31) and use the resulting expression $\pi_t - \pi_{t-1} = (1-\alpha)(\pi_t^* - \pi_{t-1})$ to eliminate $\pi_t^* - \pi_{t-1}$ above:

$$\pi_t = \pi_{t-1} + \frac{(1-\alpha)(1-\beta\alpha)}{\alpha}\left(\frac{1}{1-h}y_t - \frac{h}{1-h}y_{t-1}\right) + \beta\mathbb{E}_t(\pi_{t+1} - \pi_t). \tag{A.42}$$

where we have also written real marginal cost in terms of output by combining (A.24), (A.32), and (A.34) and linearizing.

A linear expression for the nominal growth in the monetary base is obtained by log-linearizing equation (A.35):

$$\mu_t^{\mathcal{B}} = \gamma^{\mathcal{B}}(n_t - n_{t-1}) + (1-\gamma^{\mathcal{B}})(d_t - d_{t-1}) + \pi_t, \tag{A.43}$$

where $\gamma^{\mathcal{B}} = \frac{\nu((R-1)/R)^{-\omega}}{\nu((R-1)/R)^{-\omega} + rr(1-\nu)((R-R^D)/R)^{-\omega}}$. Log-linearizing (A.36) reveals that: $\mu_t^{\mathcal{W}} = m_t - m_{t-1} + \pi_t$. Log-linearizing (A.39) provides an expression for the nominal growth rate of the unweighted monetary aggregate:

$$\mu_t^{\mathcal{U}} = \gamma^{\mathcal{U}}(n_t - n_{t-1}) + (1-\gamma^{\mathcal{U}})(d_t - d_{t-1}) + \pi_t, \tag{A.44}$$

where $\gamma^{\mathcal{U}} = \frac{\nu((R-1)/R)^{-\omega}}{\nu((R-1)/R)^{-\omega} + (1-\nu)((R-R^D)/R)^{-\omega}}$. Log-linear expressions for N_t and D_t are obtained from equations (A.26) and (A.27) as follows:

$$n_t = m_t + \omega\left[(1+\chi)\eta - \frac{1}{R-1}\right] r_t \tag{A.45}$$

$$d_t = m_t + \omega\left[(1+\chi)\eta - \frac{rr - x(1-rr)}{R-R^D}\right] r_t. \tag{A.46}$$

A.8 DSGE Calibration

We set $\beta = 0.99$ which implies an annualized nominal bond rate of 4% in this quarterly model. We set $\alpha = 0.75$ so the average duration of prices is about 1 year, as found by Nakamura and Steinsson (2008). The degree of habit persistence $h = 0.65$ as estimated in Christiano, Eichenbaum, and Evans (2005). The parameters governing the CES aggregate of monetary assets are calibrated as in Ireland (2014) who uses component level data on N_t and M_t to estimate equation (A.26) so that $\omega = 0.5$ and $\nu = 0.2$. We set $rr = 0.02$ which is the average ratio of reserve to non-currency components of M2 from 1967 to 2007 using data from the Federal Reserve Bank of St. Louis. Using data from the Center for Financial Stability we find that setting $x = 0.0067$ implies the annualized steady state spread between R^L and R^D of 2.7% which is the average interest rate differential between the benchmark interest rate used to measure R_t^L and the own-rate on the non-currency components of M2. The interest semi-elasticity of money demand is set to $\eta = 1.9$ as estimated in Ireland (2009). This value of η is achieved by setting $\chi = 12$.

REFERENCES

Barnett, William A. (1980) “Economic Monetary Aggregates: An Application of Index Number and Aggregation Theory.” *Journal of Econometrics*, 14, 11–48.

Belongia, Michael T, and Peter N Ireland. (2014) “The Barnett Critique after Three Decades: A New Keynesian Analysis.” *Journal of Econometrics*, 183, 5 – 21.

Calvo, Guillermo A. (1983) “Staggered Prices in a Utility-Maximizing Framework.” *Journal of Monetary Economics*, 12, 383–398.

Christiano, Lawrence J., Martin Eichenbaum, and Charles L. Evans. (2005) “Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy.” *Journal of Political Economy*, 113, 1–45.

Ireland, Peter N. (2009) “On the Welfare Cost of Inflation and the Recent Behavior of Money Demand.” *American Economic Review*, 99, 1040–52.

Ireland, Peter N. (2014) “The Macroeconomic Effects of Interest on Reserves.” *Macroeconomic Dynamics*, 18, 1271–1312.

Nakamura, Emi, and Jon Steinsson. (2008) “Five Facts about Prices: A Reevaluation of Menu Cost Models.” *The Quarterly Journal of Economics*, 123, 1415–1464.