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Cross-Sectional Relative Price Variability and Inflation in Turkey: Time Varying Estimation

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Abstract

This study investigates the empirical validity of the variability hypothesis in Turkey for the period of February 2005-November 2015, by using cross-sectional relative price data and by focusing on the assumptions of linearity and stability. The linearity assumption between the two variables is ensured by estimating quadratic regression equation. The assumption of stability is secured by utilizing the Kalman filter approach. The Kalman filter estimates of the regression coefficients suggest that there exists a time varying U-shaped relationship between inflation and cross-sectional relative price variability in Turkey. Time variation on the regression coefficients and the U-shaped curve is significant. The annualized inflation rate which minimizes cross-sectional relative price variability varies from 8.7% to 9.4%.

Keywords: Inflation, Cross-Sectional Relative Price Variability, Kalman Filter, U-Shape, Optimal Inflation, Time Varying Coefficient.

1. Introduction

In the literature of economics, the variability hypothesis implies a positive relationship between relative price variability (hereafter RPV) and inflation. The positive relationship between the two variables has been theoretically proposed by two main models: menu costs and imperfect information. The menu cost model theoretically developed by Ball and Mankiw (1994) predicts that the positive relationship runs from expected inflation to RPV because of firms' sluggish price adjustment process. On the other hand, the imperfect information model established by Lucas (1973) proposes that the unexpected inflation creates RPV because of suppliers' misperception about relative and general price changes.

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The essential idea of the Lucas imperfection information (island) model is based on the suppliers' inability to distinguish price movements due to cross-sectional relative price and aggregate price changes. In the case of price movements resulting from relative price changes, it is expected that suppliers should respond to new prices. If the price movements are due to aggregate price changes, they should not respond to new prices. In the Lucas island model, when the suppliers anticipate the relative price of their goods supplied on their island, they supply more of it. However, decisions about supply changes are assumed to be made on imperfect information. The price of the goods supplied on each island is perfectly observed by the suppliers of that island. The rest of the suppliers in the other islands cannot immediately observe the price of the goods supplied by the island. They can observe the price of island only with some lags.

Following the work of Vinning and Elwertowski (1976), numerous studies have empirically investigated the hypothesis for different data sets. However, one of the major critics on the subject has especially focused on the measure of the RPV. In the empirical literature, most studies such as Parks (1978), Fischer (1981), Lach and Tsiddon (1992), Akmal (2011), Rather *et al*. (2014), Kafaie and Moshref (2013), and Ukoha (2007) used intra-market RPV while some such as Parsley (1996) and Ghauri *et al*. (2013) utilize inter-market definition of RPV. A few recent works such as Hajzler and MacGee (2011), Fielding *et al*. (2011), Bick and Nautz (2008), Baglan *et al*. (2015), Debelle and Lamont (1997), Cağlayan and Filiztekin (2003) employed a panel data, combination of cross-sectional cities, and commodities.

In empirically examining the variability hypothesis in the context of the Lucas island model, definition of RPV is very crucial. Since the positive relationship between inflation and RPV arises from the inability of suppliers in distinguishing the local price changes from aggregate price changes, RPV related to aggregate inflation should be defined on the basis of geographical location: cross-sectional price variability based on city or region data.

In the literature, there have been a limited number of studies which have attempted to empirically test the variability hypothesis for the case of Turkey. Among them, the studies by Cağlayan and Filiztekin (2003) and Baglan *et al*. (2015) used a nonlinear function form while the early works by Yamak (1997), Yamak and Sivri (1999), and Yamak and Tanriover (2006) assumed the linear relationship between inflation and RPV. In all these contributions, however, the issue of stability has not been parametrically investigated together with nonlinearity.

The main objective of this study is to examine the variability hypothesis for the case of Turkey by using cross-sectional RPV and relaxing the assumptions of linearity and stability on the functional form. The linearity assumption between inflation and RVP is relaxed by estimating quadratic regression equation. The assumption of stability is ensured by applying the Kalman filter technique to the constructed quadratic regression equation.

2. Data and Methodology

The data used in this study are consumer price index for 26 major regions which are two-digit. The data are monthly and cover the period of February 2005-November 2015. All data come from the Turkish Statistical Institute. Before starting the analysis, all data were seasonally adjusted by using the Census X12 method. Aggregate and regional inflation series are then defined as the monthly log difference of respective seasonally adjusted series. Finally, the cross-sectional RPV variable is constructed by using the weighted and seasonally adjusted aggregate and regional inflation series as follows:

$$RPV_t = \sqrt{\sum_{j=1}^{26} w_j(\pi_{jt} - \pi_t)^2}$$

where $\pi_{jt} = lnP_{jt}\text{-}lnP_{jt-1}$, $\pi_t = lnP_t\text{-}lnP_{t-1}$, lnP_t is the logarithm of the aggregate (consumer) price index level at time t, lnP_{jt} is the logarithm of the price index level of region j at time t and w_j is the weight of region j in the aggregate price index. Main regions and their weights are given in Table 1. The seasonally adjusted aggregate inflation and RPV time series are shown in Figure 1. As seen in Figure 1, both series appear to be stationary at level. This is also confirmed by the Augmented Dickey-Fuller (1981) unit root test.

Table 1. Main regions and their weights

Codes	Regions	Weights
TR1	İstanbul	0.2689
TR2	Tekirdağ, Edirne, Kırklareli	0.0267
TR3	Balıkesir, Canakkale	0.0216
TR4	İzmir	0.0646
TR5	Aydın, Denizli, Muğla	0.0356
TR6	Manisa, Afyon, Kütahya, Uşak	0.0365
TR7	Bursa, Eskişehir, Bilecik	0.0627
TR8	Kocaeli, Sakarya, Düzce, Bolu, Yalova	0.0598
TR9	Ankara	0.0865
TR10	Konya, Karaman	0.0232
TR11	Antalya, Isparta, Burdur	0.0408
TR12	Adana, Mersin	0.0407
TR13	Hatay, Kahramanmaraş, Osmaniye	0.0261

Codes	Regions	Weights
TR14	Kirikkale, Aksaray, Nigde, Nevsehir, Kirsehir	0.0153
TR15	Kayseri, Sivas, Yozgat	0.0238
TR16	Zonguldak, Karabuk, Bartin	0.0126
TR17	Kastamonu, Cankiri, Sinop	0.0075
TR18	Samsun, Tokat, Corum, Amasya	0.0270
TR19	Trabzon, Ordu, Giresun, Rize, Artvin, Gumushane	0.0261
TR20	Erzurum, Erzincan, Bayburt	0.0095
TR21	Agri, Kars, Igdir, Ardahan	0.0070
TR22	Malatya, Elazig, Bingol, Tunceli	0.0140
TR23	Van, Mus, Bitlis, Hakkari	0.0115
TR24	Gaziantep, Adiyaman, Kilis	0.0180
TR25	Sanliurfa, Diyarbakir	0.0202
TR26	Mardin, Batman, Sirnak, Siirt	0.0138

Note: Regional weight is the ratio of the amount of added value created in the region for 2010 to total amount of added value in Turkey for 2010.

Following the pioneering study of Parks (1978), a large number of works have empirically investigated the hypothesis for different economies and periods. Most of the empirical studies, including Parks (1978), Lach and Tsiddon (1992), Domberger (1987), Fischer (1981), Hercowitz (1981), and Cukierman (1979) found a positive and linear relationship between inflation and RPV. The linearity assumption made by these studies has been strongly criticized by Hartman (1991), Dabus (2000), Caglayan and Filiztekin (2003), and Becker and Nautz (2009), by arguing that the relationship between the two variables could be quadratic or piecewise linear. The findings of Fielding and Mizen (2008) and Choi and Kim (2010) support the U-shaped relationship between inflation and RPV around non-zero inflation. In recent empirical literature, there is a strong consensus on the U-shaped or V-shaped relationship between the two variables. Another debate on the functional form refers to the instability of the U-shaped relationship. Many studies which use either linear or nonlinear form assume that the relationship between the two variables is time invariant. However, recent studies by Choi (2010), Caglayan and Filiztekin (2003), and Dabus (2000) demonstrate that the relationship between the two variables depends on the regimes of inflation or monetary policy.

To investigate the U-shaped effect of inflation on RVP in this study, first the following quadratic regression is estimated by the ordinary least squares (hereafter OLS) assuming that coefficients of regression are time invariant.

$$RPV_t=\beta_0+\beta_1\pi_t+\beta_2\pi_t^2+\varepsilon_t \qquad (1)$$

If β_1 and β_2 in the estimated regression are found to be negative and positive respectively, it is then said that there exists a U-shaped relationship between inflation and RPV. The inflation rate which minimizes RPV equals $-\beta_1/2\beta_2$.

In the second step, the assumption of time invariant coefficient is relaxed by applying the Kalman Filter technique to Eq. (2).

$$RPV_t=\beta_{0,t}+\beta_{1,t}\pi_t+\beta_{2,t}\pi_t^2+\varepsilon_t \qquad \varepsilon_t\sim nid(0,v) \tag{2}$$

In the Kalman filter estimation technique, the first necessary step is to construct the state space form, which consists of measurement and transition equations (Kalman, 1960). Measurement equation represents observation Eq. (2), while the transition Eq. (3)-(5) describes the process of unobserved time varying coefficients.

$$\beta_{0,t}=\tau_0\beta_{0,t-1}+\mu_{0,t} \tag{3}$$

$$\beta_{1,t}=\tau_1\beta_{1,t-1}+\mu_{1,t} \tag{4}$$

$$\beta_{2,t}=\tau_2\beta_{2,t-1}+\mu_{2,t} \qquad \mu_t\sim nid(0,q) \tag{5}$$

where β_{0t}, β_{1t} and β_{2t} are the unobserved time varying coefficients of the measurement equation; τ_0, τ_1, and τ_2 are unknown coefficients of the transition equations; v is the unknown variance term of the errors in the measurement equation, and q is the unknown variance of the residuals in the transition equations. In general, β_{0t}, β_{1t}, and β_{2t} are not observable. However, it is generally assumed that they are known to be generated by a first-order Markov process.

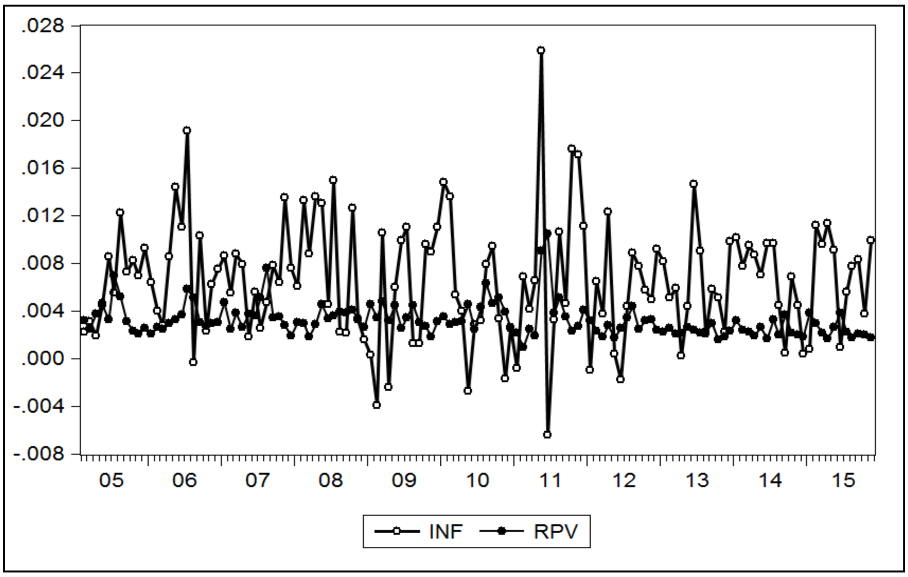

Fig. 1. Inflation and RPV

3. Empirical results

In the first step, equation 1 is estimated by the OLS, assuming that the relationship between inflation and cross-sectional RPV is time invariant. Table 2 reports the coefficient estimates and their statistics errors of quadratic regression. As seen in this table, all coefficients including intercept term are statistically significant at least at the 1% level and have also expected signs. Since the coefficient of π^2 is positive and statistically different from zero, the relationship between the two variables is quadratic. This means that the relationship between cross-sectional RPV and inflation is U-shaped curve. This nonlinear relationship between inflation and RPV is displayed in Figure 2. According to the time invariant OLS estimates given in Table 2, RPV is minimized as 0.003 when monthly inflation rate is 0.0076. The fact that the intercept of the quadratic regression is found to be positive and statistically significant implies that RPV is greater than zero (0.004) even though actual inflation rate is zero. Therefore, the curve of the relationship intersects the positive RPV axes.

Table 2. OLS estimation results

Variables	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
Intercept	0.004	0.0002	19.171	0.000
π	-0.255	0.044	-5.767	0.000
π^2	16.855	2.541	6.634	0.000
R-squared	0.257			
F-statistic	22.007			
Prob(F-statistic)	0.000			

Note: The estimated coefficients statistically significant at the 1% level

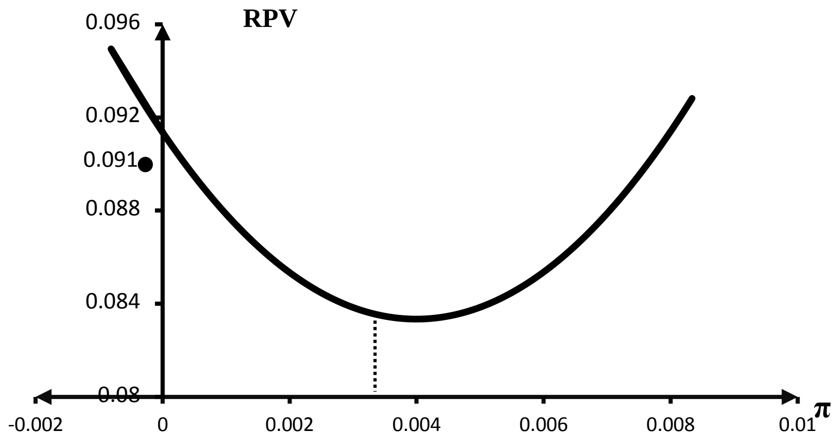

Fig. 2. U-shaped relationship between inflation and RPV

The main purpose of this study is to estimate the quadratic relationship between cross-sectional RVP and inflation, applying the Kalman filter technique to Eq. (2). Therefore, in the second step of this study, this equation is again estimated by the Kalman filter approach. Before running the Kalman filter, in order to get time varying parameters, β_{0t}, β_{1t}, and β_{2t}, the initial values of the unknown parameters of the state space model and their variance-covariance matrix are estimated by using OLS at the expense of whole observations. By using the initial values, the Kalman filter is run under the routine of optimization in order to get estimates of the rest of the unknown parameters.

Once given the optimum and initial values of the unknown parameters and their variance-covariance matrix which are coming from the time invariant OLS, the Kalman filter is again run from February 2005 - November 2015 to obtain the unconditional time varying parameter estimates. Figures 3-5 display the estimates of three time varying parameters β_{0t}, β_{1t}, and β_{2t}. The estimates of all three coefficients are found to satisfy the U-shaped relationship between inflation and RPV. In all cases, the estimate of β_0 is positive. As seen in Figure 3, time variation on the intercept is significant. The estimated intercepts range from a minimum of 0.0037 to a maximum of 0.0039 (Fig. 3). The mean of the estimated intercepts is 0.003. Time variation in β_1 and β_2 is more significant than β_0. The estimates of β_1 range from a minimum of -0.268 to a maximum of -0.214 (Fig. 4). Similarly, the coefficient estimates of the squared inflation variable range from 14.538 to 17.588 (Fig. 5).

Finally, the time varying optimal inflation rates which minimize RPV are computed by using the time varying parameter estimates in $-\beta_1/2\beta_2$. Figure 6 demonstrates the time variation on the optimal inflation rate. Monthly optimal inflation rates for cross-sectional RPV range from 0.0072 to 0.0078. Mean of the optimal inflation rates computed from time-varying estimates is about 0.0075. More specifically, when the time pattern of the optimal inflation rate is examined, three distinct sub-periods could be easily identified. Thus, the whole period could be split into three sub-periods for illustrative purposes. The first sub-period is the period of February 2005-May 2011. There appears to be a downward trend in the optimal inflation rate with a minimum of 0.0073 and a maximum of 0.0077. The computed means of optimal inflation rate is about 0.0075 per month. In the second sub-period which covers the last six months of 2011, optimal inflation rate dramatically increases from 0.0072 to a level of 0.0078 per month. Finally, in the last period of January 2012-November 2015, there again exists a significant downward trend in the optimal inflation rate. The mean of optimal inflation rate in this sub-period rate is about 0.0076 close to the mean of the whole period. It ranges from 0.0075 to 0.0078.

In order to determine whether the monetary policy conducted in Turkey for the period of 2005-2015 is effective in terms of the actual inflation, the time-variant optimal inflation rates must be compared to the actual inflation rates. If the actual inflation rate is above the minimum level of the U-shaped curve, the monetary authority has power to lower RPV by reducing actual inflation rate. In this case, contractionary monetary policy conducted by authority will not only reduce RPV but also prevent the welfare cost of the allocative efficiency of the prices disrupted by relative price variability. On the other hand, if the inflation rate is below the minimum level of the curve, monetary authority will probably use expansionary policy which creates some increases in the inflation rate increase without causing any welfare cost.

According to the results of the Kalman filter estimation in this study, the monetary policy applied in Turkey for the period of 2005-2015 is mostly effective in keeping optimal inflation rate for cross-sectional RPV. As seen in Figure 7, for the whole period, the mean of the gap between actual and optimal inflation rates is almost zero. In nearly half of the total 130 cases, monetary policy is expected to be more contractionary to reduce actual inflation and cross-sectional RPV. In the other half, effective monetary policy is expansionary and increases both the actual inflation rate and cross-sectional RPV.

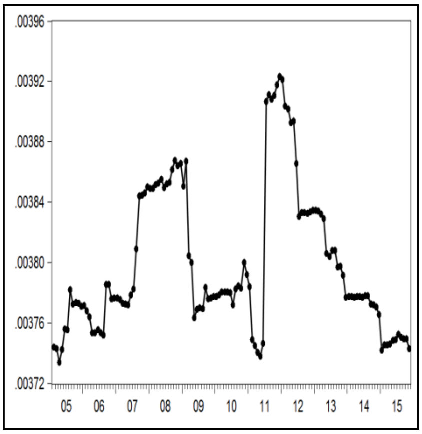

Fig. 3.Time varying parameter Estimates of the coefficient β_0

Fig. 4. Time varying parameter estimates of the coefficient β_1

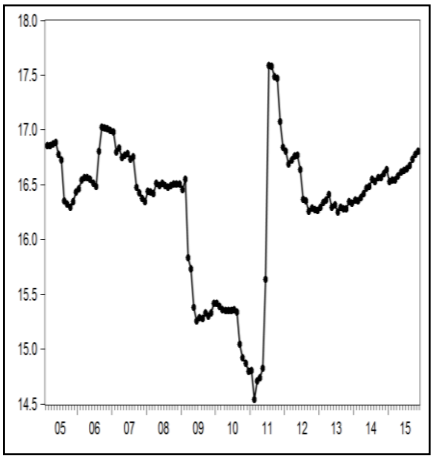

Fig. 5. Time varying parameter ($\frac{-\beta_1}{2\beta_2}$)

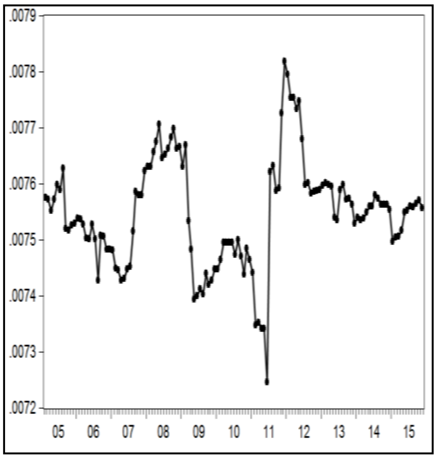

Fig. 6. Optimal estimates inflation rate of the coefficient β_2

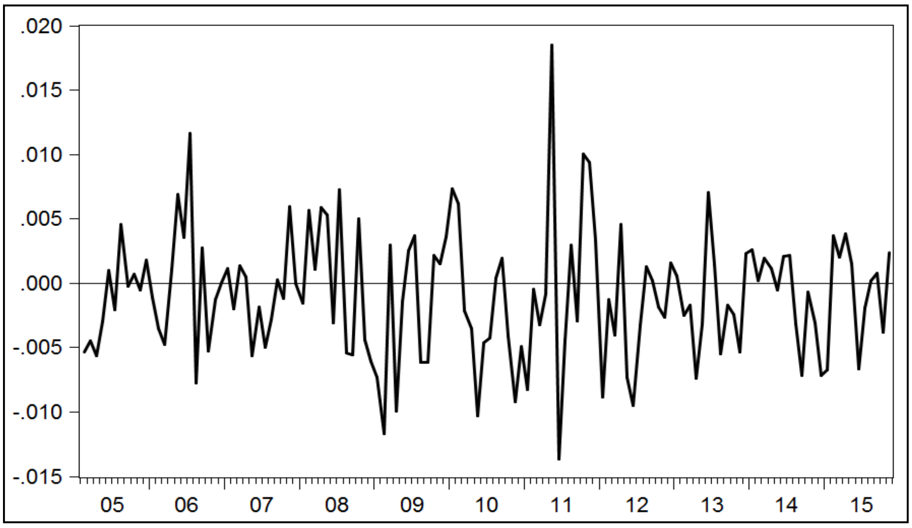

Fig. 7. The gap between actual and optimal inflation rates

4. Conclusion

The main objective of this study was to empirically investigate the effects of the aggregate inflation rate on cross-sectional RPV by allowing the relationship to be time varying and U-shaped. The parameter estimation of the quadratic regression was performed by using the Kalman filter estimation approach. This technique was chosen as the major analytical tool in this study because of the many advantages that it has over all other procedures such as moving OLS regressions, splitting whole period into two or three sub-periods, and stochastically varying estimation technique in terms of the optimal estimates. The Kalman filter can do all that OLS can do and more.

There are three main findings of this study. The first finding is related to the functional form of the relationship between cross-sectional RPV and actual inflation. According to the results of both OLS and Kalman filter, the relationship between the two variables is quadratic. This result implies that there are two different inflation rates for any level of RPV, but only one for the minimum level of RPV. The second finding related to the stability of the relationship suggests that the U-shaped curve between RPV and inflation is time variant. Significant time variation is found in the parameter estimates of the quadratic regression. This means that welfare cost of inflation in Turkey for the period of 2005-2105 is not constant on the monthly basis. The last finding is that the U-shaped curve has a turning minimum point at a positive inflation rate. This finding is consistent with the results of Fielding and Mizen (2008), Choi and Kim (2010), and Becker and Nautz (2010).

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