One Period Nominal Rigidity

Johannes Wieland
jfwieland@ucsd.edu

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Outline

Introduction

- The data consistently showed real effects of monetary policy on output, at least in the short-run.
- Our previous model was inconsistent with this data.
- We will now modify our a model so that prices are fixed for one period.
  - Important is that prices do not adjust in response to new information (e.g., increase in money supply).
  - The "simple" model provides intuition for more complex models of nominal rigidity that we will see later in class.

Outline

Sticky Prices

- We assume that prices are fixed at time 1 (today):

$$P_1 = P_0$$

where P_0 is the past price level.

  - Implicit assumption: Firm will supply whatever output is demanded at the price the firm set.
  - May not be a good assumption in certain circumstances. Why would a firm want to operate at a loss?
  - Fixed cost models are more compelling in this regard. We may study these later in the course, time-permitting.

How does the Labor Market Clear?

- At time $t = 1$ firms, must hire however many workers they need to fulfill demand $\Rightarrow$ Households on labor supply curve.

$$\frac{W_1}{P_0} = \frac{\chi N_1^{\varphi}}{C_1^{-\gamma}}$$

- But firms are not on their labor demand curve:

$$\frac{W_1}{P_0} \neq A_1 = MPL_1$$

- Firms will hire as many workers as needed to produce the output demand at price P_0.

Why Sticky Prices?

Table 1 Frequency of price change in consumer prices

	Median		Mean	
	Frequency (% per month)	Implied duration (months)	Frequency (% per month)	Implied duration (months)
Nakamura & Steinsson (2008)				
Regular prices (excluding substitutions 1988–1997)	11.9	7.9	18.9	10.8
Regular prices (excluding substitutions 1998–2005)	9.9	9.6	21.5	11.7
Regular prices (including substitutions 1988–1997)	13.0	7.2	20.7	9.0
Regular prices (including substitutions 1998–2005)	11.8	8.0	23.1	9.3
Posted prices (including substitutions 1998–2005)	20.5	4.4	27.7	7.7
Klenow & Kryvtsov (2008)				
Regular prices (including substitutions 1988–2005)	13.9	7.2	29.9	8.6
Posted prices (including substitutions 1988–2005)	27.3	3.7	36.2	6.8

- Source: Nakamura and Steinsson (2013)

Other Approaches

- Similar (but not identical) results obtain if we assume sticky wages. See your homework.
- We will study more sophisticated sticky price approaches later in class.
  - Insights will often be quite similar.
- Time-permitting, we will also cover the sticky information approach to monetary (non-)neutrality.
- What is key in all these approaches is that some price / value is indexed to money (the unit of account).

Equilibrium Equations: Long-run

- Long-run $= t \geq 2$:

$$
\begin{aligned}
Y_t &= A_t N_t \\
\frac{W_t}{P_t} &= A_t \\
\frac{W_t}{P_t} &= \frac{\chi N_t^{\varphi}}{C_t^{-\gamma}} \\
Y_t &= C_t \\
\frac{M_t}{P_t} &= \zeta^{1/\nu} \left(1 - \frac{1}{Q_t}\right)^{-1/\nu} C_t^{\gamma/\nu} \\
1 &= \beta E_t \left\{ Q_t \frac{P_t}{P_{t+1}} \frac{C_{t+1}^{-\gamma}}{C_t^{-\gamma}} \right\}
\end{aligned}
$$

- Classical Dichotomy holds in the long-run.

Equilibrium Equations: Short-run

- Short-run (period 1):

$$Y_1 = A_1 N_1$$
$$P_1 = P_0$$
$$\frac{W_1}{P_1} = \frac{\chi N_1^{\varphi}}{C_1^{-\gamma}}$$
$$Y_1 = C_1$$
$$\frac{M_1}{P_1} = \zeta^{1/\nu} \left(1 - \frac{1}{Q_1}\right)^{-1/\nu} C_1^{\gamma/\nu}$$
$$1 = \beta E_1 \left\{ Q_1 \frac{P_1}{P_2} \frac{C_2^{-\gamma}}{C_1^{-\gamma}} \right\}$$

- Sticky price assumption replaces labor demand curve.

Simplifying assumptions

- All exogenous variables constant for $t \geq 2$: $A_t = A$, $M_t = M$.

- There is perfect foresight for these paths.

$\Rightarrow$ Solve for steady state values for $C_2 = C$ and $P_2 = P$ and plug into short-run solution.

- At $t = 1$ we then "shock" M_1 and A_1 and see what happens to C_1, Y_1, P_1.

Solution: Long-run

- Solve for the steady state:

$$C = Y = \left[\frac{1}{\chi} A^{1+\varphi}\right]^{\frac{1}{\gamma+\varphi}}$$
$$\frac{M}{P} = \zeta^{1/\nu} (1-\beta)^{-1/\nu} Y^{\gamma/\nu}$$

- Classical Dichotomy holds in the long-run.
  - Any change in M causes a proportional change in P, leaving Y, C unchanged.

Equilibrium Equations: Short-run

- Short-run (period 1):

$$
\begin{aligned}
Y_1 &= A_1 N_1 \\
\frac{W_1}{P_0} &= \chi N_1^{\varphi} Y_1^{\gamma} \\
\frac{M_1}{P_0} &= \zeta^{1/\nu} \left(1 - \frac{1}{Q_1}\right)^{-1/\nu} Y_1^{\gamma/\nu} \\
1 &= \beta \left\{ Q_1 \frac{P_0}{P} \frac{Y^{-\gamma}}{Y_1^{-\gamma}} \right\}
\end{aligned}
$$

Equilibrium Equations: Short-run

- Short-run (period 1):

$$C_1 = Y_1 = \left\{ \frac{1}{\beta Q_1} \frac{P}{P_0} \right\}^{\frac{1}{\gamma}} Y$$

$$\frac{M_1}{P_0} = \zeta^{1/\nu} \left(1 - \frac{1}{Q_1} \right)^{-1/\nu} Y_1^{\gamma/\nu}$$

- From Euler equation, changes in the *nominal* interest rate Q_1 have a direct effect on output and consumption $Y_1 = C_1$.
- For given level of Y_1 can manipulate *nominal* interest rate by changing the money supply M_1

$\Rightarrow$ Classical Dichotomy does not hold in short-run.

Intuition

1. Higher M_t reduces real rate $R_{t+1} = Q_t(P_t/P_{t+1})$:
   - Nominal rate Q_t falls to induce households to hold the extra money supplied.
   - Expected inflation is fixed because current prices P_t are sticky, and future prices P_{t+1} are determined by future M.
2. Lower real rate increases demand today through intertemporal substitution:
   - (A) Low return on savings, so increase today's consumption relative to future consumption.
   - (B) But future consumption is fixed by the supply-side as prices are flexible.
   - (C) So there is an overall increase in consumption today, which is accommodated by firms hiring more workers and producing more output.

Equilibrium Equations: Short-run

- Short-run (period 1):

$$C_1 = Y_1 = \left\{ \frac{1}{\beta Q_1} \frac{P}{P_0} \right\}^{\frac{1}{\gamma}} Y$$

$$\frac{M_1}{P_0} = \zeta^{1/\nu} \left(1 - \frac{1}{Q_1} \right)^{-1/\nu} Y_1^{\gamma/\nu}$$

$$Y_1 = A_1 N_1$$

- From Euler equation, the level of output $Y_1 = C_1$ is pinned down by Q_1.
- Changes in productivity A_1 have no effect on real output.
- Higher productivity A_1 reduces employment L_1.

Intuition

3. Why does productivity not affect output? Because it does not affect the real interest rate and therefore does not affect consumption demand.

3. Employment falls because demand is fixed and with higher productivity we do not need as much labor to produce the same output.

Summary

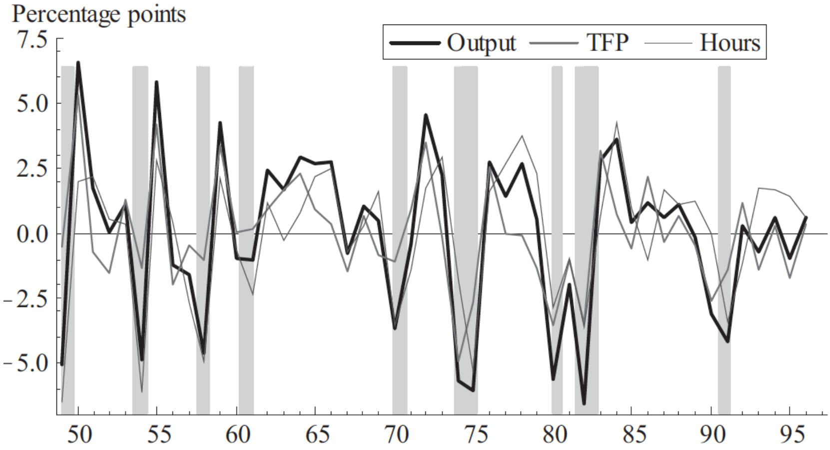
- With sticky prices, classical dichotomy no longer holds in the short-run.
  - But it does hold in the long-un.
- The jargon in the literature is:
  - In the short-run output is "demand-determined": nominal interest rates and the nominal money supply determine output, but not productivity or labor-supply preferences.
  - In the long-run output is "supply-determined": only productivity, technology, and preferences determine output.

Outline

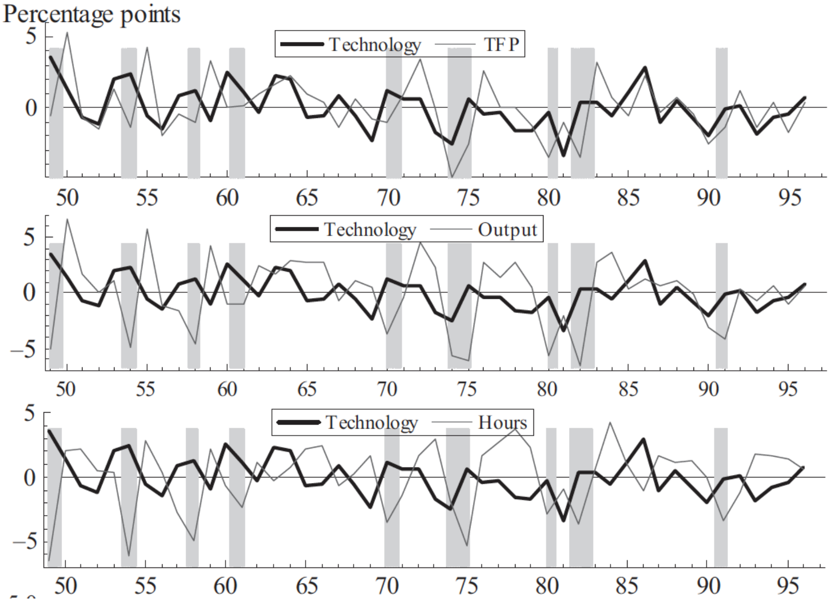
Basu et al. (2006): "Purifying" The Solow Residual

- Difficult to measure A_t: lots of unobserved variation in input intensity of labor capital.
- Basu, Fernald, and Kimball (2006):
  - Control for aggregation effects, varying utilization of K and L, non-constant returns to scale, imperfect competition.
  - Varies half as much as Solow Residual.
  - Shocks are permanent and serially uncorrelated.
- What happens when technology improves?

Basu et al. (2006): Solow Residual



Basu et al. (2006): Technology



Labor Market and Labor Wedge

- The distortion (implicit tax) in the labor market is called the *labor wedge:*

$$(1-\tau_t^N) \equiv \frac{MRS_t}{MPL_t} = \frac{\chi N_t^{\varphi} C_t^{\gamma}}{(1-\alpha)Y_t/N_t}$$

- $\tau_t^N = 0$ (no distortion) when:
  - Firms are on their labor demand equation.
  - Households are on their labor supply equation.
  - Perfect competition.

FINDING: τ_t^N IS COUNTERCYCLICAL

$$\tau_t^N = 1 - \frac{MRS_t}{MPL_t} \Rightarrow MPL_t > MRS_t \text{ in Recessions}$$

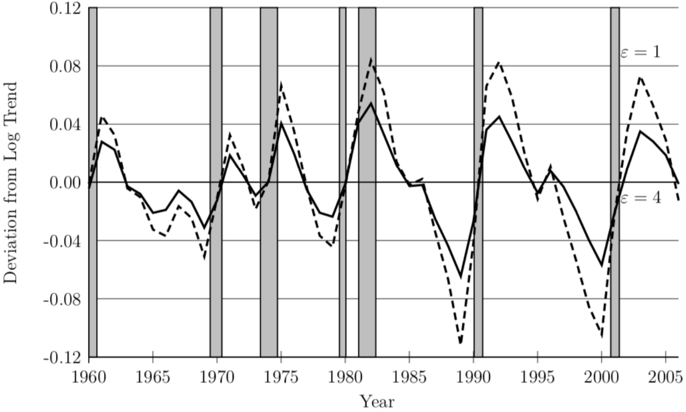


Figure 3: Deviation of the labor wedge from log trend, HP filter with parameter 100. The solid line shows $\varepsilon = 1$ and the dashed line shows $\varepsilon = 4$. In both cases, I fix the remaining parameters to ensure that the average labor wedge is 0.40. The gray bands show NBER recession dates.

Labor Wedge In Our Sticky Price Model

- The labor wedge at $t = 1$ is:

$$(1 - \tau_1^N) \equiv \frac{MRS_t}{MPL_t} = \chi A_1^{\gamma-1} N_1^{\gamma+\varphi}$$

- In a recession N_1 is low and labor wedge is high. This is consistent with the data.

- Important: labor market distortion does not have to originate in the labor market. Here the problem is a sticky price in the output market.

Outline

Next Steps

- Who sets prices? Why are they rigid?
- Develop New Keynesian model that relaxes several assumptions we have made.
- For next class, read Gali Ch. 3.