Endogenous Wage Indexation and Aggregate Shocks

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Motivation

- Price and wage inflation are typically very persistent

- DSGEs assume prices and wages are indexed to past inflation
  
  (To fix terms: Aggregate indexation = past-inflation indexation)

- Indexation is hard-wired as a fixed and policy invariant parameter

- But indexation practices are choices/agreements between agents

- Why should they remain permanently constant? (Lucas critique)

- Evidence suggests wage indexation has varied a lot
Motivation

- **Macro evidence for U.S.:** Hofmann, Peersman, and Straub (2012) find that U.S. wage dynamics are consistent with
  - high indexation for the *Great Inflation* (70s), and
  - low indexation for the *Great Moderation* (2000s)

- **Micro evidence for U.S.:** # contracts with cost-of-living adj. (COLA) clauses

  ![Temperature chart]

- **Macro evidence for Europe:** Wage negotiations are starting to follow observed inflation rather than the ECB’s inflation target.
Motivation

- High wage indexation renders inflation more persistence, making it more difficult to bring it back to target.

- Gray (1976) and Fischer (1977) offer a rationale for *socially optimal* changes in wage indexation.

- To reduce output fluctuations, wage indexation should
  - decrease with supply-side shocks, and
  - increase with demand-side shocks.

- However, the Gray-Fischer hypothesis is problematic for two reasons:
  - Did demand shocks drive the 70s and supply shocks the 2000s?
  - The U.S. is driven by a decentralized wage setting (Calmfors and Driffil, 1988).
Within a microfounded environment, we ask

**Which macro factors influence workers’ wage indexation choices?**

We proceed as follows:

- In a stylised NK-DSGE model,
  - Utility-maximizing workers select a wage indexation rule: past inflation or inflation target.
  - Workers respond to prevailing shocks, policy, and market structures.
- We use the model’s predictions to ask: **What caused wage indexation changes in the U.S.?**
1. Workers index wages to
   - past inflation in face of perm. productivity and inflation-target shocks
   - target inflation in face of aggregate-demand shocks

2. The decentralized wage indexation equilibrium carries an externality
   - Social planner choices are different than decentralised equilibrium
   - A worker does not internalise the effect of his choice on the aggregate

3. Model correctly predicts
   - high aggregate indexation for the Great Inflation and
   - low aggregate indexation for the Great Moderation
   - Changes in the volatility of productivity shocks drive results
New Keynesian model with sticky prices and wages (Ercerg, Henderson, and Levin, 2000)
- Linear technology on labor with no capital
- Monetary policy: CB follows Taylor-type rule and sets inflation target
- Shocks: Technology (perm.), Gov’t spending (temp.), Target inflation

Households have a unique labor type
- Re-optimize labor contract infrequently
  - Step 1, HH choose *indexation rule given economic structure*
  - Step 2, HH choose *optimal wage given indexation rule*
  - In both steps, HH maximise expected utility

It is illustrative to analyse step 2 first, and then step 1
Households, step 2: wage-setting

- Household \( i \)'s objective is

\[
\max_{c_{i,T}, b_{i,T}, W_{i,t}^k} \mathbb{E}_t \left\{ \sum_{T=t}^{\infty} \beta^{T-t} \left( \log \left( c_{i,t} - \gamma^h c_{i,t-1} \right) - \psi \frac{(\ell_{i,t,T})^{1+\omega}}{1+\omega} \right) \right\},
\]

subject to

\[
c_{i,T} + \frac{b_{i,T}}{R_T} \leq \frac{W_{i,t}^k}{P_T} \ell_{i,T} + \frac{b_{i,T-1}}{1 + \pi_T} + \frac{\Upsilon_{i,T}}{P_T},
\]

\[
\ell_{i,t,T}^k = \left( \frac{\delta_{t,T}^k W_{i,t}^k}{W_T} \right)^{-\theta_w} \ell_T
\]

- HH sets new contract with probability \( 1 - \alpha_w \)

- Available indexation rules are

\[
\delta_{t-1,t}^{\text{trend}} = 1 + \pi_t^* \quad \text{and} \quad \delta_{t-1,t}^{\text{past}} = 1 + \pi_{t-1}
\]

\( \pi_t^* \) is the central bank inflation target = trend inflation.
If wages were flexible, usual welfare maximizing condition holds

Mg. rate of substitution between $c_{i,t}$ and $\ell_{i,t} \propto$ real wage

$$\frac{\psi \ell_t^\omega}{\lambda_t} = \frac{w_t}{\mu_w}.$$

Since wages are sticky, this condition may not be satisfied

Sticky wages imply welfare losses,

but an indexation rule may close the gap between the desired and actual labor supply
Households, step 1: indexation-rule setting

- Workers select an indexation rule to maximise expected utility

\[
\max_{\delta_i \in \{\delta_{\text{trend}}, \delta_{\text{past}}\}} \mathbb{E}_t \left\{ \sum_{T=t}^{\infty} (\beta \alpha_w)^{T-t} U(c_T(\xi_T, \Sigma_T), \ell_i, T(\delta_i, \xi_T, \Sigma_T)) \right\},
\]

subject to the economy’s structure, \(\Sigma_t\)

- \(\Rightarrow c_t\) does not depend on \(\delta_i^*\) (perfect risk sharing)
- \(\Rightarrow\) Only expected labor disutility matters

- A worker chooses \(\delta_i^*\) to minimize

\[
\Omega_{i,t}(\delta_i, \xi_t) = \mathbb{E}_t \left\{ \sum_{T=t}^{\infty} (\beta \alpha_w)^{T-t} \frac{\psi}{1+\omega} \ell_i^{1+\omega} \right\}
\]

\(\xi_t = \#\) workers indexing to past inflation, taken as given by an individual worker
Shocks & Policy

- Productivity shock:
  \[ y_{j,t} = A \exp(z_t) n_{j,t}, \text{ with } z_t = z_{t-1} + \varepsilon_{z,t}, \]

- Government-spending shock (aggregate-demand shock):
  \[ g_t = g \exp(\varepsilon_{g,t}) y_t \text{ with } \varepsilon_{g,t} = \rho_g \varepsilon_{g,t} + \eta_{g,t}, \]

- Monetary policy:
  - Interest-rate rule:
    \[ R_t = \left[ R_{t-1} \right]^{\rho_R} \left[ R_t^* \right]^{1-\rho_R} \left[ \frac{1 + \pi_t}{1 + \pi_t^*} \right]^{a_\pi(1-\rho_R)} \left[ y_t \right]^{a_y(1-\rho_R)} \left[ \frac{y_t}{y_{t-1}} \right]^{a_{\Delta y}}, \]
    where \( R_t^* \) is the long-term gross nominal rate
  - Trend-inflation rule:
    \[ \pi_{t+1}^* = \rho_{\pi^*} \pi_t^* + \varepsilon_{\pi,t+1} \text{ with } \rho_{\pi^*} \in [0, 1]. \]
Table 1. Calibration based on HPS (2012)’s estimation

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\gamma^h$</td>
<td>Habit formation</td>
<td>.37</td>
</tr>
<tr>
<td>$\gamma^p$</td>
<td>Inflation inertia</td>
<td>.17</td>
</tr>
<tr>
<td>$\alpha_p$</td>
<td>Calvo-price rigidity</td>
<td>.78</td>
</tr>
<tr>
<td>$\alpha_w$</td>
<td>Calvo-wage rigidity</td>
<td>.54</td>
</tr>
<tr>
<td>$a_{\pi}$</td>
<td>Taylor Rule: inflation</td>
<td>1.35</td>
</tr>
<tr>
<td>$a_y$</td>
<td>Taylor Rule: output gap</td>
<td>.1</td>
</tr>
<tr>
<td>$a_{\Delta y}$</td>
<td>Taylor Rule: output gap growth</td>
<td>.39</td>
</tr>
<tr>
<td>$\rho_R$</td>
<td>Taylor Rule: smoothing</td>
<td>.78</td>
</tr>
</tbody>
</table>

Great Moderation year 2000

Other parameters: $\beta = .99$, $\sigma = 1$, $\phi = 1$, $\omega = 2$, $\theta_w = \theta_p = 10$. 
Welfare costs are approx to the second order (leisure-equivalent $\lambda_k$)

- Workers pick *past* index. in the productivity shock regime
- Workers pick *trend* index. in the gov’t spending regime
- The equilibria are globally stable
If the $\pi^*$-shocks are permanent, then workers pick past index.

If the $\pi^*$-shocks are temporal, there’s an interior solution

Again, the equilibria are globally stable
At the steady state, labor disutility is given by (let $\omega = 1$)

$$\Omega_{ss}^k \approx \frac{\psi}{1 - \beta \alpha_w} \left( R_{ss}^k + V_{ss}^k \right),$$

where

$$R_{ss}^k = \frac{1}{2} \left[ \int_{i \in I_k} \left( \frac{W_i}{\tilde{W}} \right)^{-\theta_w} di \right] \times \ell_{ss} \right]^2,$$

and

$$V_{ss}^k = \frac{1}{2} \text{var} \left( \ell_t^k \right),$$

where $\tilde{\zeta}^k = \zeta$ if $k = \text{past}$ and $1 - \zeta$ if $k = \text{trend}$

- $R_{ss}^k$ depends on wage dispersion within a sector
- $V_{ss}^k$ is a total measure of variance in hours worked
- We show that differences in $R_{ss}^k$ are the main drivers of wage indexation decisions
How workers choose their indexation rule?

Here’s the intuition:

- A larger wage dispersion means a larger variance in hours worked,
- Workers dislike uncertainty on their labor and wages ($\omega > 0$),
- So they choose a labor contract ($\delta^k, W^k$) that minimizes that uncertainty.
In single-shock regimes, workers prefer contracts with lower relative wage dispersion.

(black is trend and red is past)
In multiple-shocks regimes, changes in relative wage dispersion drive changes in aggregate indexation.
Social planner vs. Decentralized eq

- A worker disregards his own impact on the aggregate
- Coordination failure leads to a suboptimal equilibrium

![Graphs showing economic variables](image-url)
## Great Inflation calibration

Table 2. Calibration based on HPS (2012)’s estimation

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Great Moderation 2000 (benchmark)</th>
<th>Great Inflation 1974</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\gamma^h$ Habit formation</td>
<td>.37</td>
<td>.71</td>
</tr>
<tr>
<td>$\gamma^p$ Inflation inertia</td>
<td>.17</td>
<td>.8</td>
</tr>
<tr>
<td>$\alpha_p$ Calvo-price rigidity</td>
<td>.78</td>
<td>.84</td>
</tr>
<tr>
<td>$\alpha_w$ Calvo-wage rigidity</td>
<td>.54</td>
<td>.64</td>
</tr>
<tr>
<td>$a_\pi$ Taylor Rule: inflation</td>
<td>1.35</td>
<td>1.11</td>
</tr>
<tr>
<td>$a_y$ Taylor Rule: output gap</td>
<td>.10</td>
<td>.11</td>
</tr>
<tr>
<td>$a_{\Delta y}$ Taylor Rule: output gap growth</td>
<td>.39</td>
<td>.5</td>
</tr>
<tr>
<td>$\rho_R$ Taylor Rule: smoothing</td>
<td>.78</td>
<td>.69</td>
</tr>
</tbody>
</table>

Common parameters: $\beta = .99, \sigma = 1, \phi = 1, \omega = 2, \theta_w = \theta_p = 10$. 
Predictions for U.S.

Table 3. Calibration of shocks

<table>
<thead>
<tr>
<th></th>
<th>Great Moderation 2000 (benchmark)</th>
<th>Great Inflation 1974</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma_z$</td>
<td>Std. dev. Tech. shock (HPS)</td>
<td>.31</td>
</tr>
<tr>
<td>$\sigma_g$</td>
<td>Std. dev. Dem. shock (HPS)</td>
<td>3.25</td>
</tr>
<tr>
<td>$\sigma_{\pi^*}$</td>
<td>Std. dev. inflation target (HPS)</td>
<td>NaN</td>
</tr>
<tr>
<td>$\hat{\chi}$</td>
<td>Estimated indexation (HPS)</td>
<td>.17</td>
</tr>
</tbody>
</table>

**Case 1: $\sigma_{\pi^*} = 0$**

- $\chi^*$ Implied equilibrium indexation: 0, .89
- $\chi^S$ Implied social optimum: 1, 0

**Case 2: $\sigma_{\pi^*} > 0$**

- $\sigma_{\pi^*}$ Std. dev. inflation target (CPS, 2010): .049, .081
- $\chi^*$ Implied equilibrium indexation: .05, .89
- $\chi^S$ Implied social optimum: 1, 0
## Table 4. Counterfactual exercises

<table>
<thead>
<tr>
<th></th>
<th>2000: $\xi^* = 0$,</th>
<th>1974: $\xi^* = .89$,</th>
<th>put 1974 value to:</th>
<th>put 2000 value to:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\xi_{counterfactual}$</td>
<td>$\xi_{counterfactual}$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### I - Shocks

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma_z$ Std. dev. Tech. shock</td>
<td>1</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma_g$ Std. dev. Dem. shock</td>
<td>0</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\sigma_{\pi^*}$ Std. dev. inflation target</td>
<td>.6</td>
<td>.89</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### II - Policy parameters

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$a_{\pi}$ Taylor Rule: inflation</td>
<td>0</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$a_y$ Taylor Rule: output gap</td>
<td>.05</td>
<td>.89</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$a_{\Delta y}$ Taylor Rule: output gap growth</td>
<td>0</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\rho_R$ Taylor Rule: smoothing</td>
<td>0</td>
<td>.94</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Remarks:** Main driver is change in the volatility of the productivity shock, not monetary policy!
Evidence suggest that wage indexation has also changed in Mexico

Consider the following regression for Mexican employees’ contractual wage revisions, $\Delta w_t$

$$\Delta w_t = c_t + \rho_t \Delta w_{t-1} + \beta_{lag,t} \sum_{i=0}^{12} \pi_{t-i} + \beta_{trend,t} \bar{\pi}_t + \gamma_t \Delta s_t + \varepsilon_t$$

where $\Delta s_t$ is the percent change in the peso/dollar exchange rate, and $c_t$, $\rho_t$, $\beta_{lag,t}$, $\beta_{trend,t}$, and $\gamma_t$ are time-varying coefficients.
According to the theory, wage indexation to past inflation should have been high in the 90s, and low in the 2000s.
As expected, wage revisions followed more past inflation in the 90s, when trend inflation was drifting.

When trend inflation settled, wage revisions followed this variable.
Conclusions

- We propose a microfounded approach to endogenize wage indexation in DSGE models.

- We let workers select their own indexation rule.
  - Expected changes in hour worked (aka, relative wage dispersion) is the most important driver in a worker’s decision.
  - However, this decentralized equilibrium suffers from an externality and is suboptimal.

- The decentralized equilibrium offers a rationale to changes in U.S. wage indexation from the Great Inflation to the Great Moderation.

- And it may offer predictions to SOEs too.