Inflation Dynamics under the Sticky Information Phillips Curve

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Contents

Introduction (1)

- Mankiw and Reis (2002) (MR (2002) hereafter) propose the sticky information model of price adjustments to address some of the failures of the sticky prices model
- specifically, the sticky prices model has problems in explaining the following stylized facts:
  - inflation is high persistent
  - disinflations always have contractionary effects
  - monetary policy shocks affect inflation with a substantial delay
- the assumption of sticky prices brings forth the new Keynesian Phillips curve (NKPC), while the assumption of sticky information yields the sticky information Phillips curve (SIPC)
- MR (2002) offer the analitical derivation of the SIPC model from microeconomic fundamentals, propose some calibration values and perform a series of simulations to argue the usefulness of the model.

Introduction (2)

- the empirical validity of the SIPC is tested by applying the methodology of Coibion (2010)
- this consists in estimating both SIPC and NKPC conditional on the same measure of inflation expectations
- in order to generate inflation and output gap expectations, I will use the methodology outlined by Stock and Watson (2003) and applied by Khan and Zhu (2006) in the case of the sticky information model
- briefly, the procedure consists in constructing measures of expectations as VAR out-of-sample forecasts
- this methodology is consistent with the testing procedure of Coibion (2010), as he uses the VAR expectations data set as an alternative to survey data

NKPC vs SIPC

- inflation dynamics under the NKPC

$$\pi_t = \frac{(1-\theta)(1-\beta\theta)}{\theta}\alpha y_t + \beta E_t \pi_{t+1} \quad (1)$$

- where

  θ is the probability that a firm uses old prices in a given period

  α is the coefficient of real rigidity (degree of strategic complementarity)

- inflation dynamics under the SIPC

$$\pi_t = \frac{(1-\lambda)}{\lambda}\alpha y_t + (1-\lambda)\sum_{j=0}^{\infty}\lambda^j E_{t-j-1}\left(\pi_t + \alpha \Delta y_t\right) \quad (2)$$

- where

  λ is the probability that a firm optimizes prices using old information in a given period

Interpretation of the parameters

- using the theoretical structure of each model, it can be shown that:
  - $1/(1-\theta)$ is equivalent to the average time of price change
  - $1/(1-\lambda)$ is equivalent to the average time of information arrival
- the coefficient of real rigidity, α, denotes the weight that firms give to the conditions of aggregate demand in their pricing decisions
- alternatively, according to Cooper and Andrew (1988), α can be interpreted as the degree of strategic complementarity

General issues regarding the estimation of the SIPC

- it is necessary to make a truncation of the lag length in equation (2) and to introduce an error term:

$$\pi = \frac{\lambda\alpha}{1-\lambda} y_t + \lambda \sum_{j=0}^{j_{max}-1} (1-\lambda)^j E_{t-j-1} \left(\pi_t + \alpha \Delta y_t\right) + \epsilon_t \quad (3)$$

- following Khan and Zhu (2002, 2006) and Coibion (2010) expectations are proxied using simulated data obtained as out of sample forecasts from VAR and AR models
- according to Coibion (2010), output gap is subject to the endogeneity problem
- parameter values are estimated using a numerical procedure which can lead to more than one result; for all estimates, I will use as starting values the ones proposed by MR (2002) for calibration, i.e. $\lambda = 0.75$ and $\alpha = 0.1$.

Expectations simulation procedure (1)

- we define two sets of bivariate VARs of the form:

$$\begin{bmatrix} Z_t \\ X_t \end{bmatrix} = \mu + \beta(L) \begin{bmatrix} Z_t \\ X_t \end{bmatrix} \tag{4}$$

where X_t corresponds to output or inflation and Z_t is one of the indicators that is believed to be relevant for output, in the first set, and inflation, in the second set.

- definition of the two central series:

  inflation calculated using the quarterly CPI: $\Delta log(CPI)$

  output gap calculated by applying the HP filter with $\lambda = 1600$ to real GDP

- similar to Coibion (2010), the forecasting variables are:
  - $ROBOR1M$, capacity utilization (cu), crude oil price (oil), registred unemployment ($ureg$), industrial production ($yind$), $M0$.

Expectations simulation procedure (2)

- the specification of each VAR from (4) is chosen as to minimize the mean square prediction error:
  - for inflation we use: $ROBOR1M$, $log(cu)$, $\Delta\Delta log(oil)$, $\Delta ureg$, $\Delta ygap$, $log(yind)$
  - for output gap we use: $ROBOR1M$, $\Delta log(cu)$, $\Delta\Delta M0$, $\Delta\Delta ureg$, $\Delta log(yind)$
  - all VARs, with one exception, have a length of two lags
- forecasts are also performed using an AR(2) model for inflation and an AR(1) model for output gap
- all the forecasts for a given variable are averaged excluding the minimum and the maximum values and imposing the AR forecast as one of the forecasts to be averaged over.

Model comparison

- the two models are compared on statistical grounds using the nonnested Davidson-Mackinnon J test
- we test the validity of one model relative to the other
  - testing the null of NKPC $H_0 : \delta_{SI} = 0$

$$\pi_t = ky_t + E_t\pi_{t+1} + \delta_{SI}\widehat{\pi}_t^{SI} + \epsilon_t \tag{5}$$

  - testing the null of SIPC $H_0 : \delta_{SP} = 0$

$$\pi_t = \frac{(1-\lambda)\alpha}{\lambda}y_t + (1-\lambda)\sum_{j=0}^{j_{max}-1}\lambda^j E_{t-j-1}\left(\pi_t + \alpha\Delta y_t\right) + \delta_{SP}\widehat{\pi}_t^{SP} + \epsilon_t \tag{6}$$

Implementation of the simulation procedure (1)

- I chose a forecasting horizon of 8 periods ($j_{max} = 8$)
- available data sample 1998Q1 - 2009Q4 (48 observations)
- VAR estimation sample t_0 = 1998Q1 - t_1 , where $t_1 = \overline{2002Q4, 2009Q4}$ (29 iterations)
- VAR forecasting sample $t_{f1} - t_{f2}$, where $t_{f1} = \overline{2003Q1, 2010Q1}$, and $t_{f2} = t_{f1} + 8$ (29 iterations)
- for AR models $t_1 = \overline{2000Q4, 2009Q4}$, $t_{f1} = \overline{2001Q1, 2010Q1}$
- after applying this procedure and arranging the forecasts we obtain 16 series of expectations: $E_{t-1}(\pi_t), \ldots, E_{t-8}(\pi_t)$, $E_{t-1}(y_t), \ldots, E_{t-8}(y_t)$

Implementation of the simulation procedure (2)

- to test the robustness of the results, the estimation is performed using the following expectations series, calculated as outlined in section 3:

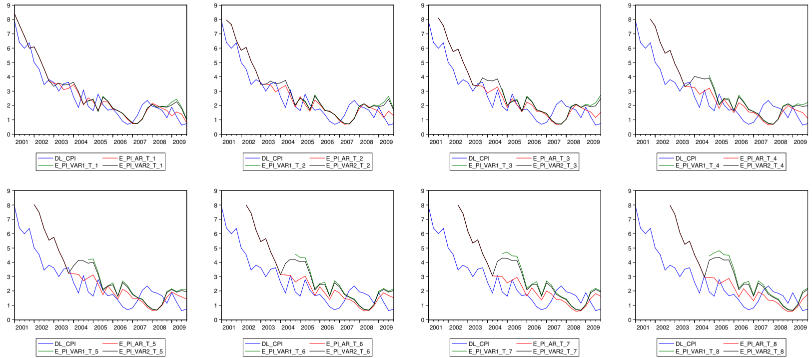
  AR simple AR forecasts
  VAR_1 averaged VAR forecasts
  VAR_2 averaged AR and VAR forecasts.

- we also test the robustness to varying the sample:

  short sample $2004Q4 - 2009Q4$
  extended sample $2002Q4 - 2009Q4$

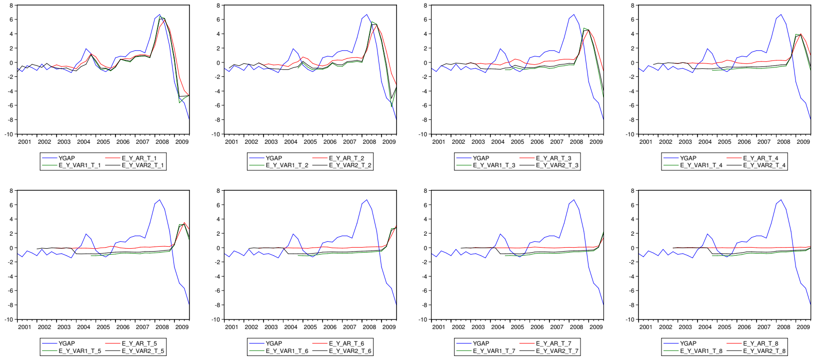
Results of the simulation (1)

Figure: VAR expectations, AR expectations and actual inflation



Results of the simulation (2)

Figure: VAR expectations, AR expectations and actual output gap



Results for the SIPC (1)

Table: Estimates of the SIPC using nonlinear least squares

	estimation sample				
	2002Q4-2009Q4		2005Q1-2009Q4		
	expectations series		expectations series		
	AR	VAR_2	AR	VAR_1	VAR_2
		$j=8$			
λ	0.78*** (0.03)	0.82*** (0.02)	0.69*** (0.08)	0.81*** (0.12)	0.79*** (0.04)
α	0.23* (0.12)	0.37*** (0.13)	0.14** (0.07)	0.38*** (0.12)	0.35*** (0.12)
S	0.87	0.79	0.95	0.82	0.84
Q	0.15	0.10	0.12	0.09	0.10
		$j=6$			
λ	0.73*** (0.04)	0.77*** (0.02)	0.59*** (0.12)	0.73*** (0.05)	0.72*** (0.05)
α	0.17(0.11)	0.26*** (0.09)	0.07(0.05)	0.25*** (0.07)	0.23*** (0.07)
S	0.84	0.80	0.96	0.85	0.86
Q	0.09	0.08	0.15	0.10	0.11
		$j=4$			
λ	0.58*** (0.05)	0.62*** (0.03)	-0.50*** (-0.05)	0.62*** (0.07)	0.60*** (0.08)
α	0.06(0.04)	0.12*** (0.04)	-0.00(0.01)	0.14*** (0.05)	0.12*** (0.05)
S	0.88	0.86	0.94	0.86	0.87
Q	0.22	0.20	0.72	0.12	0.13

For λ and α Newey-West standard errors are reported in brackets. S denotes the sum of the coefficients of the second right hand side term in (3). Q denotes the asymptotic p-value of the Ljung-Box statistic for one lag autocorelation test of the residuals.
* significant at 10%; ** significant at 5%; *** significant at 1%.

Results for the SIPC (2)

- global results
  - all estimates of λ, with one exception, are statistically significant and consistent with the underlying theory
  - the average time of information arrival, $1/(1-\lambda)$, ranges between 2.4 and 5.6 quarters
  - this corresponds to a slightly higher degree of informational rigidity than previously estimated in the literature
  - the sum of the weights in (3) is in most cases close to 1, the lowest value reported being 0.79
  - in most of the cases, α is also statistically significant
  - almost all estimates of α exceed the 0.1 value proposed by MR (2002), indicating a low degree of real rigidity (firms give a bigger weight to aggregate demand conditions when optimizing their prices).

Results for the SIPC (3)

- robustness analysis
  - in both samples the estimates corresponding to the autoregressive expectations indicate a lower degree of informational stickiness
  - the expanded sample indicates a higher degree of informational stickiness
  - using the VAR_2 series we find lower values for λ than when using the VAR_1 series, as a result of incorporating the AR information
  - in all cases a lower j_{max} yields a lower degree of informational stickiness and a higher degree of real rigidity, but surprisingly, it does not have a clear effect on the value of S, as we might expect.

Assesing the endogeneity problem of the regressors (1)

- variables suspect of endogeneity:
  - $E_t(\pi_{t+1})$: specific to the NKPC framework (see Gali and Gertler (1999))
  - output gap: according to Coibion (2010), shocks to the Phillips curve are correlated to the output gap
- the problem of endogeneity is addressed by GMM estimation
- following Coibion (2010), we use the following instruments:
  - for $E_t(\pi_{t+1})$: $E_{t-1}(\pi_{t+1})$
  - for $ygap$: $ygap_{t-1}$,$ygap_{t-2}$.

Assesing the endogeneity problem of the regressors (2)

- we address the problems common to the GMM framework in the reduced form NKPC:
  - validity of the orthogonality conditions: Hansen's J test for overidentification
  - the relevance of the instruments: Stock and Yogo (2002) weak instruments test
  - endogeneity of the regressors: Durbin-Wu-Hausman (DWH) test
- according to Adam and Padula (2003), using survey data mitigates the problem of weak instruments in NKPC.

Results for the NKPC (1)

Table: GMM estimates of the reduced form NKPC. Output gap treated as endogenous

	estimation sample				
	2002Q4-2009Q4		2005Q1-2009Q4		
	expectations series		expectations series		
	AR	VAR_2	AR	VAR_1	VAR_2
k	0.003 (0.008)	0.02 (0.02)	0.001 (0.007)	0.02(0.03)	0.02(0.02)
β	1.01^{***}(0.01)	0.98^{***}(0.02)	0.99^{***}(0.02)	0.95^{***}(0.03)	0.95^{***}(0.03)
J	1.73 (0.42)	1.77(0.41)	2.89 (0.23)	2.45 (0.29)	2.52 (0.28)
CD	41.58	40.84	38.28	34.19	34.87
DWH_1	0.09 (0.77)	0.58 (0.45)	0.006(0.93)	0.16 (0.69)	0.18 (0.67)
DWH_2	3.25 (0.07)	3.38 (0.07)	1.35(0.24)	1.30 (0.25)	1.18 (0.17)
DWH_3	3.73 (0.15)	3.99 (0.14)	1.90(0.39)	2.09 (0.35)	1.88 (0.39)

In brackets are reported, for k and β, Newey-West standard errors, and for J,DWH_1,DWH_2 and DWH_3, asymptotic p-values. GMM estimation method: Newey West HAC weighting matrix, iteration to convergence. Endogeneity tests are performed individually for output gap (DWH_1), $E_{t-1}(\pi_{t+1})$ (DWH_2) and jointly for the two regressors (DWH_3).
* significant at 10%; ** significant at 5%; *** significant at 1%

- the estimates of the output gap coefficient are not statistically significant
- output gap could be treated as exogenous
- the null of weak instruments is rejected in each case.

Results for the NKPC (2)

Table: GMM estimates of the reduced form NKPC. Output gap treated as exogenous

	estimation sample				
	2002Q4-2009Q4		2005Q1-2009Q4		
	expectations series		expectations series		
	AR	VAR_2	AR	VAR_1	VAR_2
k	0.0007 (0.006)	0.025^{*} (0.01)	-0.0006 (0.006)	0.0226 (0.02)	0.019(0.01)
β	1.01^{***}(0.01)	0.96^{***}(0.03)	0.99^{***}(0.02)	0.91^{***}(0.06)	0.91^{***}(0.05)
J	1.56 (0.21)	0.06(0.93)	2.61 (0.11)	2.30 (0.13)	1.97 (0.16)
CD	490.58	483.2	195.44	165.55	178.49
H_2	3.34 (0.07)	4.36 (0.04)	1.40(0.24)	0.23 (0.63)	0.68 (0.41)

In brackets are reported, for k and β, Newey-West standard errors, and for J and DWH asymptotic p-values.
GMM estimation method: Newey West HAC weighting matrix, iteration to convergence.
Endogeneity tests are performed for $E_{t-1}(\pi_{t+1})$ (DWH_2)
* significant at 10%; ** significant at 5%; *** significant at 1%

- the estimates of the coefficients are almost unchanged
- standard errors are smaller relative to the previous case
- using the VAR_2 series for the extended sample, we get a statistically significant coefficient for output gap.

Results for the NKPC (3)

Table: GMM estimates of the structural form NKPC
Output gap treated as exogenous

		estimation sample				
		2002Q4-2009Q4		2005Q1-2009Q4		
		expectations series		expectations series		
		AR	VAR_2	AR	VAR_1	VAR_2
$\alpha = 0.1$	θ	0.92^{***}	0.62^{***}	1.00	0.64^{***}	0.67^{***}
		(0.33)	(0.09)	(524.3)	(0.11)	(0.10)
$\alpha = 0.4$	θ	0.95^{***}	0.80^{***}	1.00	0.82^{***}	0.83^{***}
		(0.17)	(0.06)	68.3	(0.07)	(0.06)
	β	1.01^{***}	0.96^{***}	0.99^{***}	0.91^{***}	0.91^{***}
		(0.01)	(0.03)	(0.02)	(0.06)	(0.05)
	k	0.0006	0.025	0.000	0.0226	0.019

In brackets are reported Newey-West standard errors.
GMM estimation method: Newey West HAC weighting matrix, iteration to convergence.
* significant at 10%; ** significant at 5%;*** significant at 1%

- the VAR-based expectations yield sensible results:
  - the estimates are statistical significant
  - conditional on α , the average time of price change ranges between 2.6 and 3 quarters in the case of $\alpha = 0.1$ and between 5 and 5.9 quarters in the case of alpha=0.4.
  - the estimates corresponding to a lower degree of real rigidity are closer to the ones reported in the literature
  - the values of k and β are identical with the ones of the reduced form.

Results for the SIPC (4)

Table: GMM estimates of the SIPC. Output gap treated as endogenous

		estimation sample				
		2002Q4-2009Q4		2005Q1-2009Q4		
		expectations series		expectations series		
		AR	VAR_2	AR	VAR_1	VAR_2
	λ	0.79^{***}	0.81^{***}	0.73^{***}	0.77^{***}	0.77^{***}
		(0.02)	(0.02)	(0.04)	(0.04)	(0.04)
j=8	α	0.32^{*}	0.49^{***}	0.12	0.21^{***}	0.18^{***}
		(0.09)	(0.09)	(0.08)	(0.06)	(0.06)
	S	0.84	0.81	0.92	0.87	0.88
	Q	0.16	0.12	0.08	0.06	0.05

In brackets are reported Newey-West standard errors.
GMM estimation method: Newey West HAC weighting matrix, iteration to convergence.
Instruments: $ygap_{t-1}$, $ygap_{t-2}$, $E_{t-1}(\pi_t)$, $E_{t-1}(y_t)$
* significant at 10%; ** significant at 5%; *** significant at 1%

- the results are similar to the ones obtained using nonlinear least squares
- this confirms our previous findings according to which output gap should be treated as exogenous.

Model comparison results (1)

Table: Estimates of the SIPC and NKPC including the intercept

estimation sample: 2002Q4 - 2009Q4

	NKPC		SIPC		Nonnested model tests
c	0.013 (0.17)	c	0.387 (0.38)	δ_{SI}	0.32 (0.24)
k	0.025 (0.015)	λ	0.879^{***} (0.03)	δ_{SP}	0.65^{***} (0.17)
β	0.952^{***} (0.07)	α	0.541^{*} (0.32)		
R^2	0.87	R^2	0.65		

Note: HAC standard errors are reported in brackets. All estimates are done by updating the HAC weighting matrix to convergence.

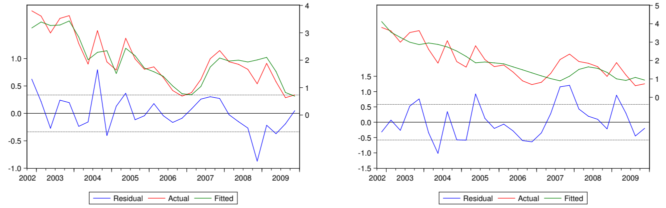
List of instruments for augmented *NKPC* (eq. (5)): constant, ygap, $E_{t-1}(\pi_{t+1})$.

List of instruments for augmented *SIPC* (eq. (6)): constant, ygap, $E_{t-1}(\pi_t)$,$E_{t-1}(y_t)$,$E_{t-1}(\pi_{t+1})$.

- according to R^2, the NKPC explains a larger proportion of inflation variability
- the null of the SIPC is rejected
- the null of the NKPC is not rejected
- the results are highly sensitive to the choice of instruments.

Model comparison results (2)

Figure: Comparing the fit of the two models

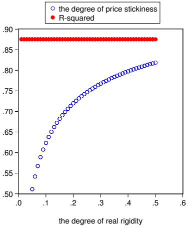


(a) NKPC (b) SIPC

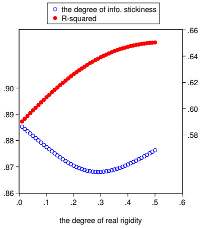
- the SIPC fails to adjust to surprise shocks in inflation and exhibits a substantial degree of inertia
- this comes from the fact that fitted inflation is constructed as a weighted average of past forecasts, causing recent information to be incorporated by all agents slowly
- the NKPC is able to account for a much larger amount of inflation variability
- the equation relies on current expectations of future inflation, which is, by means of construction, highly correlated with current inflation.

Testing the critique of Coibion

Figure: Comparing the sensitivity to α



(a) NKPC



(b) SIPC

- both λ and θ react to different calibration values of the real rigidity coefficient
- only the fit of the SIPC is influenced by α
- the critique of Coibion (2010): a high α favours the estimation of a high λ, but causes R^2 to fall
- in our case, λ does not increase monotonically with α and a high α increases R^2

Conclusions

- the major drawbacks of the analysis:
    - the small data sample (28 observations)
    - the unavailability of a quarterly survey for inflation and output
    - the NKPC and the SIPC were designed to account for a closed economy
- the empirical results validate the SIPC, which contradicts the findings of Coibion (2010)
- however, the NKPC has a superior ability to capture inflation dynamics, as argued by Coibion (2010)
- it is unlikely that the price adjustment mechanism can be accounted only by informational rigidities
- it would be desirable to see the extent to which these relate to other rigidities documented in the recent literature

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