Price Setting under low and high Inflation: Evidence from Mexico

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Motivation (1/3)

- Although price stickiness has been at the hearth of the macroeconomic since Keynes (1936), the amount of direct evidence on the adjustment of individual prices was embarrassingly limited until very recently.

- The situation is changing rapidly as statistical agencies worldwide are making available to researchers the micro data used for the purpose of computing price indices.

Motivation (2/3)

- There is currently no shortage of mechanisms to explain the apparent stickiness of individual prices…
  - Fixed-duration contracts (Taylor 1980);
  - Calvo pricing (Calvo 1983);
  - Menu costs and sticky plans (Dotsey-King-Wolman 1999, Golosov-Lucas 2007, Gertler-Leahy 2006, Midrigan 2006, Burstein 2005…);
  - Sticky or imperfect information (Mankiw-Reis 2002, Sims 2003, Maćkowiac-Wiederholt 2007…);
  - Consumer anger (Rotemberg 2005);
  - Uncertain and sequential trade (Prescott 1975, Eden 1990);
  - Market-share concerns, habit formation (Kleshchelski-Vincent 2007, Schmitt-Grohe-Ravn-Uribe, 2007);
  - Search frictions (Konieczny-Skrzypacz 2006, Arsenault-Chugh 2007…);
  - …

Motivation (3/3)

- The choice of a particular price-setting mechanism matters much as it bears directly on a model's predictions, including:
  - Dynamic responses to shocks;
  - Effectiveness of monetary policy;
  - Shape of Phillips curve;
  - Exchange rate pass-through;
  - Optimal monetary and fiscal policy…
- There is hope is that micro facts will shed light on which model(s) should be used and when.

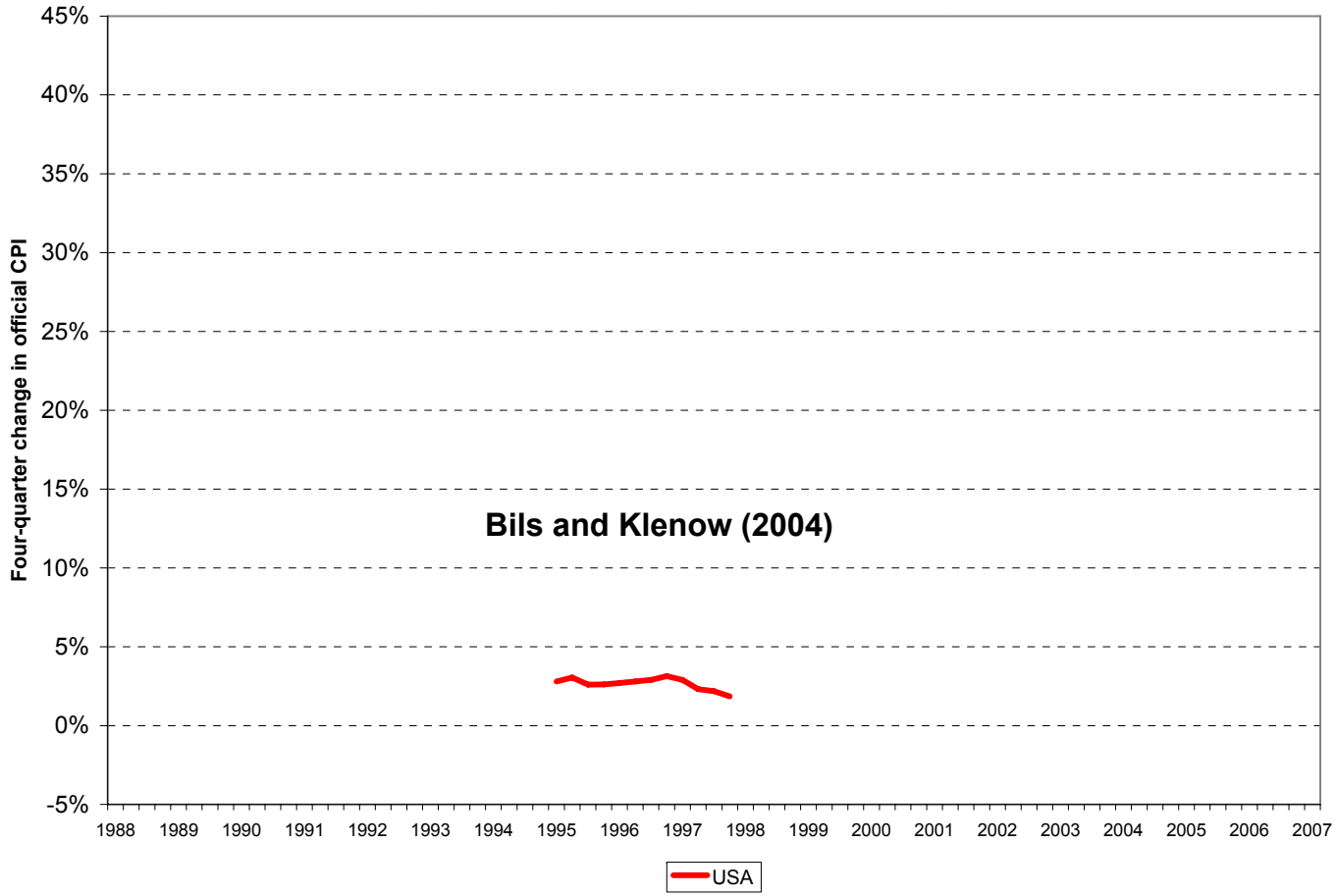
Main contributions

- In this paper, I…
  - Assemble a data set of individual consumer prices with an extensive product and inflation coverage;
  - Provide new facts about the setting of individual prices under low and high inflation;
  - Assess whether a menu-cost model with idiosyncratic technology shocks can replicate my key findings.

Outline

- Review of empirical literature using CPI micro data;
- Description of my data set;
- Inflation accounting principles;
- Main empirical results;
- Can a menu-cost model fit the main facts?
- Concluding remarks

Inflation and Time Coverage of CPI Studies



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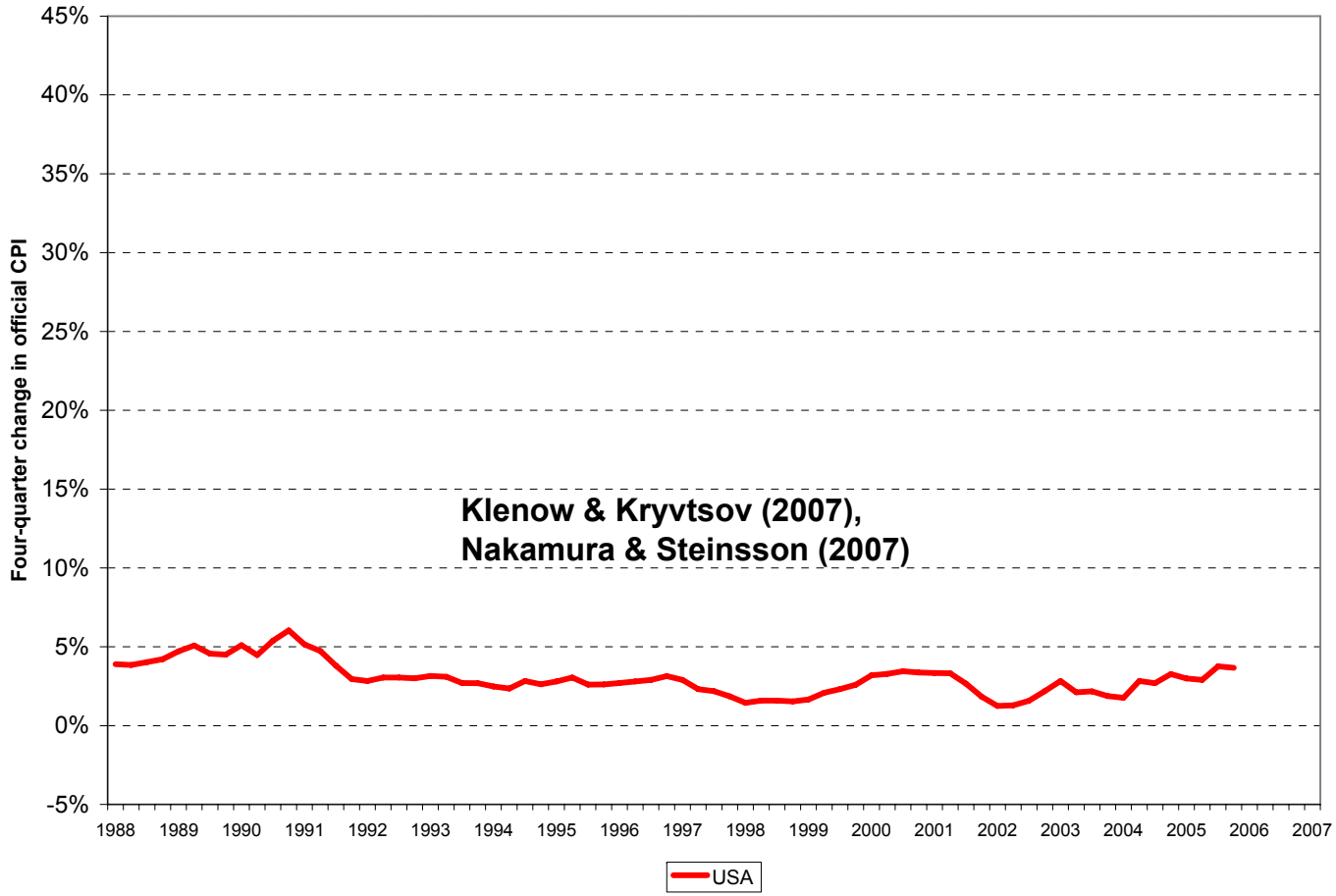

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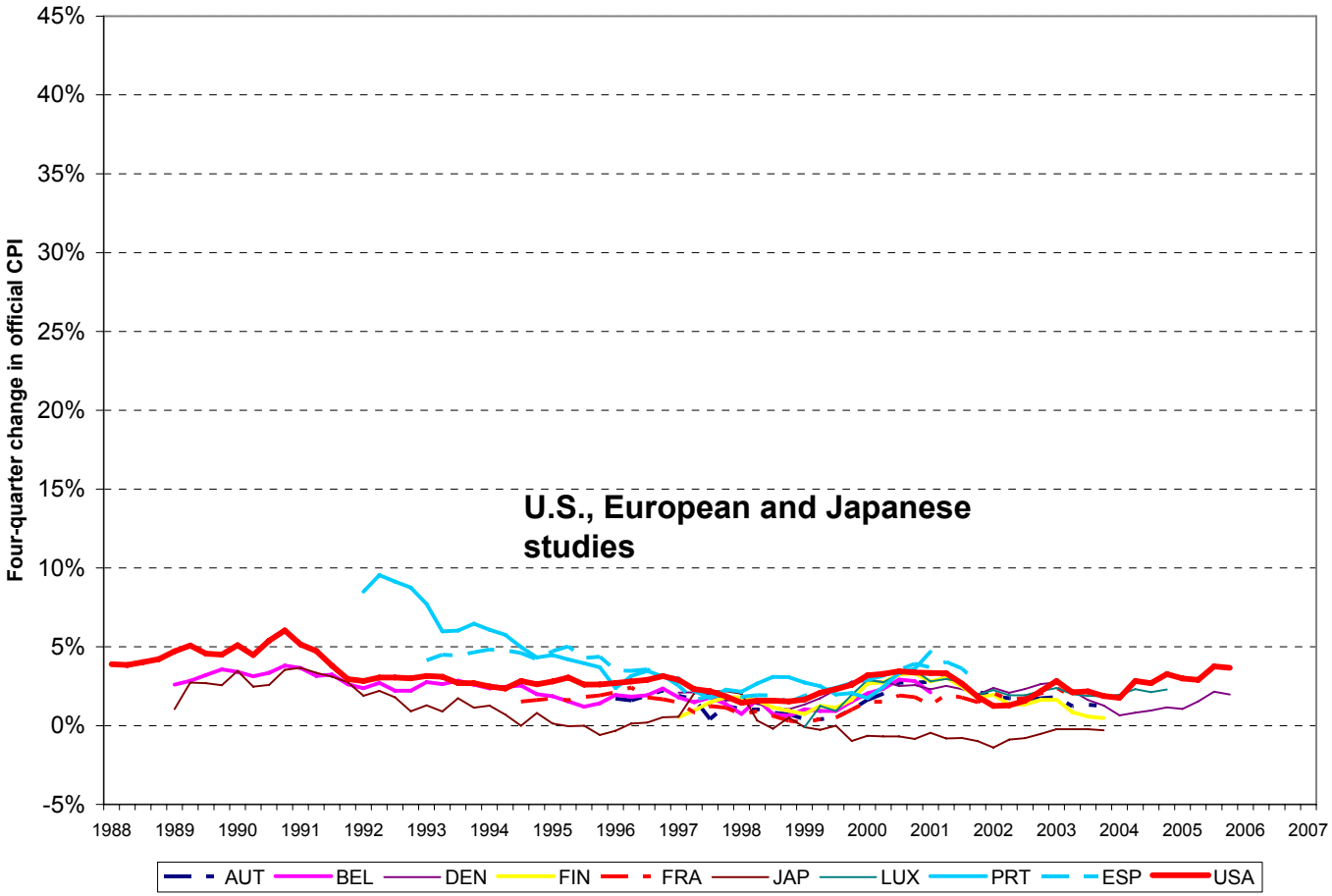

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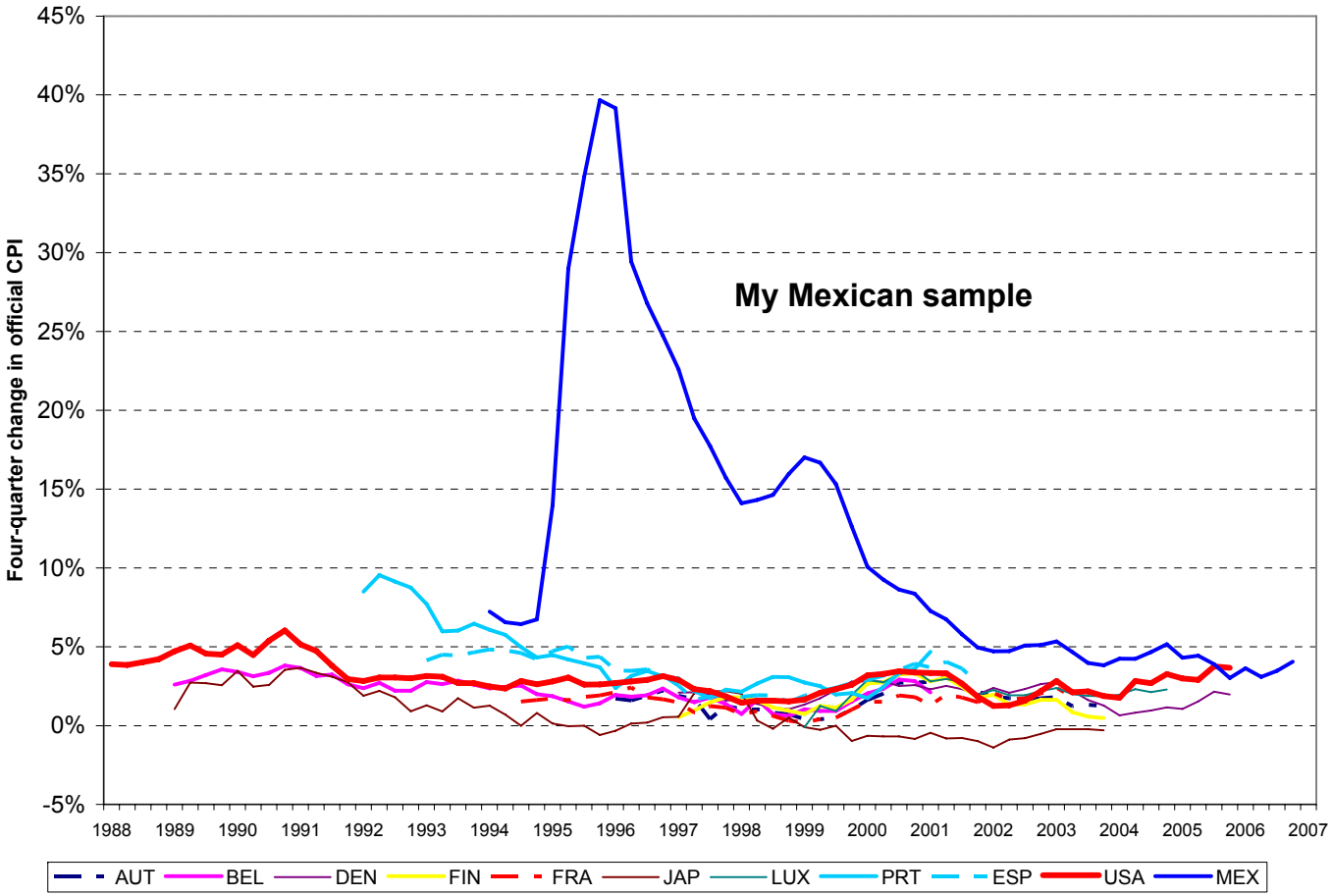


Other high-inflation studies

Country	Authors	Sample product coverage	Observations per month[a]	Sample period	Inflation (%, a.r.)[b]	Mean monthly frequency (%)
Argentina	Burstein et al. (2005)	58 goods sold in 8 supermarkets in Buenos Aires and 10 services	563	Mar. to Dec. 2002	39.7	66
Israel	Lach and Tsiddon (1992)	26 food products (mostly meat and alcoholic beverages)	250	1978-1979	77.0	41
Israel	Lach and Tsiddon (1992)	26 food products (mostly meat and alcoholic beverages)	530	1981-1982	116.0	61
Israel	Eden (2001), Baharada and Eden (2004)	up to 390 narrowly-defined products from the Israeli CPI	2800	1991-1992	13.6	24
Poland	Konieczny and Skrzypacz (2005)	52 goods, including 37 grocery items, and 3 services	up to 2400	1990-1996	-	-
			-	1990	249.3	59
			-	1992	44.3	39
			-	1994	29.5	32
			-	1996	18.5	30
Mexico	Ahlin and Shintani (2006)	44 food products sold in Mexico City	573	1994-1995	-	-
			-	1994	7.1	49.3
			-	1995	52.0	66.0
Mexico	Gagnon (2007)	227 product categories, representing 54.1 percent of Mexican consumption expenditures	31,500	1994-2002	-	-
			-	1995	52.0	39.2
			-	1996	27.7	32.2
			-	1997	15.7	28.3
			-	1999	12.3	27.5
			-	2001	4.4	27.3

Notes: (a) Author's calculations for Israel and Poland. (b) Author's calculations based on change in official CPI over sample period for Argentina, Israel, and Mexico. The figures are not in logarithmic changes, as in the remainder of the paper.

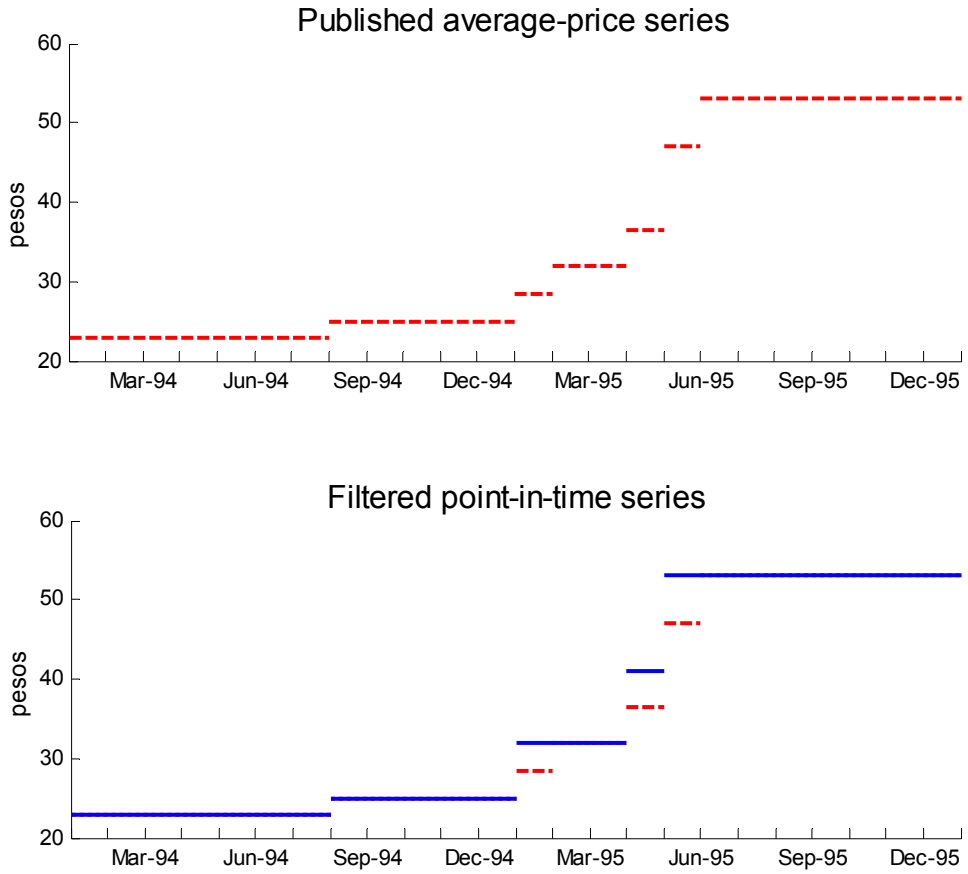
Mexican CPI dataset

Period	January 1994 - June 2002
Price quotes	
Total	3,209,947
Average per month	31,470
Trajectories	44,272
Substitutions	10,457
Product categories	227
CPI coverage (%)	54.1
Sample composition (%)	
Unprocessed food	26.4
Processed food	21.7
Energy	0.4
Nonenergy industrial goods	26.4
Services	25.1

Main issues with data

- Averaging: collection takes place four times per month for food items, twice for all others, prices are then averaged;
- Sales: sales conditional on something else than purchase of a single item are not taken into account (ex. regular price reported in 3-for-2 promotion);
- Indexes: dropped from sample (housing, gasoline, gas, electricity, car insurance, car ownership costs);
- Store samples: for clothing, the price corresponds to a sample of three similar items from the same store (dropped);
- Imputations: prices are not always observed directly (stockouts, close outlet, out-of-season), number has changed over time;

Example of price trajectory



Note: The dashed line represents the actual monthly average price published in the Diario of a single copy of the book "The Universal History of Litterature" sold in a Mexico City outlet. The solid line represents the filtered point-in-time series.

Section summary

- My Mexican data set has a significantly larger inflation coverage than other studies using a similarly large amount of consumer price data.
- At the same time, it has a much broader product coverage than related empirical of high-inflation economies.
- The large variation in inflation offers hope to discriminate among price setting mechanisms, as it is in the face of large shocks that the predictions of those models differ most.

Inflation Accounting Principles

- Indicator that price of item *i* has changed $I_{i,t}$. Inflation is defined as

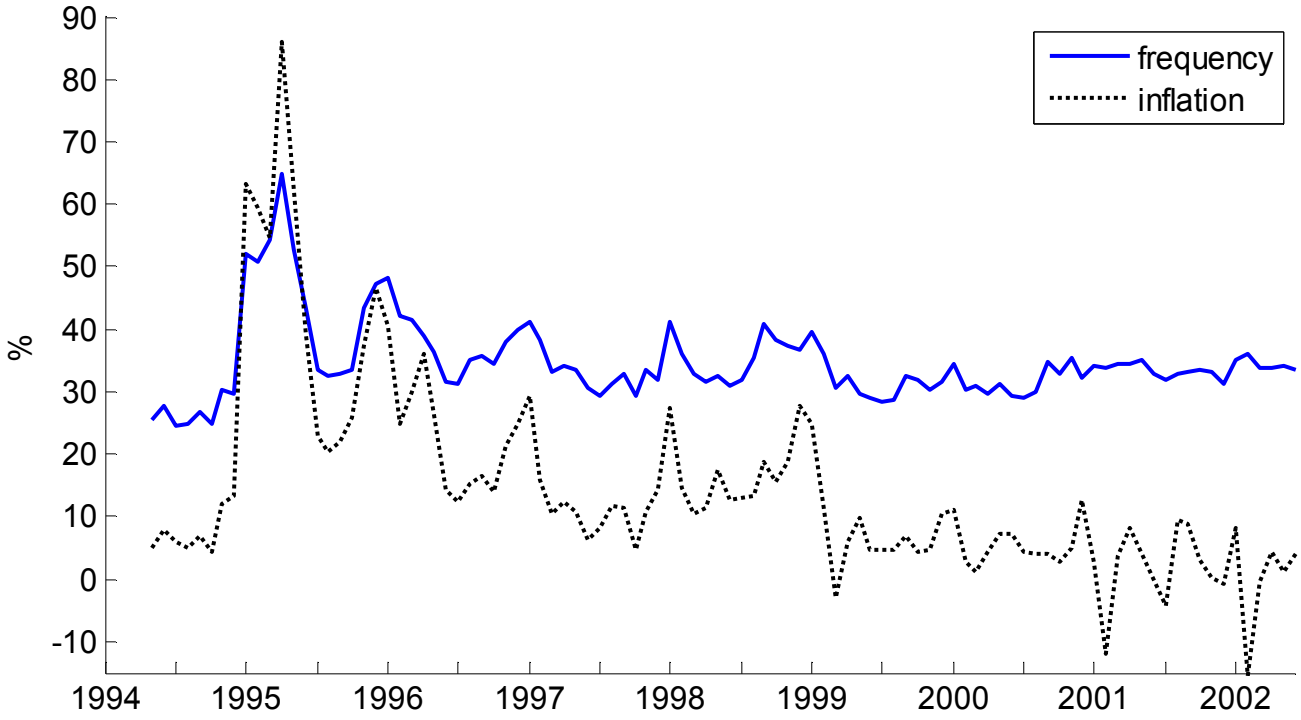
$$\pi_t \triangleq fr_t \cdot dp_t = \underbrace{\left(\sum_i \omega_{it} I_{it}\right)}_{fr_t} \cdot \underbrace{\left(\frac{\sum_i \omega_{it} I_{it} \Delta p_{it}}{\sum_i \omega_{it} I_{it}}\right)}_{dp_t}$$

- It is convenient to further decompose inflation as

$$\pi_t \triangleq \underbrace{\left(\sum_i \omega_{it} I_{it}^{+}\right)}_{fr_t^{+}} \cdot \underbrace{\left(\frac{\sum_i \omega_{it} I_{it}^{+} \Delta p_{it}}{\sum_i \omega_{it} I_{it}^{+}}\right)}_{dp_t^{+}} + \underbrace{\left(\sum_i \omega_{it} I_{it}^{-}\right)}_{fr_t^{-}} \cdot \underbrace{\left(\frac{\sum_i \omega_{it} I_{it}^{-} \Delta p_{it}}{\sum_i \omega_{it} I_{it}^{-}}\right)}_{dp_t^{-}}$$

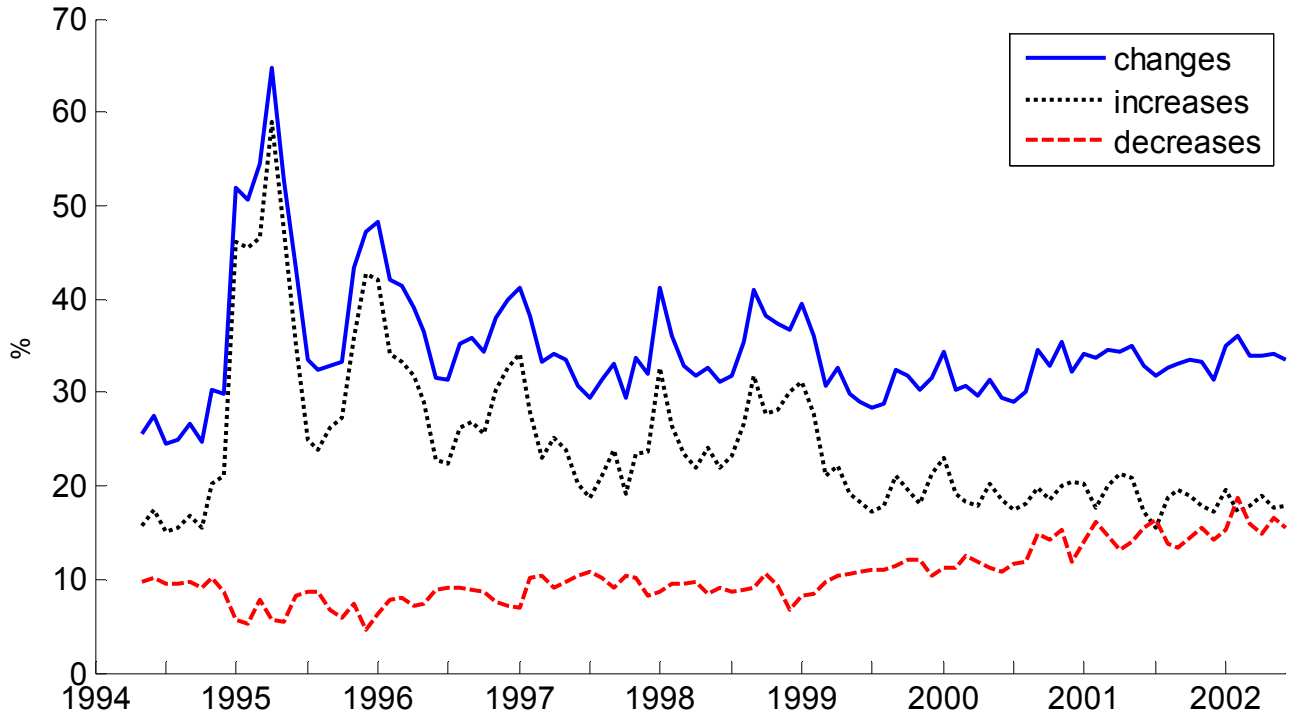
Frequency of price changes

(nonregulated goods)



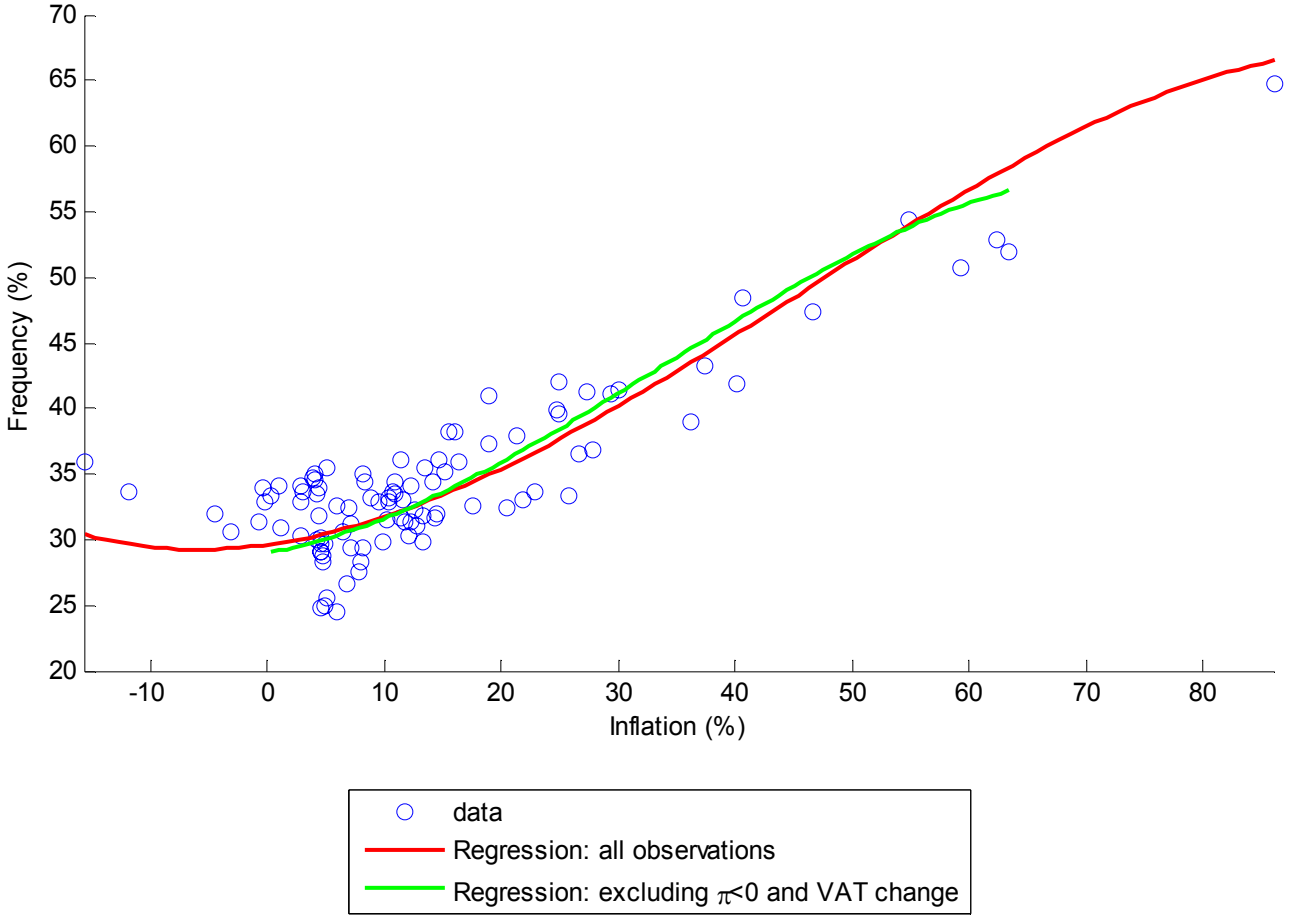
Frequency of price increases and decreases

(nonregulated goods)



Scatterplot, frequency of price increases and decreases

(nonregulated goods)



Regression coefficients: frequency

	fr		fr+		fr-	
	All	Restricted	All	Restricted	All	Restricted
Constant	0.25	0.25	0.15	0.14	0.11	0.11
	(47.13)	(33.19)	(32.94)	(19.52)	(43.3)	(28.44)
π	0.13	0.14	0.26	0.35	-0.14	-0.22
	(3.2)	(1.08)	(5.62)	(2.69)	(-6.8)	(-3.54)
π2	0.98	1.29	0.89	0.94	0.09	0.35
	(6.06)	(2.37)	(5.42)	(1.66)	(1.44)	(1.36)
π3	-0.74	-1.31	-0.74	-1.08	0.00	-0.23
	(-4.53)	(-2.23)	(-4.58)	(-1.76)	(0.01)	(-0.83)
R^2	0.92	0.90	0.95	0.95	0.92	0.90

The regression includes a full set of calendar year dummies.

The standard errors were computed using the Huber-White estimator.

Regression coefficients: magnitude

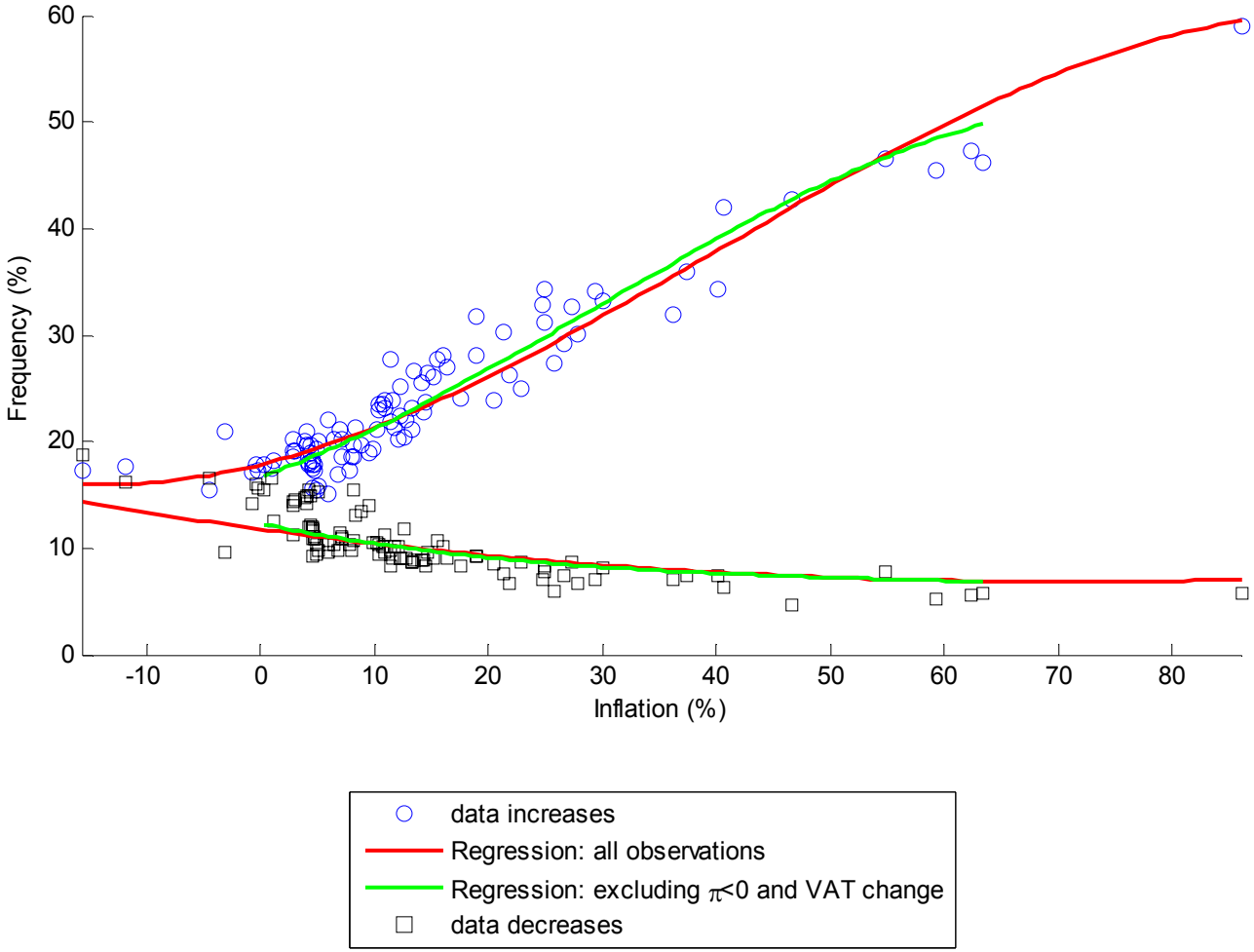
	dp		dp+		dp-	
	All	Restricted	All	Restricted	All	Restricted
Constant	0.01	0.00	0.08	0.08	0.11	0.10
	(8.34)	(3.85)	(40.44)	(26.33)	(29.8)	(18.59)
π	0.24	0.30	0.07	0.13	-0.23	-0.08
	(25.1)	(20.04)	(6.89)	(2.67)	(-4.85)	(-0.87)
π2	-0.20	-0.42	0.01	-0.20	0.64	0.19
	(-5.86)	(-5.37)	(0.31)	(-1.06)	(5.56)	(0.54)
π3	0.06	0.28	-0.03	0.19	-0.46	-0.06
	(2.13)	(3.2)	(-0.86)	(0.97)	(-5.34)	(-0.16)
R^2	0.99	0.99	0.79	0.77	0.48	0.31

The regression includes a full set of calendar year dummies.

The standard errors were computed using the Huber-White estimator.

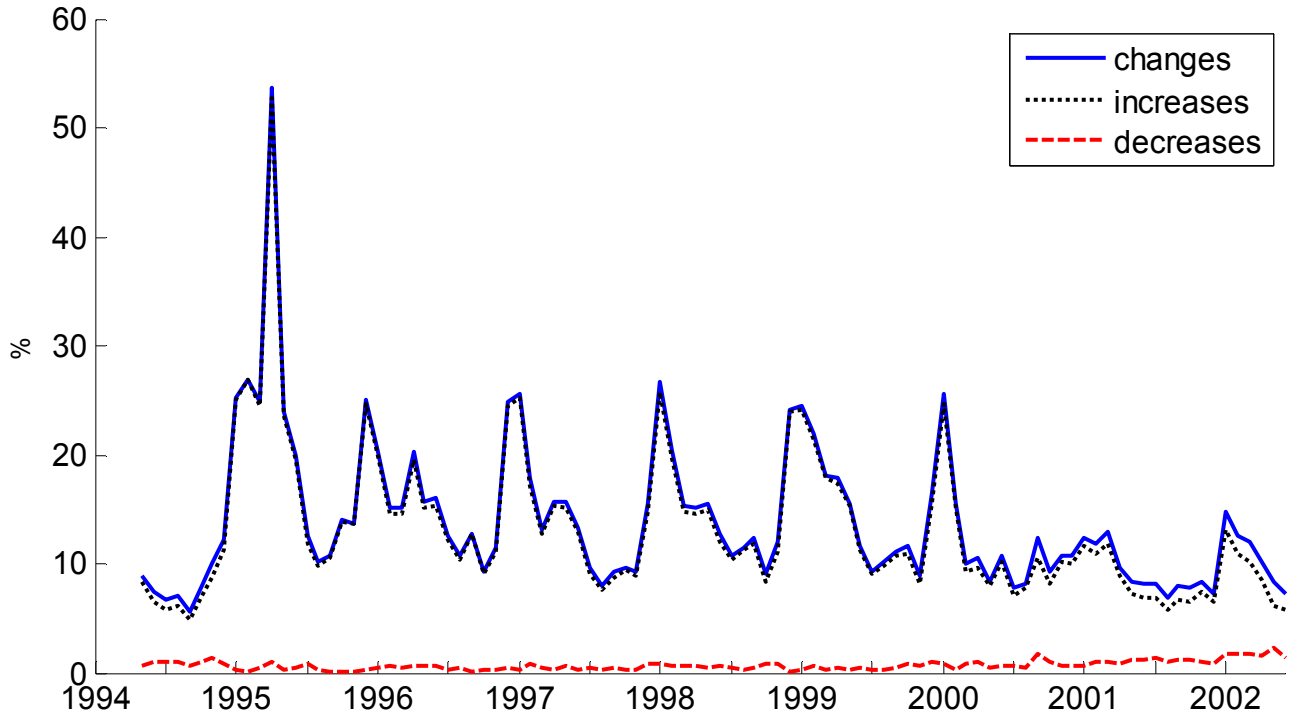
Frequency of price changes

(nonregulated services)



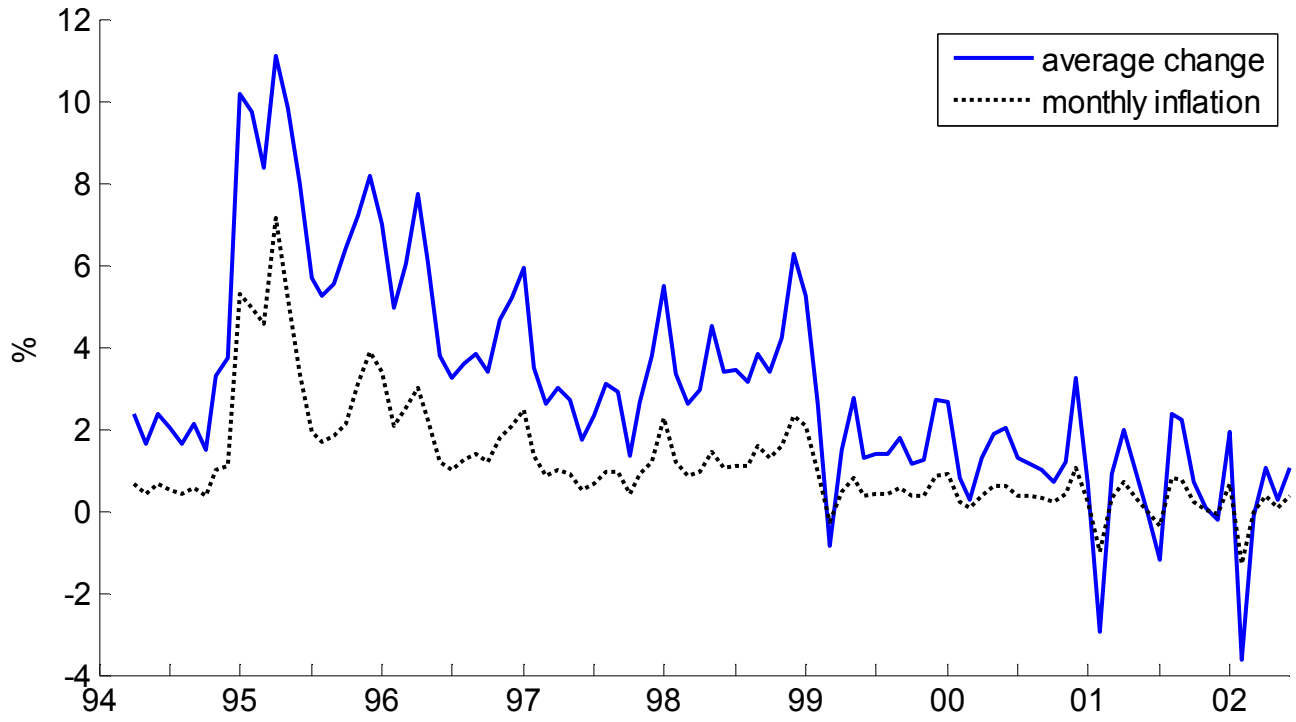
Frequency of price increases and decreases

(nonregulated services)



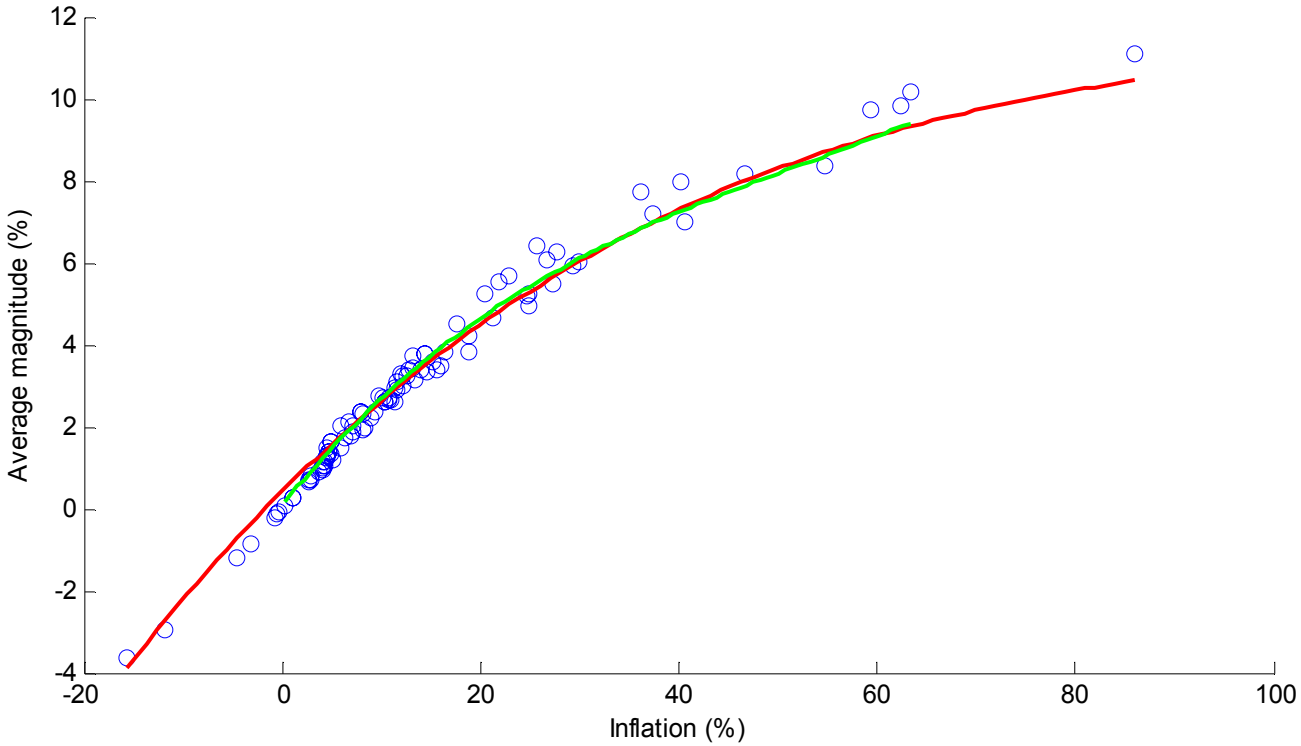
Average price change

(nonregulated goods)

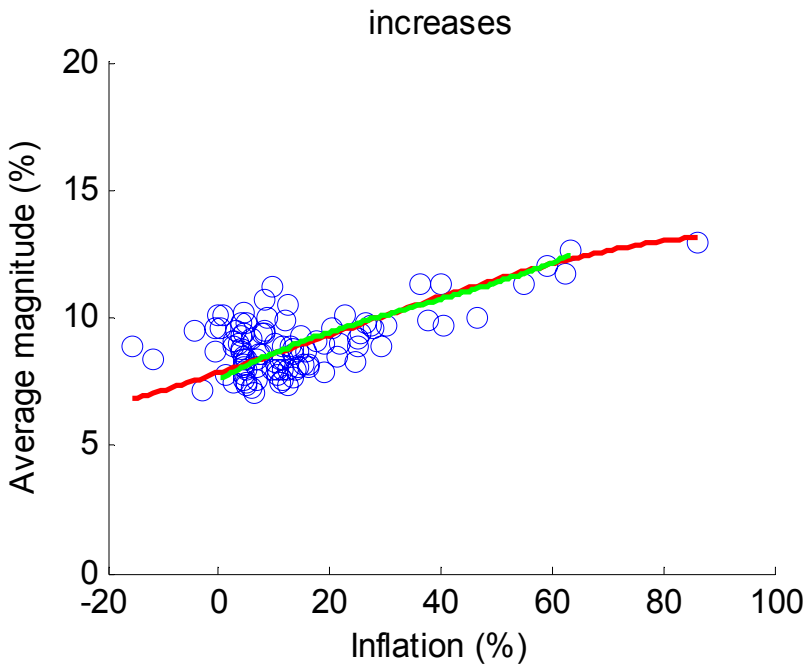


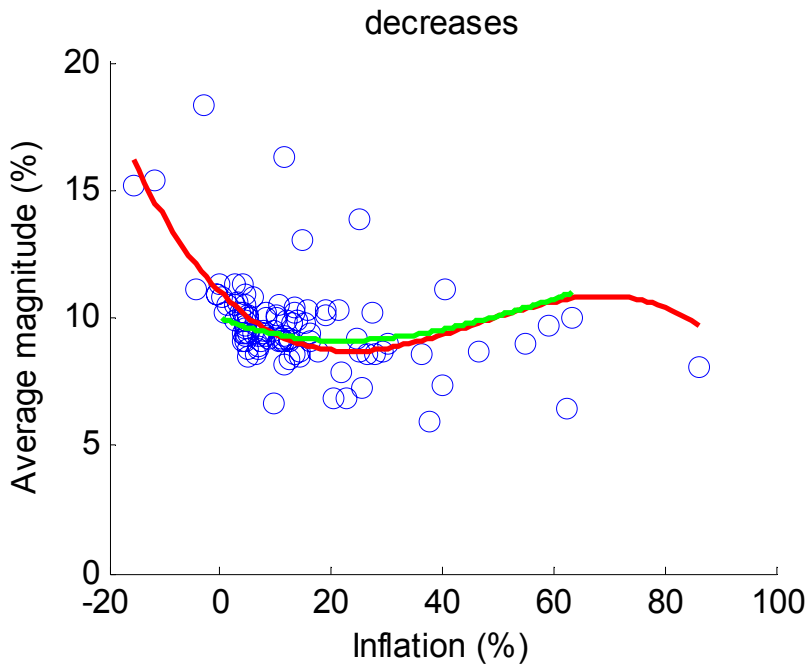
Scatterplot, average magnitude of price changes

(nonregulated goods)



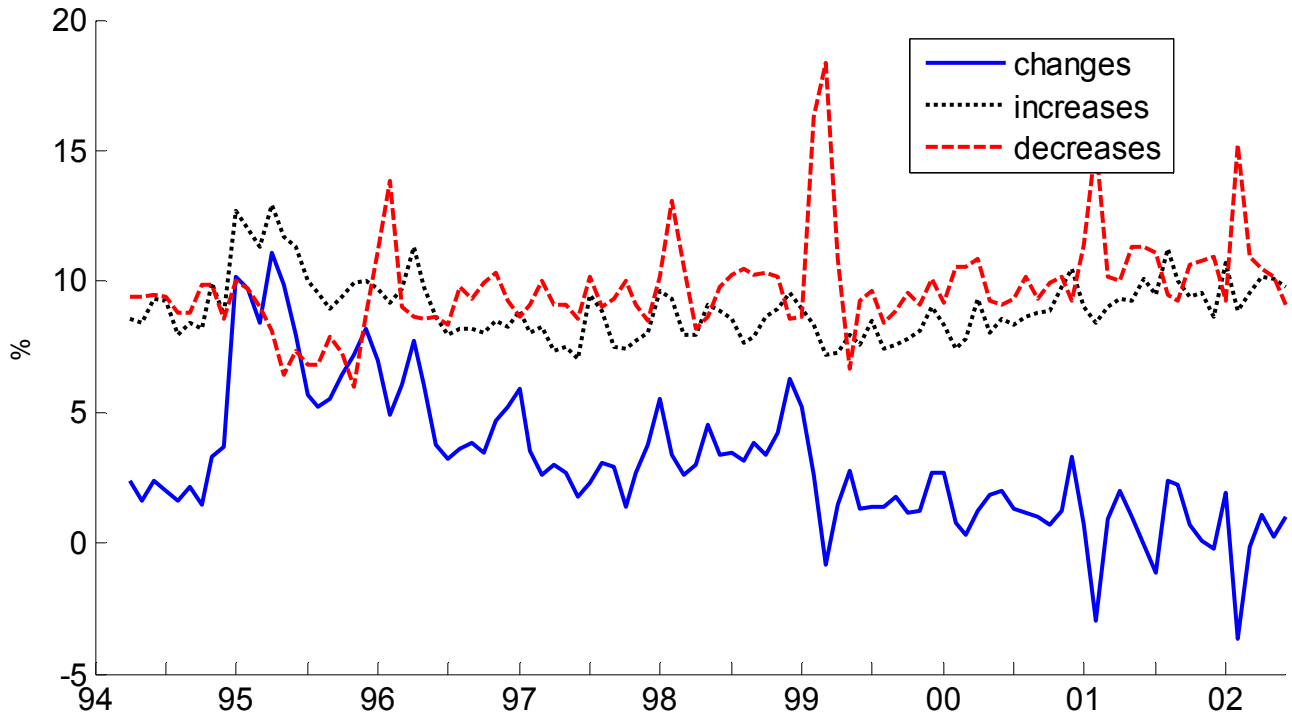
Scatterplot of average magnitude of price increases and decreases (nonregulated goods)





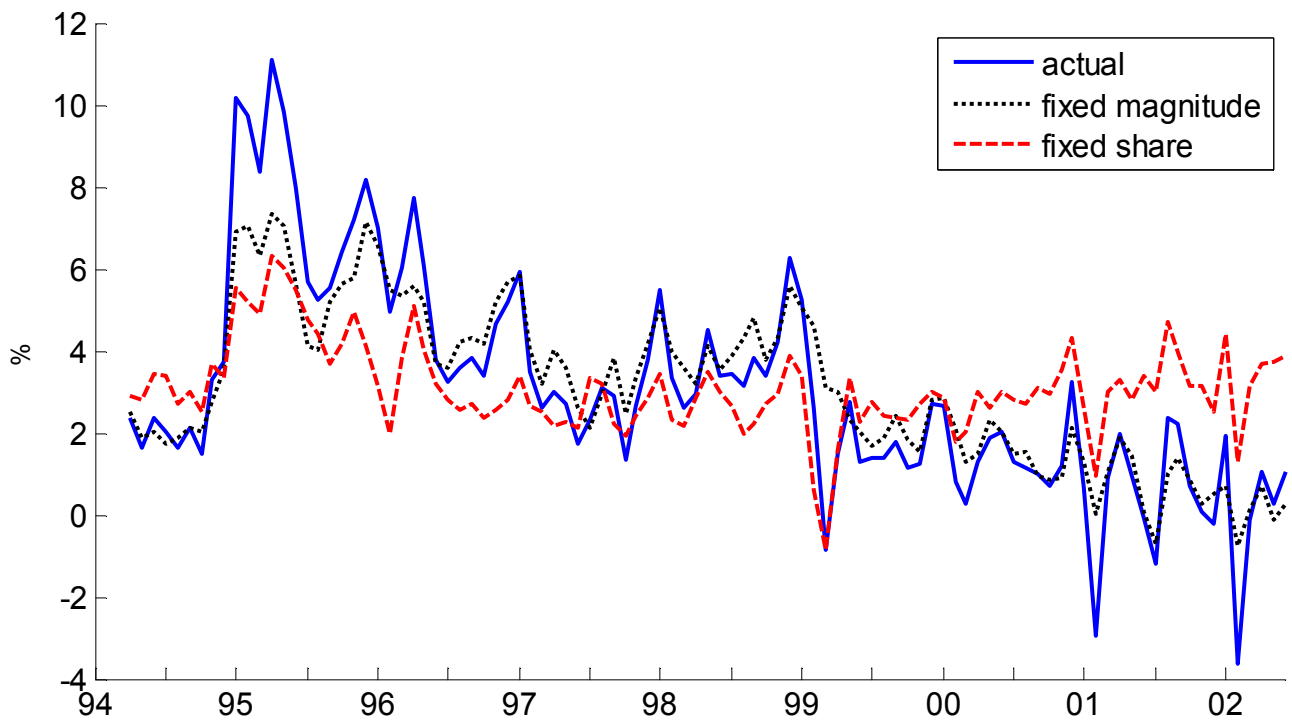
Average price increase and decrease

(nonregulated goods)



Changes in absolute magnitude or composition?

$$dp_t = s_t \cdot dp_t^+ + (1 - s_t) \cdot dp_t^-, \quad \text{where } s_t = \frac{fr_t^+}{fr_t^- + fr_t^+}$$



Frequency of price increases and decreases

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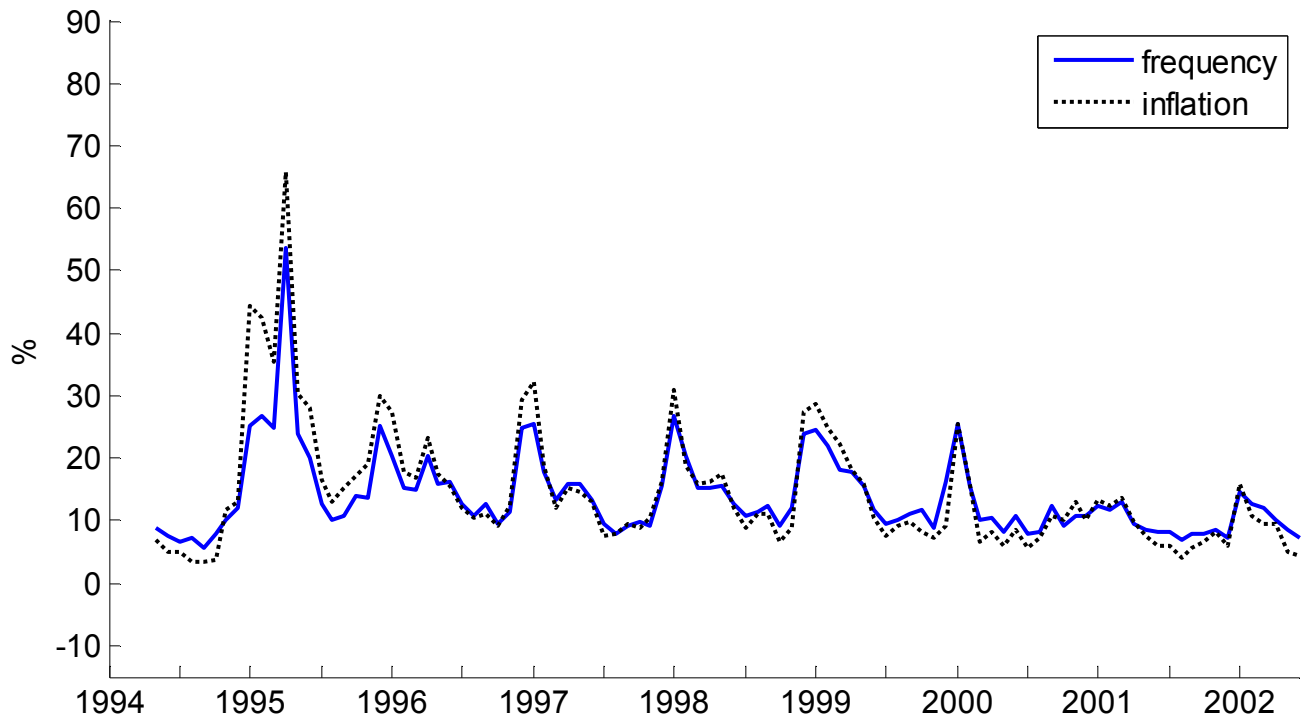

Inflation Variance Decomposition

- Taking a first-order approximation of

$$\pi_t = fr_t \cdot dp_t,$$

Klenow and Kryvtsov (2005) decompose the variance of inflation as

$$var(\hat{\pi}_t) = \underbrace{(\overline{fr})^2 var\left(\widehat{dp_t}\right)}_{\text{Intensive margin}} + \underbrace{(\overline{dp})^2 var\left(\widehat{fr_t}\right) + (\overline{fr})(\overline{dp}) cov\left(\widehat{dp_t}, \widehat{fr_t}\right) + O^2}_{\text{Extensive margin}}.$$

- In the United States, the share inflation variance accounted for by the intensive margin is ≈95%.

Inflation Variance Decomposition

	Inflation		IM's Share of Inflation
	Mean	Std. Dev.	Variance (%)
Full Sample Period (January 1994 - June 2002)			
Full Sample	14.4	14.2	41.2
Nonregulated goods	14.3	16.1	48.1
Nonregulated services	14.5	10.0	10.5
Crisis (January 1995 - June 1999)			
Full Sample	21.7	15.3	34.5
Nonregulated goods	22.5	17.2	41.5
Nonregulated services	19.1	11.0	9.8
Postcrisis (July 1999 - June 2002)			
Full Sample	5.0	4.4	89.2
Nonregulated goods	3.5	5.6	93.9
Nonregulated services	9.2	4.1	18.0

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Section summary

- As for the United States, movements in the frequency of price changes account for a small share of the inflation variance over the low-inflation period.
- Over the high-inflation period, however, movements in the frequency of price changes matter much for the variance of inflation.
- Due to the presence of seasonality, most notably in the first few months of the year, the frequency is an important determinant of the inflation variance of services.

An experiment: the April 1995 VAT change

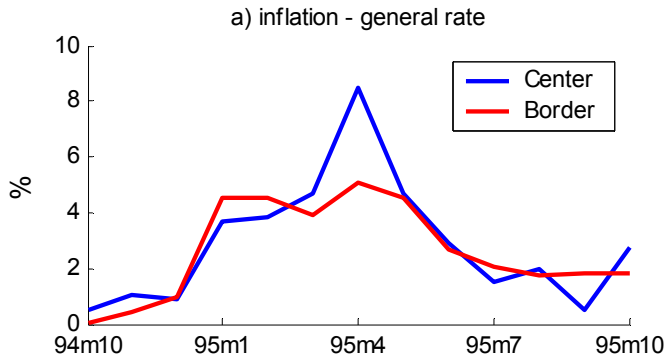
- Three months after the beginning of the Tequila crisis, the general rate of the value-added tax (VAT) increased from 10 to 15% everywhere in Mexico, with the exception of cities located in Baja California or within a corridor along the southern and northern borders.

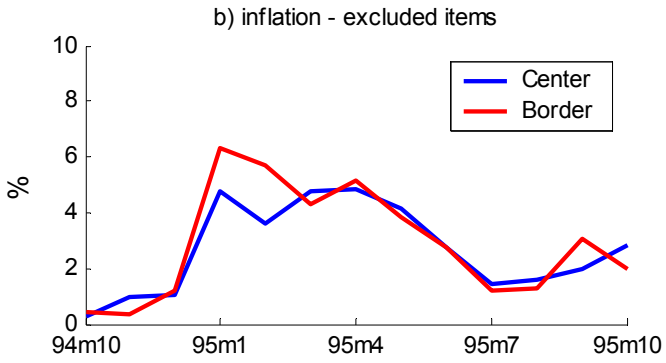
- What some popular price-setting models predict following VAT hike:

  - Calvo or Taylor contracts: no change to frequency, persistent response of magnitude of price changes and inflation;

  - Menu-cost models: the frequency should rise as soon as the shock hits, little persistence.

Impact of April 1995 VAT change





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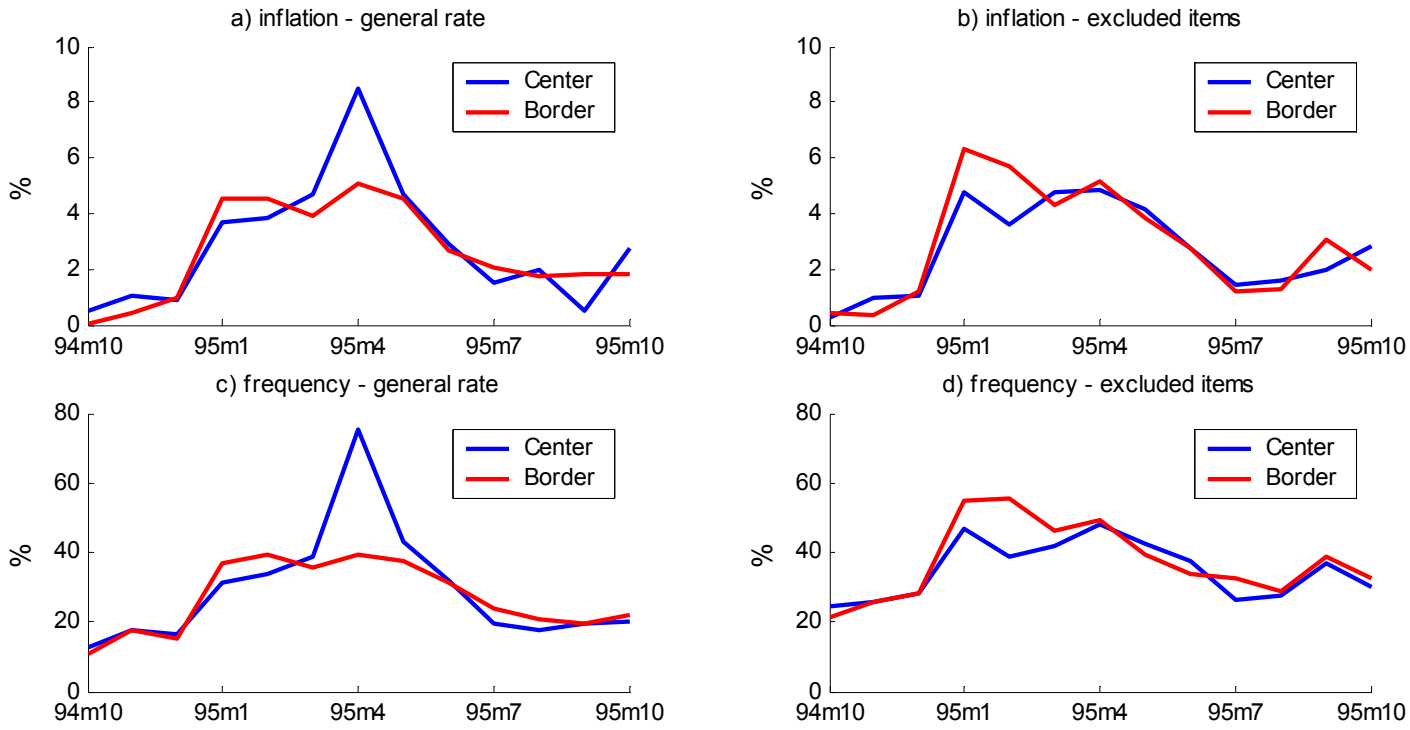

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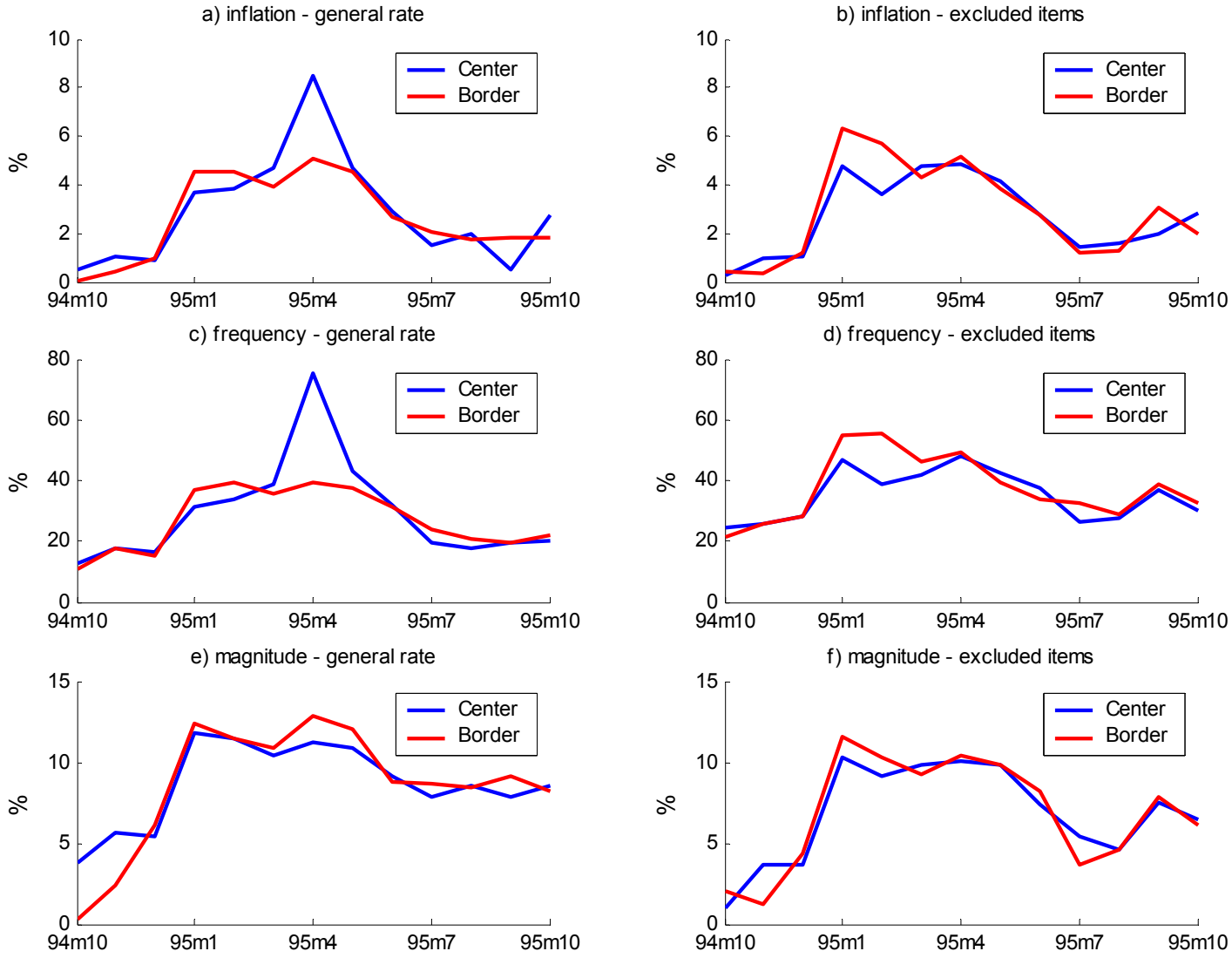


Section summary

- The VAT pass-through occurred almost entirely through more frequent price adjustments, not through larger price changes;
- This piece of evidence strongly favors state-dependent models which allow the frequency of price changes to respond to shocks.
- The VAT change episode is inconsistent with price-setting models generating persistent responses to all types of shocks, such as Calvo and Taylor contracts.
- Not all shocks are created equal: The change in the VAT was fully observable, which may have alleviated information problems or negative reactions to price increases from consumers.

Summary of the main empirical facts

- Consumer price adjustments are infrequent and lumpy: Even around the peak of inflation, the nominal price of many items remained unchanged.
- The frequency of price changes is positively correlated with inflation, especially during high-inflation period. At low inflation, movements in the frequency of price increases and decreases partly offset each other.
- The average magnitude of price changes is highly correlated with inflation over both the low- and high-inflation periods. This correlation stems mainly from movements in the relative occurrence of price increases and decreases, not in the absolute size of price changes.
- What models are consistent with these facts?

Can a menu-cost model fit the key facts?

- I consider a menu-cost model with idiosyncratic technology shocks along the lines of Danziger (1999) and especially Golosov & Lucas (2007).
- The model contains three types of agents:
  - Representative household;
  - Continuum of differentiated firms;
  - Monetary authority.
- I focus on stationary equilibrium with constant money growth.

Representative Household

- The representative household's problem is:

$$\max_{\{C_t, N_t\}} \quad \sum_{t=0}^{\infty} \beta^t (\log C_t - \psi N_t)$$

- Subject to a budget constraint and a simple money demand equation:

$$P_t C_t = W_t N_t + P_t \Pi_t$$

$$P_t C_t = M_t$$

- Consumption is a basket of differentiated items:

$$C_t = \left(\int (c_{j,t})^{\frac{\mu-1}{\mu}} dj \right)^{\frac{\mu}{\mu-1}}$$

Firms

- The production function is linear in labor:

$$y_{j,t} = c_{j,t} = \phi_{j,t} n_{j,t}$$

- Technology evolves according to:

$$\log \phi_{j,t} = (1-\rho)\log \bar{\phi} + \rho \log \phi_{j,t-1} + \varepsilon_{j,t}$$

where idiosyncratic innovation are given by:

$$\varepsilon_{j,t} \sim N(0, \sigma_{\varepsilon}^2)$$

- Timing: Firms enter period *t* with relative price (p_{t-1}/P_t) and the idiosyncratic shock is realized. Firms then choose whether to retain their past price or to incur a menu cost ξ (in units of labor) in order to post a new price.

Firms (cont'd)

- Firms maximize the present discounted value of real profits. For convenience, their problem is expressed recursively.

$$V(\phi;p) = \max \quad \{V_{nc}(\phi;p), V_c(\phi)\},$$

where

$$V_{nc}(\phi;p) = \pi(\phi;p) + \beta \int V\left(\phi'; \frac{p}{1+g}\right) d\mu(\phi'|\phi)$$

$$V_c(\phi) = \max_{\tilde{p}} \quad \pi(\phi;\tilde{p}) + \beta \int V\left(\phi'; \frac{\tilde{p}}{1+g}\right) d\mu(\phi'|\phi) - \xi \frac{W}{P}$$

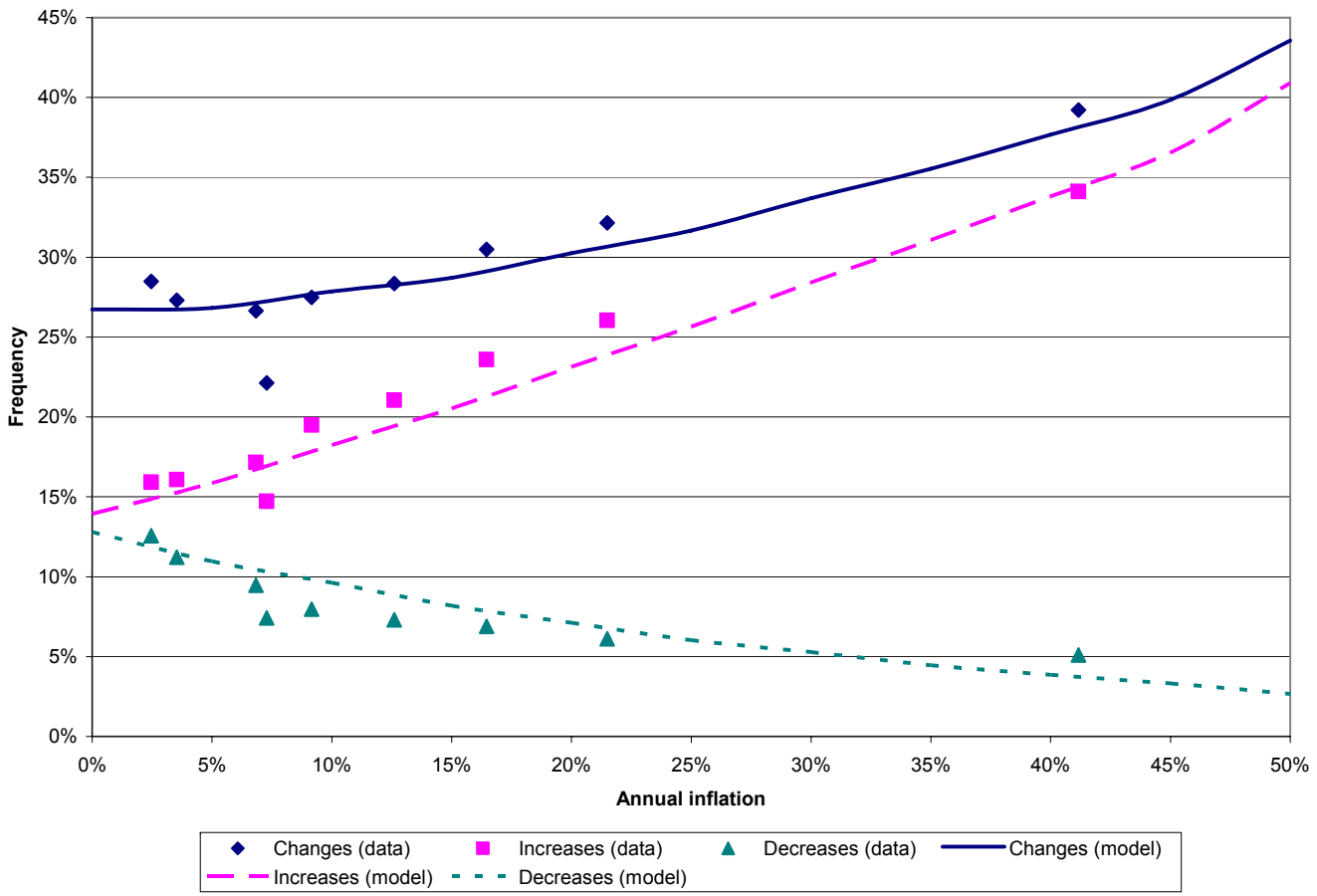
Model calibration and solution method

- The model is solved by approximating the value functions with Chebyshev polynomials and iterating until numerical convergence.

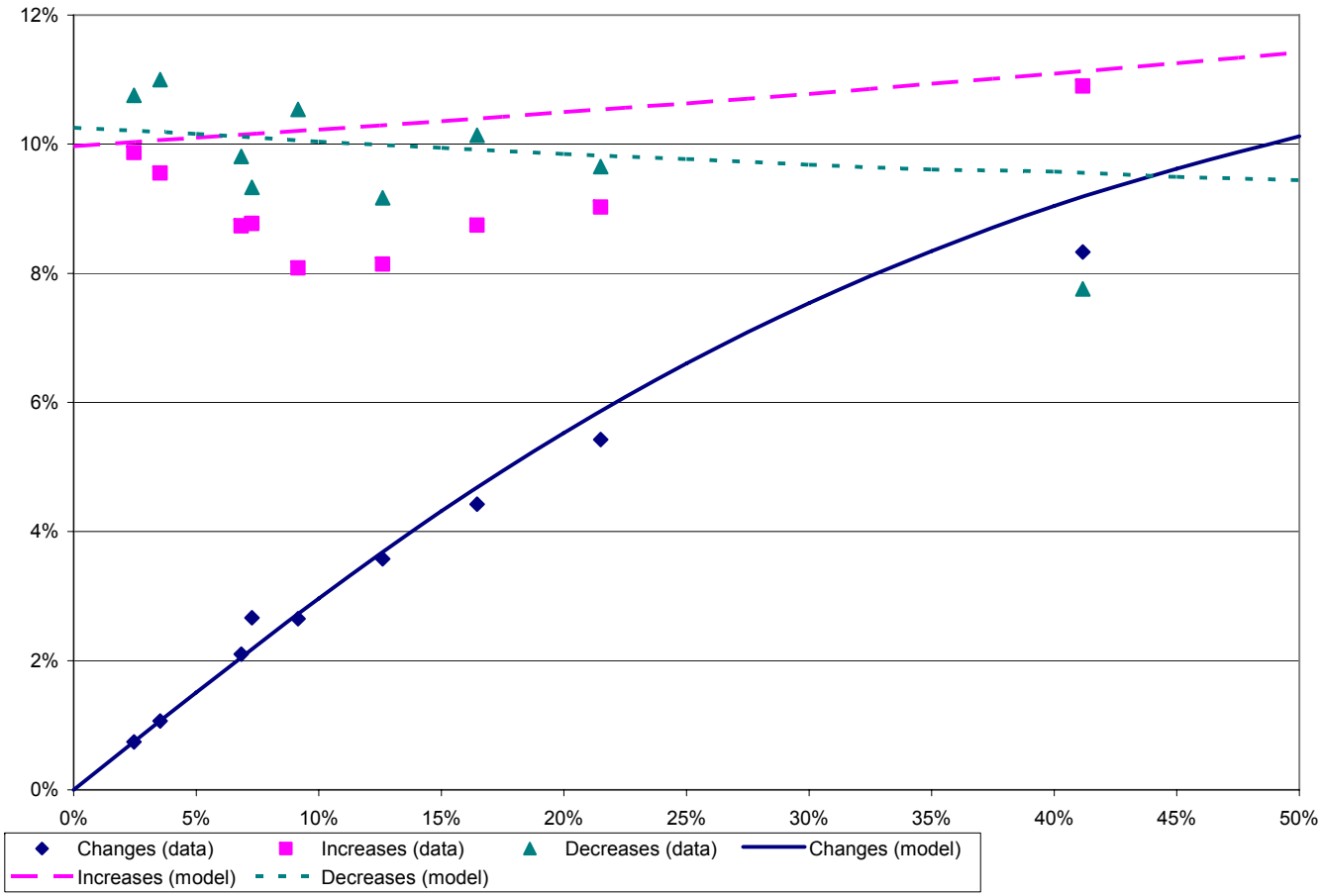
- The size of the menu cost and the variance of idiosyncratic shocks are calibrated to match the following statistics over the last year of the sample:
  - average frequency of price changes (27.5%);
  - average absolute magnitude of price changes (10.0%).

- The calibrated model is then simulated over a range of inflation similar to the one experienced by Mexico.

Model's fit of the frequency of price changes



Model's fit of the average magnitude of price changes



Section summary

- The model predicts remarkably well the level of the average frequency and magnitude of price changes over a range of inflation similar to the one experienced by Mexico over the sample period.
- This goodness of fit comes partly from the presence of idiosyncratic shocks, which help generate opposite movements in the frequency of price increases and decreases.
- Menu costs ensure that nominal adjustments are infrequent and lumpy. Consistent with the data, the absolute size of price changes is relatively insensitive to the level of inflation.
- Contrary to the data, the distribution of price changes generated by the model contains few small price changes.

Concluding remarks (1/2)

- The analysis offers a few hints for the design of macro/monetary models consistent with the micro evidence:
  - There is support for a multi-sector model
    - Price setting practices differ markedly among goods and services.
    - Among goods, unprocessed food stands out for its high frequency of price changes.
  - Idiosyncratic shocks matter
    - Large number of price changes at low levels of inflation
    - Movements in the distribution of positive and negative price changes help understand

Concluding remarks (2/2)

- There is clear state-dependence in the data when it comes to the effects of inflation. The frequency and composition of price changes should thus be allowed to move in response inflation.

- Not all shocks are created equal. Economists may need to think more carefully about what frictions are important for what shocks. For example, VAT hikes are observable shocks that spur a large number of price changes, while a general rise in inflation may leave more prices unchanged.