Economics Bulletin

Volume 38, Issue 4

Inflation and Relative Price Variability in Brazil: A Time-Varying Parameter Approach

Cleomar Gomes da Silva
Federal University of Uberlandia, Institute of Economics (IERI-UFU), Brazil

Gilberto O. Boaretto
Department of Economics, Pontifical Catholic University of Rio de Janeiro (PUC-Rio), Brazil

Abstract

This paper aims at analyzing the relationship between inflation and relative price variability (RPV) in Brazil, for the period spanning from July 1999 to May 2017. State Space models, together with Kalman Filter, are used as main econometric methodology. As a benchmark exercise, ARDL-OLS and GMM estimations are applied, enabling to compare time-fixed and time-varying parameter approaches, and to examine the impact of potential endogeneity on the results. A GARCH-type model is also assessed to account for inflation variability. Results show that: i) the correlation between inflation and RPV is positive, but with statistical significance only in some months up to 2003 and from 2015 on; ii) the passthrough from inflation to RPV seems to increase when inflation increases, especially in the beginning of 2015; iii) the time-varying parameter approach proves to be relevant due to instabilities found in time-fixed estimations; iv) inflation variability is statistically significant and affects relative price variability throughout the whole period analyzed.

Cleomar Gomes da Silva is also a CNPq Associate Researcher. The authors thank CNPq, CAPES and FAPEMIG for financial support.
Citation: Cleomar Gomes da Silva and Gilberto O. Boaretto, (2018) "Inflation and Relative Price Variability in Brazil: A Time-Varying Parameter Approach", *Economics Bulletin*, Volume 38, Issue 4, pages 1947-1956
Contact: Cleomar Gomes da Silva - cleomargomes@gmail.com, Gilberto O. Boaretto - gilbertoboaretto@hotmail.com.
Submitted: December 01, 2017. **Published:** October 17, 2018.

1 Introduction

The relationship between inflation and relative price variability (RPV) has been a source of ongoing research aimed at a better understanding of an inflationary process and its dispersion, and how this affects welfare costs. In terms of sacrifice ratio, RPV can be closely related to high inflation costs, as it might be responsible for long lasting negative impact on well-being. If relative prices are distorted, decisions of economic agents can be distorted as well, resulting in scarce resources not being allocated to their most efficient use. Therefore, examining the effects of inflation in RPV, and vice versa, can be very useful in order to give policymakers important tools to take preventive actions against possible inflationary pressures at the lowest possible cost in terms of variability of output and employment.

When one looks at the relationship between inflation and RPV from a theoretical standpoint, two approaches can be analyzed: i) signal extraction (imperfect information) models (Lucas, 1973; Barro, 1976; Hercowitz, 1981; Cukierman, 1984); ii) menu costs models (Rotemberg, 1983; Ball & Mankiw, 1995). As from an empirical perspective, Mills (1927) was one of the first to analyze the U.S. case, followed by Parks (1978), Vining & Elwertowski (1976), Bomberger & Makinen (1993), Parsley (1996), Debelle & Lamont (1997), Jaramillo (1999), Chang & Cheng (2000), Chang & Cheng (2002), Caglayan & Filiztekin (2003), Fielding & Mizen (2008). As for other economies, Domberger (1987) looked at the case of Great Britain, while Van Hoomissen (1988) and Lach & Tsiddon (1992, 1993) examined the case of Israel, and Tommasi (1993) and Dabus (2000) analyzed Argentina. Nautz & Scharff (2005) did the same for Germany and Berument, Sahin & Saracoglu (2009) for Turkey. Fielding & Mizen (2000) investigated 10 European countries and Choi (2010) focused on the data related to Japan and the U.S.

As for the Brazilian case, some previous studies are worth mentioning. For instance, Moura da Silva & Kadota (1982) appear to be the first ones to examine the relationship between inflation and RPV, for the period spanning from 1972 to 1979, which was characterized by considerable high inflation in Brazil. Their focus was to investigate whether the country's price dispersion could be linked to its inflationary process. They reached this result, and also showed that inflation breaks coming from supply shocks influenced relative price dispersion considerably. Resende & Grandi (1992) aimed at Brazil's wholesale price index and its causality to RPV. For the period also characterized by high inflation rates, from 1976 to 1985, the authors were not able to reach a conclusion on such causality. Fava & Cyrillo (1999) also examined the Brazilian case, between 1977 and 1997, aiming at both menu cost and asymmetric response theories. The former was not corroborated by the results, because a dual causality between RPV and inflation was found. However, the asymmetric response of prices to random shocks was not rejected, at least for some sub-periods of the sample. Guillien & Garcia (2011) showed, for the period between August 1999 and July 2006, that price dispersion was altered due to changes in interest rates and in exchange rates. The authors also argued that macroeconomic shocks seemed to affect all price distribution in Brazil. Gomes da Silva (2015) also investigated the RPV-inflation relationship in Brazil, from January 1995 to June 2011. The focus was on both headline and core inflation rates. Besides the usual positive relationship between inflation and RPV, the author showed that price dispersion decreased after inflation targeting was implemented, and that shocks to core inflation didn't affect core-RPV as much as shocks to aggregate inflation affected aggregate

RPV.

The aim of this paper is to study the causal relationship between inflation and RPV in Brazil, for the period spanning from July 1999 to May 2017. Our focus is on the Brazilian Consumer Price Index (IPCA). We apply State Space models with time-varying parameter, as our main econometric methodology. As a benchmark and initialization of the Kalman Filter algorithm, we make use of Autoregressive Distributed Lag (ARDL) time-fixed estimations, and to verify the possibility of endogeneity affecting the parameters, we make use of GMM estimations. We also deal with inflation variability, obtained by means of an ARCH/GARCH model, in order to have this control variable in the RPV model, as in Chang & Cheng (2000). Also, we justify our TVP analysis by implementing an OLS-based Hansen parameter instability test.

Our first result shows the typical positive relationship between inflation and RPV in Brazil, but with statistical significance only in some months up to 2003 and from 2015 on. Our second result found is the increasing passthrough from inflation to RPV when inflation rises, especially in the beginning of 2015. In fact, this result was possible to be reached when the time varying approach was applied, which was also relevant in our study because of instabilities present in fixed parameters. Therefore, applying the TVP approach in this context seems to be an important contribution to the related empirical literature and an important issue regarding economic policy action in Brazil. In fact, even though the country has been targeting its inflation since 1999, the central target was not reached in 14 years, and in 2 years (2002 and 2015) Brazil faced a double-digit inflation. It means that, the more we analyze the relationship between inflation and RPV, the clearer it is the importance of maintaining inflation under control, with a minimum of relative price dispersion. Finally, inflation variability has negative significant effects on the Brazilian relative price variability throughout the whole period analyzed, and it is relatively stable with only a level break in the end of 2002, when inflation increased considerably in Brazil.

Besides this introduction, Section 2 brings the data, RPV measure and econometric approach and Section 3 reports the estimations and results. The last section concludes.

2 Data, RPV Measure and Econometric Approach

The disaggregated dataset used come from the Brazilian Institute of Geography and Statistics Database and refers to the disaggregated monthly inflation rate for every item included in the Brazilian Consumer Price Index (IPCA), along with their respective weight. As in Debelle & Lamont (1997), and others, RPV is the price variation in several goods and services categories around an average inflation rate of consumer prices, which is a measure of inter-market prices variability. As in Parks (1978), amongst others, our RPV measure considers the weight on each item used in the final price index, and it is calculated as follows:

$$\mathrm{RPV}_t = \sqrt{\frac{1}{n}\sum_{i=1}^{n} w_{it}(\mathrm{INF}_{it} - \mathrm{INF}_t)^2}$$

where: INF_{it} and w_{it} are price variation and category's weight related to item i in period t; INF_t is monthly IPCA inflation; n is number of categories. Figure 2 in the Appendix depicts the Brazilian monthly inflation rate and its RPV, for the period of analysis.

All variables used in the article span from July 1999 to May 2017. The reason for considering the data from July 1999 on is due to the beginning of inflation targeting in Brazil. Prior to that, Brazil was under a fixed exchange rate, which began in July 1994, together with the new monetary regime called Plano Real. As Brazilian international reserves declined considerably from 1994 to 1998, Brazil was forced to abandon the pegged exchange rate regime in the end of 1998. Therefore, with the floating exchange rate implemented, the country's Finance Ministry also started to adopt an inflation targeting regime in July 1999.

In order to estimate inflation variability by means of an ARCH/GARCH family model, we use two proxies for economic activity and exchange rate shocks in the model's mean equation. The first one is the log of Central Bank of Brazil Monthly GDP (HP-filtered GAP), which is seasonally adjusted and deflated by IPCA. This proxy was chosen due to lack of availability of another variable for the period analyzed. The second proxy used is ΔREER, the log difference of the Brazilian Real Effective Exchange Rate (source: BIS Bank).

The main econometric methodology applied is a state-space representation using a Kalman Filter as estimator, as in Hamilton (1994) and Durbin & Koopman (2001). To initialize the Kalman Filter we use, as prior information, time-fixed coefficients defined by ARDL-OLS estimations. We allow each ARDL regression to go up to six lags and select the best model via Schwarz Bayesian Criteria. To test parameter stability we apply a Hansen's LM test for individual coefficients and a joint test for all coefficients, as in Hansen (1992). In order to verify the effects of potential endogeneity in OLS estimator, we apply an ARDL model using the GMM estimator.

Although the influence of Kalman Filter initialization priors disappears, as sample size increases, its choice can drastically affect the initial behavior of time-varying parameters. To mitigate this difficulty, we also refer to the time-fixed ARDL estimated results and use that information to assume that the initial values of the time-varying parameters, and their respective variances, are identical to both coefficient and square of the standard errors estimated via ARDL. To guarantee positive estimates for the variances of the state-space representation equations, we express them in exponential form by making $\sigma^2 = \exp(\tau)$, where σ^2 is a variance vector and τ is the vector of hyperparameters to be estimated. We also use a diagonal variance-covariance matrix for the state equation, assuming that the covariance between different states is null.

The time-varying parameter (TVP) approach captures parameter instabilities, and its random walk hypothesis allows for smoother transitions and simpler interpretation. The estimated TVP model is:

$$\mathrm{RPV}_t = \alpha_t + \sum_{j=1}^{p} \beta_{j,t}\mathrm{RPV}_{t-j} + \sum_{k=0}^{q} \gamma_{k,t}\mathrm{INF}_{t-k} + \sum_{l=0}^{r} \phi_{l,t}\mathrm{INFVAR}_{t-l} + \varepsilon_t, \quad \varepsilon_t \sim N(0, \sigma_\varepsilon^2)$$

$$\alpha_t = \alpha_{t-1} + \eta_t, \quad \eta_t \sim N(0, \sigma_\eta^2)$$

$$\beta_{j,t} = \beta_{j,t-1} + \nu_{j,t}, \quad \nu_{j,t} \sim N(0, \sigma_{\nu_j}^2)$$

$$\gamma_{k,t} = \gamma_{k,t-1} + \xi_{k,t}, \quad \xi_{j,t} \sim N(0, \sigma_{\xi_k}^2)$$

$$\phi_{l,k} = \phi_{l,t-1} + \zeta_{l,t}, \quad \zeta_{l,t} \sim N(0, \sigma_{\zeta_l}^2)$$

where: i) INFVAR_t is the inflation variability; ii) α, β, γ and ϕ are random walk TVPs; iii) $\varepsilon, \eta, \nu_j, \xi_k$ and ζ_l are i.i.d. error terms with variances σ^2_ε, σ^2_η, $\sigma^2_{\nu_j}$, $\sigma^2_{\xi_k}$ and $\sigma^2_{\zeta_k}$, respectively; iv) p, q and r are the number of lags for RPV, inflation and inflation variability, defined in the ARDL estimations.

We also estimate a second model with a break dummy detected by an ADF-type endogenous break unit root test, proposed by Perron (1997) and Vogelsang & Perron (1998).

3 Estimations and Results

Table 2 (in the Appendix) reports the estimated ARCH/GARCH model for inflation and Figure 3 (in the Appendix) shows the inflation variability obtained. The model's mean equation consisted of inflation regressed on a constant, lagged inflation, ΔREER (2nd lag), GDP GAP (1st lag), with a Student-t error term. In its turn, the model's variance equation followed an ARCH(1) structure. Other variance equation structures, not reported in this paper, were also accounted for, such as: GARCH(1,1), GARCH(2,1), TGARCH(1,0) – considering a Student-t error term – and ARCH(1), with normally distributed error term. They led to inflation variabilities very similar to those reported and used in the estimations performed in the article.

Table 1 reports the time-fixed parameters results[1] for both ARDL models estimated for RPV, with and without a break dummy. The break date, detected in March 2015, was estimated by an ADF-type endogenous innovative outlier break unit root test. The null hypothesis of a unit root was rejected, but trend and break dummy were statistically significant at 1%.

As commonly found in many other articles, all models show a positive relationship between inflation and RPV for Brazil (INF_t coefficient), regardless of the model estimated (with or without dummy). They also show a relative price inertia (RPV_{t-1}) of around 0.33. Hansen's individual tests, and a joint test, indicate parameter instability in the estimations, except for inflation variability parameters in both models and a parameter associated with the break dummy in the second model. This pattern justifies the application of TVP procedure, as they can capture such instabilities. In other words, the question to be asked is how the estimated parameters behave if they are allowed to vary.

In order to examine the impact of potential endogeneity on ARDL-OLS regressions, we estimate a benchmark GMM model, with results reported in Table 3 in the Appendix. Comparing results with those from Table 1 indicates that OLS and GMM estimates for intercept and inflation variability coefficients are close to each other. On the other hand, lagged RPV and inflation coefficients from GMM estimations are higher and lower, respectively, than their OLS counterparts.

We can now proceed with our main econometric methodology, which are TVP estimations, via Kalman Filter, for models with and without a dummy. As priors, we use information related to the time-fixed parameters obtained by means of ARDL-OLS. We also tested for the use of GMM estimates, as priors, and obtained similar results. Figure 1 shows the estimations for the model without a break dummy. The average time-varying coefficient for

[1] We estimated ADF, PP, DF-GLS and KPSS unit root tests to find stationarity of the series. Results are available upon request.

Table 1: **ARDL(1,0,0) Estimations: Time-Fixed Parameters**

Dependent Variable: RPV_t						
Explanatory Variables		**Intercept**	$\mathbf{RPV_{t-1}}$	$\mathbf{INF_t}$	$\mathbf{INFVAR_t}$	**Dummy**
Model Without Dummy	**Coefficient (Std. error)**	0.533*** (0.094)	0.349*** (0.095)	0.271*** (0.063)	-0.235*** (0.086)	–
	Hansen's Indiv. Test	1.109***	0.850***	0.608**	0.184	–
	R-squared = 0.302					
	White Heterosk. Test (F-stats) = 5.338***					
	BG Test with 2 lags (F-stats) = 0.120					
	Hansen's Joint Stability Test = 1.908***					
Model With Dummy	**Coefficient (Std. error)**	0.576*** (0.085)	0.313*** (0.087)	0.248*** (0.065)	-0.189** (0.078)	0.793*** (0.071)
	Hansen's Indiv. Test	1.033***	0.788***	0.399*	0.156	0.127
	R-squared = 0.352					
	White Heterosk. Test (F-stats) = 2.320**					
	BG Test with 2 lags (F-stats) = 0.718					
	Hansen's Joint Stability Test = 1.997**					

Notes: ***, ** and * mean statistical significance at 1%, 5% and 10%, respectively.
Std. errors corrected by Huber-White HC.
Hansen's (Joint and Indiv.) LM Test Null: parameter(s) is(are) stable(s). Critical values in Hansen (1992).
Break Dummy in March 2015.

the inflation-RPV relationship is 0.272, positive and similar to the one reported in Table 1. However, such relationship is statistically significant only in some months up to 2003 and from 2015 on.

It appears that every time there is an inflation surge in Brazil, RPV increases considerably, as it can be seen in the end of 2002 and beginning of 2003, and from 2015 onwards. In the first case, the reason was the Brazilian presidential election dispute, which caused strong currency devaluation, with major impact on inflation. As for the second case, the story begins in the beginning of 2012, with substantial government intervention on administered prices, such as energy and gasoline. At least in the short run, such intervention policy was able keep inflation under control, but a major price dispersion was under way. In 2015, in the beginning of President Dilma Rousseff's second term in office, administered prices started to be adjusted. However, such inflation upsurge caused a considerable passthrough from inflation to relative price variability (see Figure 2 in the Appendix).

Figure 1 also shows results related to other estimated parameters. Regarding the intercept, the average price dispersion has been increasing constantly in Brazil, even though long-run inflation has been kept under control. As for the lagged RPV coefficient, it shows that RPV inertia seems not be the case, as it has been decreasing over the years. Finally, the inflation variability coefficient has shown stability during the entire period analyzed, except for a level break in the end of 2002. This break is related to strong increase in inflation variability (see Figure 3 in the Appendix) due to a great currency devaluation already mentioned. Figure 4 in the Appendix depicts the parameter estimations for the model with a break dummy. The dynamics are quite similar to what was analyzed above.

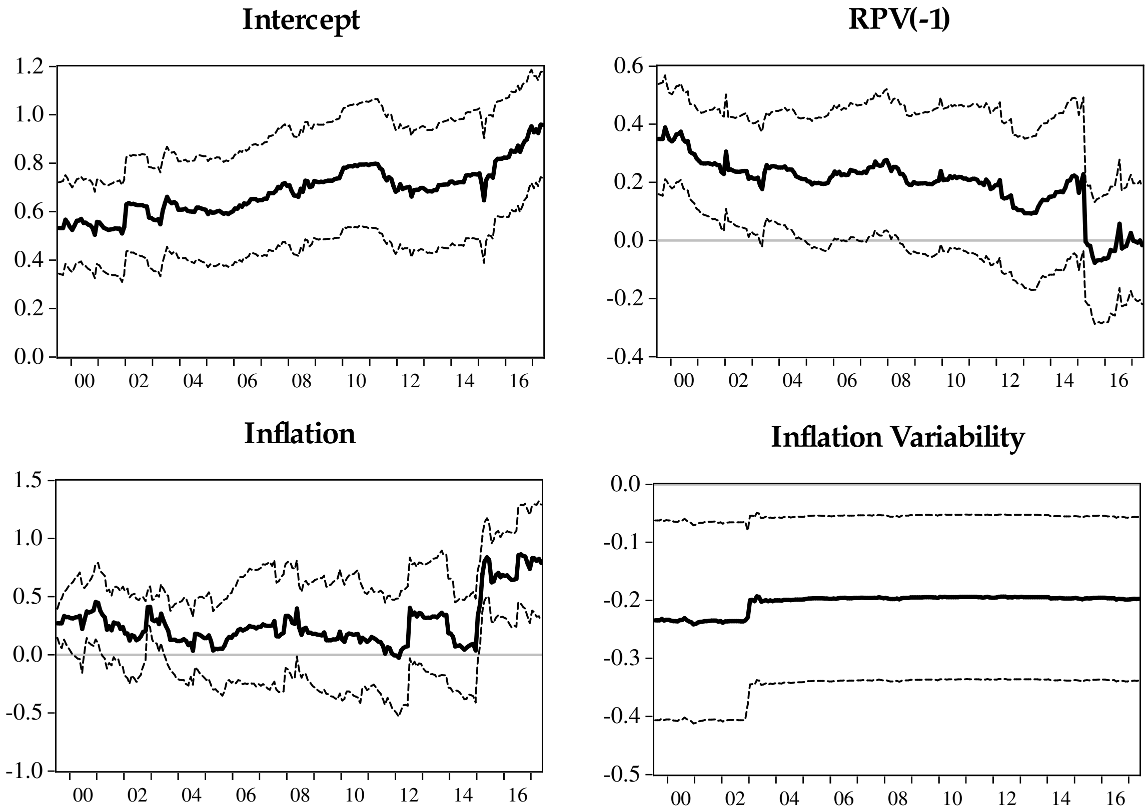

Figure 1: **Time-Varying Parameters ±2RMSE (No Dummy)**

4 Conclusion

This article examined the empirical relationship between inflation and relative price variability in Brazil, for the period spanning from January 1999 to May 2017. State Space models, together with Kalman Filter, were used as main econometric methodology. ARDL-OLS and GMM estimations were applied as benchmark, allowing for a comparison between time-fixed and time-varying parameters approaches, and for an impact analysis of potential endogeneity on the results. Effects of inflation variability were also controlled.

Firstly, we were able to find a typical result in the related empirical literature, which is a positive relationship between inflation and RPV in Brazil. However, this correlation was not statistically significant in a considerable part of the sample until 2015. Secondly, by making use of time-varying parameter approach, we found an increasing passthrough from inflation to RPV, due to increasing inflation, especially in the beginning of 2014. In fact, the TVP approach was very useful in the study, as it allowed for corrections in instabilities found in the time-fixed parameters. Finally, in our inflation variability analysis, we found it to be statistically significant with negative effects on the dispersion of relative prices in Brazil.

Regarding policy perspectives, we have seen the importance of examining the relationship between relative price variability and inflation, once price dispersion can influence the decision making of economic agents and, as a result, affect welfare. When this investigation is combined with other crucial analysis, such as unemployment rate and output growth, it is clear that monetary and fiscal authorities should be very careful when conducting their economic policies, because higher inflation eventually leads to social welfare loss and less credibility in policy actions. And watching closely how relative prices behave is one of the first steps to see how inflation behaves, and vice versa. There is no doubt that this task is very helpful to help policymakers to take monetary policy actions, such as using interest rates, to control demand shocks, and watching carefully all supply shocks. Fiscal authorities also have an important role in the process, and they ought to coordinate their actions with monetary authorities in order to achieve a controlled inflation rate.

References

Ball, L. and N. G. Mankiw (1995) "Relative Price Changes as Aggregate Supply Shocks" *Quarterly Journal of Economics* **10**, 161-93.

Barro, R. J. (1976) "Rational Expectations and the Role of Monetary Policy" *Journal of Monetary Economics* **10**, 1-32.

Berument, M. H.; Sahin, A. and B. Saracoglu (2009) "The Choice of Monetary Policy Tool(s) and Relative Price Variability: Evidence from Turkey" *Journal of Applied Sciences* **9**, 2238-46.

Bomberger, W. A. and G. E. Makinen (1993) "Inflation and Relative Price Variability: Parks' Study Reexamined" *Journal of Money, Credit and Banking* **25**, 854-861.

Caglayan, M. and A. Filiztekin (2003) "Nonlinear Impact of Inflation on Relative Price Variability" *Economics Letters* **79**, 213-218.

Chang, E. C. and J. W. Cheng (2000) "Further Evidence on the Variability of Inflation and Relative Price Variability" *Economics Letters* **66**, 71-77.

Chang, E. C. and J. W. Cheng (2002) "Inflation and Relative Price Variability: A Revisit" *Applied Economics Letters* **9**, 325-330.

Choi, C. (2010) "Reconsidering the Relationship between Inflation and Relative Price Variability" *Journal of Money, Credit and Banking* **42**, 769-798.

Cukierman, A. (1984) *Inflation, Stagflation, Relative Prices and Imperfect Information*, Cambridge: Cambridge University Press.

Dabus, C. (2000) "Inflationary Regimes and Relative Price Variability: Evidence from Argentina" *Journal of Development Economics* **62**, 535-547.

Debelle, G. and O. Lamont (1997) "Relative Price Variability and Inflation: Evidence from U.S. Cities" *The Journal of Political Economy* **15**, 132-152.

Domberger, S. (1987) "Relative Price Variability and Inflation: A Disaggregated Analysis" *The Journal of Political Economy* **95**, 547-566.

Durbin, J. and S. J. Koopman (2001) *Time Series Analysis by State Space Methods*, Oxford: Oxford University Press.

Fava, V. L. and D. C. Cyrillo (1999) "Inflação e Dispersão de Preços Relativos: Qual a Direção da Causalidade?" *Economia Aplicada* **3**, 438-456.

Fielding, D. and P. Mizen (2000) "Relative Price Variability and Inflation in Europe" *Economica* **67**, 57-78.

Fielding, D. and P. Mizen (2008) "Evidence on the Functional Relationship between Relative Price Variability and Inflation with Implications for Monetary Policy" *Economica* **75**,

683-99.
Gomes da Silva, C. (2015) "Relative Price Variability in Brazil: An Analysis of Headline and Core Inflation Rates" *Nova Economia* **25**, 83-100.
Guillén, D. and M. Garcia (2011) "Dispersão na Fixação de Preços no Brasil" *Revista Brasileira de Economia* **65**, 47-69.
Hamilton, J. (1994) *Time Series Analysis*, Princeton University Press: Princeton, NJ.
Hansen, B. (1992) "Testing for Parameter Instability in Linear Models" *Journal of Policy Modeling* **14**, 517-533.
Hercowitz, Z. (1981) "Money and the Dispersion of Relative Prices" *Journal of Political Economy* **89**, 328-56.
Jaramillo, C. F. (1999) "Inflation and Relative Price Variability: Reinstating Parks' Results" *Journal of Money, Credit, and Banking* **31**, 375-385.
Lach, S. and D. Tsiddon (1992) "The Behavior of Prices and Inflation: An Empirical Analysis of Disaggregated Price Data" *Journal of Political Economy* **100**, 349-389.
Lach, S. and D. Tsiddon (1993) "The Effects of Expected and Unexpected Inflation on the Variability of Relative Prices" *Economics Letters* **41**, 53-56.
Lucas, R. (1973) "Some International Evidence on Output-Inflation Tradeoffs" *American Economic Review* **63**, 326-34.
Mills, F. (1927) *The Behavior of Prices*, New York: Arno.
Moura da Silva, A. and D. K. Kadota (1982) "Inflação e Preços Relativos: O Caso Brasileiro 1970-79" *Estudos Econômicos* **12**, 249-262.
Nautz, D. and J. Scharff (2005) "Inflation and Relative Price Variability in a Low Inflation Country: Empirical Evidence for Germany" *German Economic Review* **6**, 507-523.
Parks, R. W. (1978) "Inflation and Relative Price Variability" *The Journal of Political Economy* **86**, 79-95.
Parsley, D. (1996) "Inflation and Relative Price Variability in the Short and Long Run: New Evidence from the United States" *Journal of Money, Credit, and Banking* **28**, 323-341.
Perron, P. (1997) "Further Evidence on Breaking Trend Functions in Macroeconomic Variables" *Journal of Econometrics* **80**, 355-385.
Resende, M. and R. Grandi (1992) "Inflação e Variabilidade dos Preços Relativos no Brasil: A Questão da Causalidade" *Revista Brasileira de Economia* **46**, 595-604.
Rotemberg, J. (1983) "Aggregate Consequences of Fixed Costs of Price Adjustment" *American Economic Review* **73**, 433-436.
Tommasi, M. (1993) "Inflation and Relative Prices: Evidence from Argentina". In: Sheshinski, E.; Weiss, Y. (Eds). *Optimal Pricing, Inflation, and the Cost of Price Adjustment*, Cambridge and London: MIT Press.
Van Hoomissen, T. (1988) "Price Dispersion and Inflation: Evidence from Israel" *Journal of Political Economy* **96**, 1303-1314.
Vining, D. R. and T. C. Elwertowski (1976) "The Relationship between Relative Prices and the General Price Level" *American Economic Review* **66**, 699-708.
Vogelsang, T. and P. Perron (1998) "Additional Tests for a Unit Root Allowing for a Break in the Trend Function at an Unknown Time" *International Economic Review* **39**, 1073-1100.

Appendix

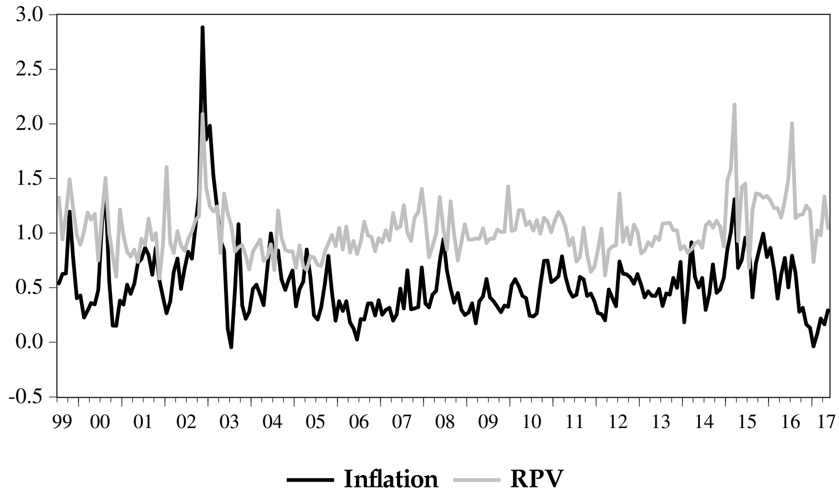

Figure 2: **Monthly, Seasonally Adjusted Inflation and RPV**

Source: Brazilian Institute of Geography and Statistics.

Table 2: **ARCH(1) Model: Inflation Variability Estimation**

Dependent Variable: INF_t								
Explanatory Variables	**Mean equation**				**Variance equation**			**R-squared**
	Intercept	**INF_{t-1}**	**$\Delta REER_{t-2}$**	**GAP_{t-1}**	**Intercept**	**$ARCH_{t-1}$**	**t-distr. par.**	
Coefficient (Std. Error)	0.143*** (0.023)	0.697*** (0.037)	0.007** (0.003)	0.009 (0.006)	0.024*** (0.006)	0.557*** (0.172)	7.409** (3.163)	0.512

Notes: *** and ** mean statistical significance at 1% and 5%, respectively.

Table 3: **Benchmark GMM Estimation**

Dependent Variable: RPV_t				
Explanatory Variable	**Intercept**	**RPV_{t-1}**	**INF_t**	**$INFVAR_t$**
Coefficient (Std. error)	0.511*** (0.100)	0.439*** (0.076)	0.128 (0.152)	-0.212 (0.628)
J-statistic	3.675	**P-value (J-statistic)**		0.452

Notes: *** mean statistical significance at 1%.
Two-step GMM with Newey-West HAC weighthing matrix (Akaike criteria lag spec. and Bartlett kernel).
Instrumental variables list: RPV_{t-1}, INF_{t-1}, INF_{t-2}, $VARINF_{t-1}$, $\Delta REER_{t-3}$, GAP_{t-1}, GAP_{t-2}.
Std. errors corrected by Newey-West HAC.

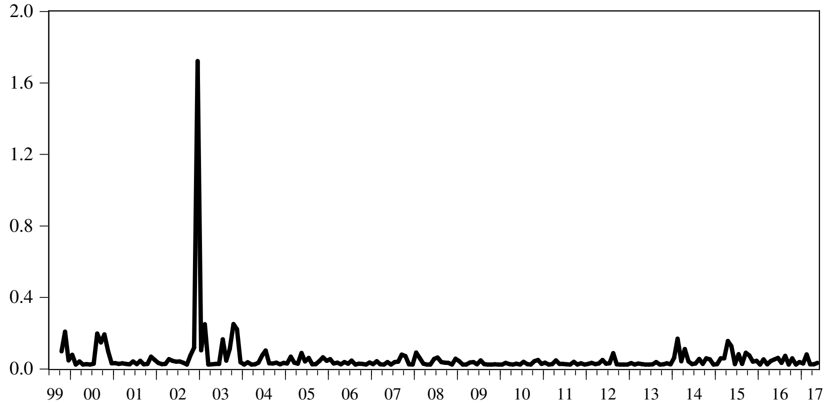

Figure 3: **Estimated Monthly Inflation Variability**

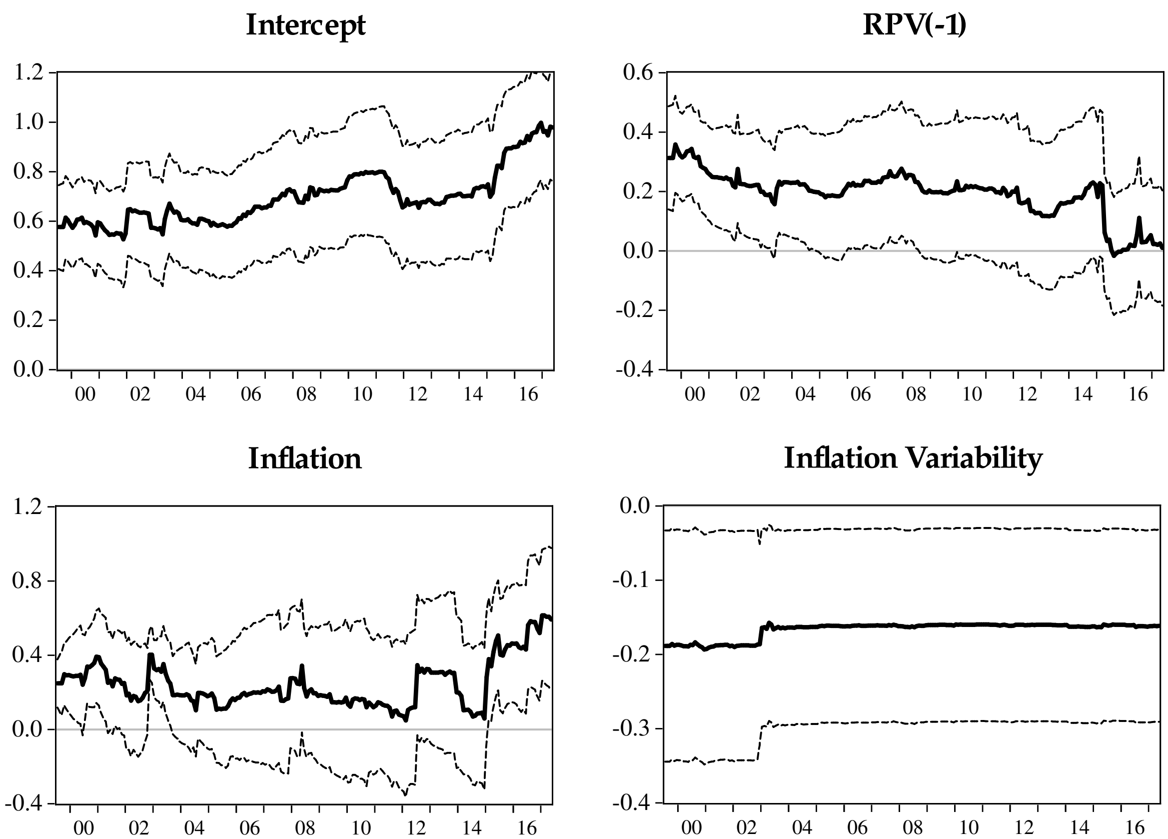

Figure 4: **Time-Varying Parameters ±2RMSE (With Dummy)**