RELATIVE PRICE VARIABILITY AND INFLATION IN TURKEY: RESULTS FROM KALMAN FILTER ESTIMATION

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Abstract

This study re-examines the relationship between inflation rate and relative price variability in Turkey for the period of February 2005-November 2015, by relaxing the assumptions of linearity and stability. The linearity assumption between the two variables is relaxed by estimating quadratic regression equation. The assumption of stability is removed by utilizing the Kalman filter approach. The Kalman filter estimates of the regression coefficients are found to satisfy the U-shaped relationship between inflation and relative price variability. Time variation on the regression coefficients and the U-shaped curve is significant. The annualized inflation rate which minimizes relative price variability varies from 4.26% to 4.93%.

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

JEL Classification: E30, E31, C22

1. Introduction

In the inflation literature, the hypothesis that a rise in inflation increases relative price variability (hereafter RPV), called variability hypothesis is recently attracting considerable interest. The positive relationship between the two variables has been theoretically produced by two main models: menu costs and imperfect information. The menu cost model developed by Ball and Mankiw (1994) predicts

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that the expected inflation affects RPV because of firms' sluggish price adjustment process. The imperfect information model introduced by Lucas (1973) argues that the unexpected inflation creates RPV because of suppliers' misperception about relative and general price changes.

Following the pioneering study of Parks (1978), large number of works has empirically investigated the hypothesis for different economies and periods. The most of empirical studies, including Parks (1978), Lach and Tsiddon (1992), Domberger (1987), Fischer (1981), Hercowits (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 Hartmann (1991), Dabus(2000), Caglayan and Filiztekin (2003) and, Becker and Nautz (2009), 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) supported 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 two variables depends on the regimes of inflation or monetary policy.

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

The main purpose of this study is to re-examine the variability hypothesis for the case of Turkey by relaxing the assumptions of linearity and stability about the functional form. The linearity assumption between inflation and RVP is relaxed by estimating quadratic regression equation. The assumption of stability is removed 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 12 major commodity groups 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 sub-aggregate inflation series are then defined as the monthly log difference of respective seasonally adjusted series. Finally, the RPV variable is constructed by using the weighted and seasonally adjusted aggregate and sub-aggregate inflation series as follows:

$$RPV_t=\sqrt{\sum_{i=1}^{12} w_i(\pi_{it}-\pi_t)^2}$$

Where: $\pi_{it}= lnP_{i,t}-lnP_{i,t-1}$, $\pi_t= lnP_t-lnP_{t-1}$, lnP_t is the logarithm of the consumer price index level at time t, $lnP_{i,t}$ is the logarithm of the price index level of commodity group i at time t and w_i is the weight of commodity group i in the consumer price index. Main expenditure groups and their weights are given in Table 1. The seasonally adjusted aggregate inflation and RPV time series are shown in Figure 1.

Table 1

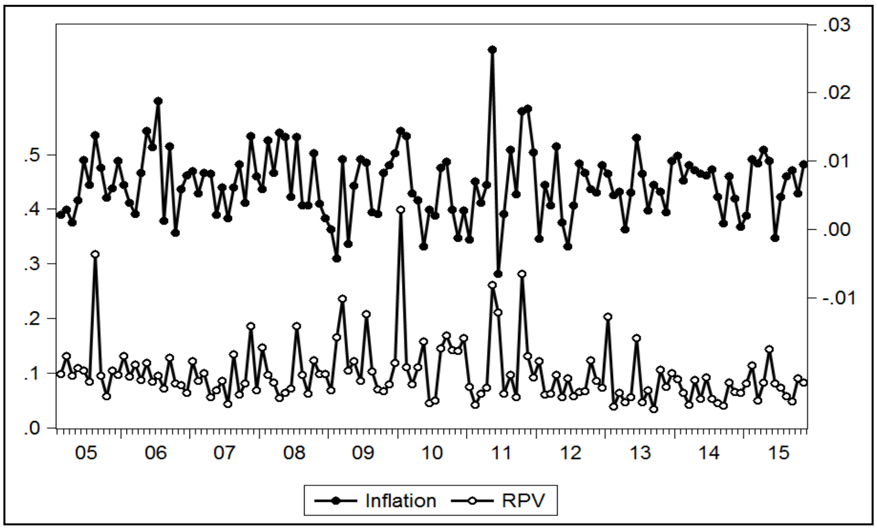
Main expenditure groups and weights

Food and Non-Alcoholic Beverages	0.2863
Alcoholic Beverages and Tobacco	0.0500
Clothing and Footwear	0.0807
Housing, Water, Electricity and Gas	0.1660
Furnishings and Household Equipment	0.0742
Health	0.0254
Transport	0.1259
Communications	0.0430
Recreation and Culture	0.0281

Education	0.0224
Hotels, Cafes and Restaurants	0.0564
Miscellaneous Goods and Services	0.0416

Figure 1

Inflation and RPV



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

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

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

In the second step, the assumption of time invariant coefficient is relaxed by applying the Kalman Filter technique to the following equation.

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

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 equation 2, while the transition equations 3-5 describe the process of unobserved time varying coefficients.

$$\beta_{0,t}=\tau_0\beta_{0,t-1}+\mu_{0,t} \quad (3)$$

$$\beta_{1,t}=\tau_1\beta_{1,t-1}+\mu_{1,t} \quad (4)$$

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

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.

3. Empirical results

As first step, equation 1 is estimated by the OLS, assuming that the relationship between inflation and 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 5% level and have also expected signs. The coefficient of determination is found to be 0.254. By looking at this value, it can be argued that the model does not fit the data well. However, the purpose of OLS estimation is only to provide the initial values for the unknown parameters and matrix in the Kalman filter estimation. Therefore, at this point the low value of R-squared does not matter. Since the coefficient of π^2 is statistically different from zero, the relationship between the two variables is quadratic. This means that the relationship between RPV and inflation is U-shaped curve. This nonlinear relationship between inflation and RPV is displayed in Figure 2. According to the OLS estimates shown in Table 2, RPV is minimized as 0.084 when monthly inflation rate is 0.004. Finally, the fact that the intercept of the quadratic regression is found to be positive and statistically significant implies that RPV is greater than zero (0.091) event though inflation rate is zero. Therefore, the curve of the relationship intersects the positive RPV axes.

Table 2

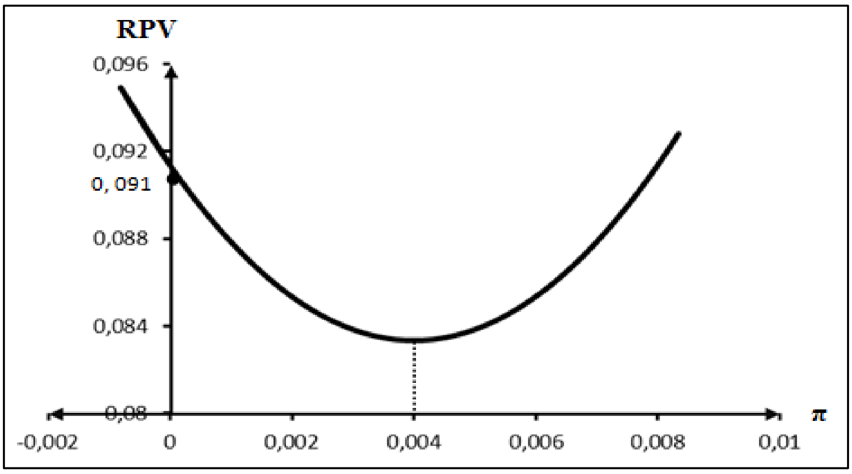
OLS estimation results

Variables		*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
Intercept		0.091	0.008	11.846	0.000
π		-4.011	1.724	-2.327	0.021
π^2		501.973	99.099	5.065	0.000
R-squared	0.254				
F-statistic	21.599				
Prob(F-statistic)	0.000				

Note: The Breusch-Godfrey serial correlation LM test indicates that the residuals are not serially correlated. LM_1: 0.15 [0.70], LM_4: 1.68[0.79], LM_8: 3.65[0.89], LM_{12}: 8.81 [0.72].

Figure 2

U-shaped relationship between inflation and RPV

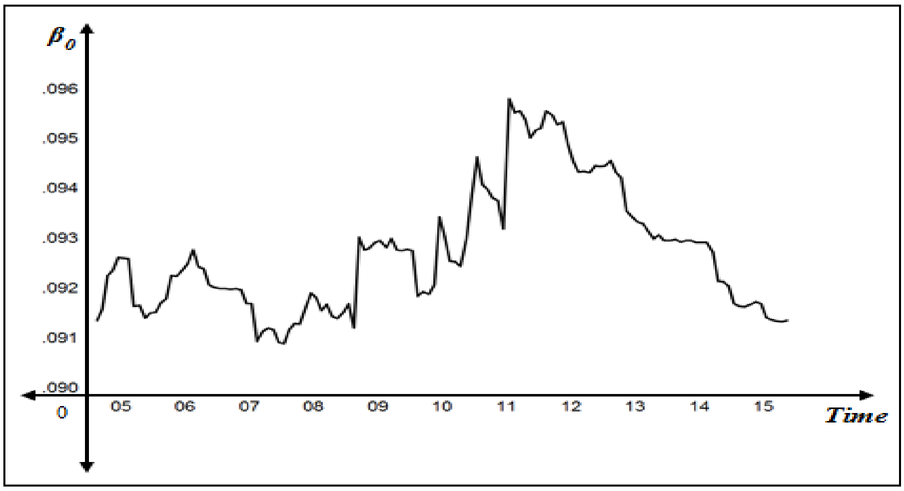


The main purpose of this study is to estimate the quadratic relationship between RVP and inflation, applying the Kalman filter technique to equation 2. Therefore, as second step of this study, this equation is estimated by Kalman filter approach. Before running the Kalman filter, in order to get time 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, 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 0.091 to a maximum 0.096 (Figure 3). Time variation in β_1 and β_2 is more significant than β_0.

Figure 3

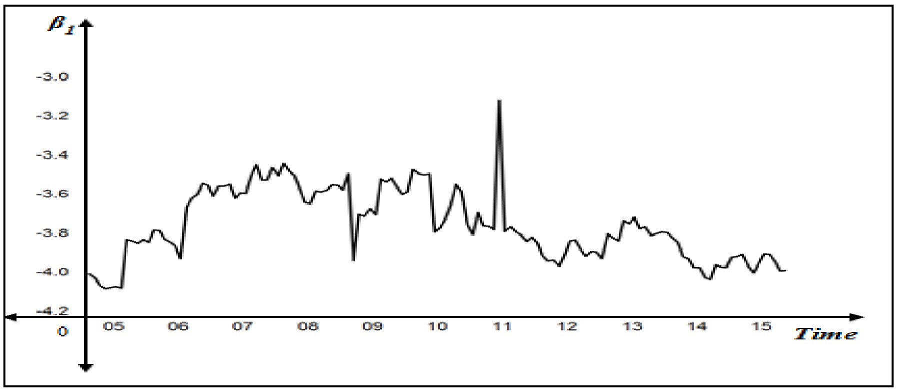
Time varying parameter estimates of the coefficient β_0



The estimates of β_1 range from a minimum of -4.086 to a maximum of -3.123 (Figure 4).

Figure 4

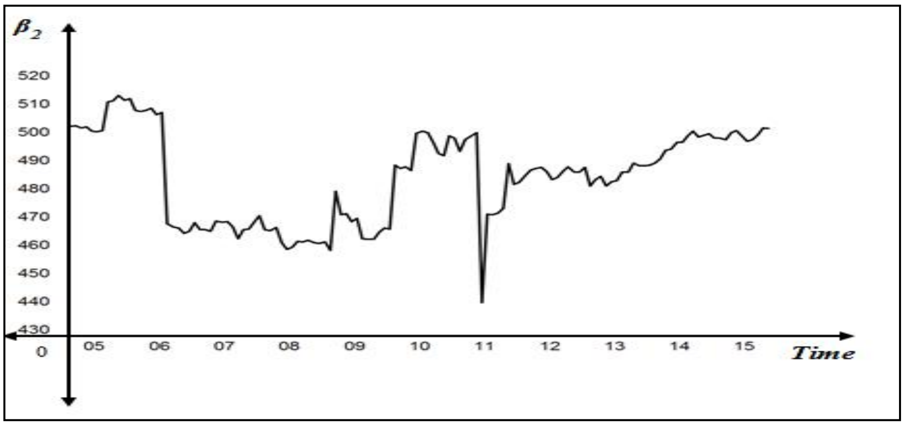
Time varying parameter estimates of the coefficient β_1



Similarly, the coefficient estimates of squared inflation variable range from 439 to 512 (Figure 5).

Figure 5

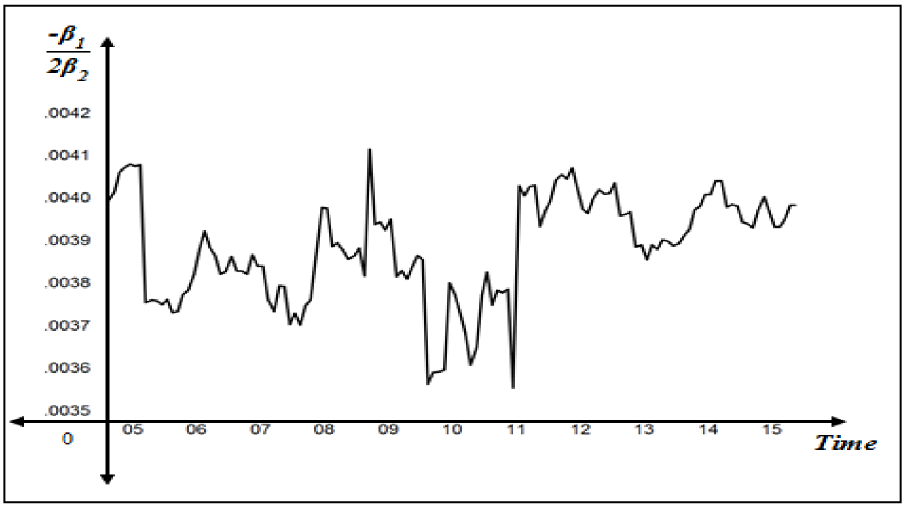
Time varying parameter estimates of the coefficient β_2



Finally, the time varying optimal inflation rates which minimize RPV are computed by using the time varying parameter estimates. Figure 6 gives the time variation on the optimal inflation rate. Optimal inflation rates range from 0.0035 to 0.0041. 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 purpose. The first sub-period is the period of February 2005- January 2010. The computed means of optimal inflation rate is about 0.00386 per month. In the second sub-period which covers the period of February 2010 – June 2011, optimal inflation rate drops to a level of 0.00369 per month. Finally, for the sub-period of July 2011-November 2015, it increases to a level of 0.00397 per month.

Figure 6

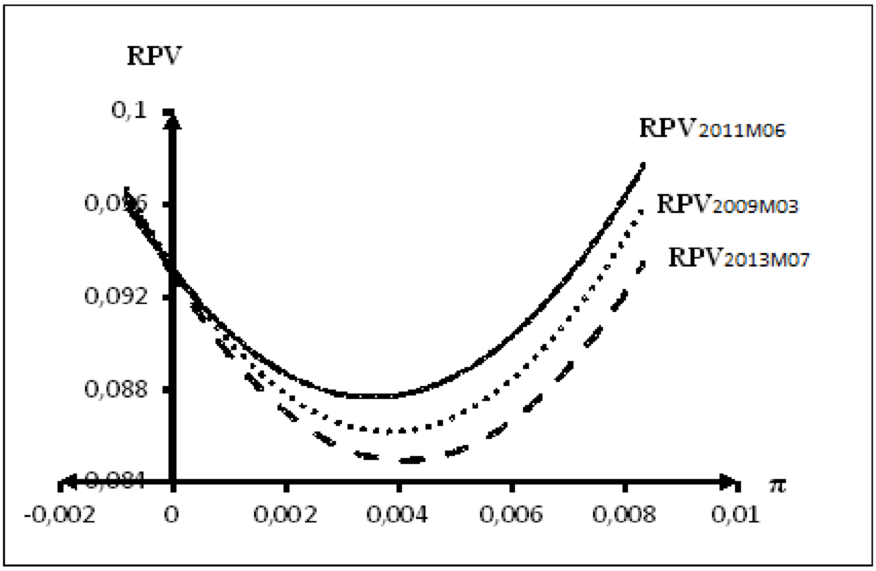
The optimal inflation rate ($\frac{-\beta_1}{2\beta_2}$)



In order to demonstrate how the U-shaped curve shifts over time, first three time points in the whole period were selected and then the related three curves were separately shown in Figure 7. Among three curves, the closest one to origin and horizontal axis is the relationship curve of March 2009. According to this curve, optimal inflation rate for RPV is about 0.0041 per month. However, for June 2011, the same curve shifts up and left markedly by expressing that optimal inflation rate decreases to a level of 0.0035 per month. At the same time, the curve of June 2011 is the farthest from origin and the horizontal axes. From June 2011 to July 2013, the same curve shifts down and is located between the curves of 2009 and 2011. Inflation rate which minimizes RPV rises to a level of 0.0038. Meanwhile, it is found that the annualized inflation rate which minimizes RPV varies from 4.26% to 4.93% for the entire period.

Figure 7

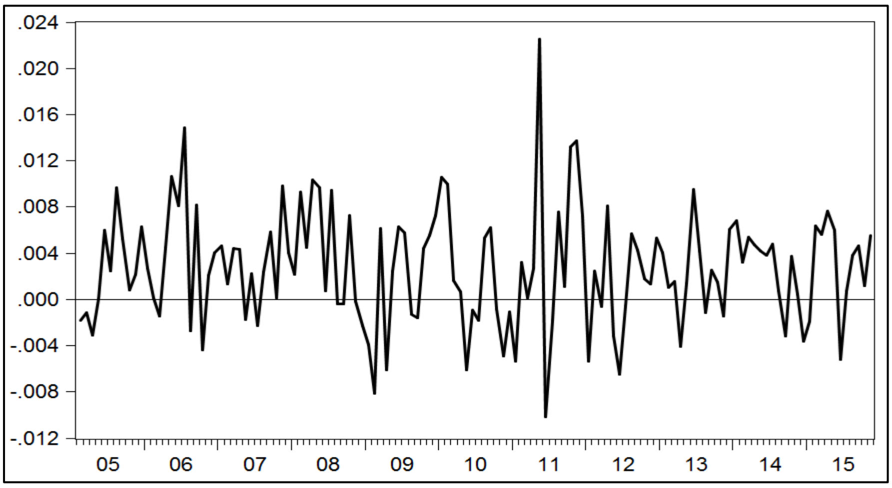
Time variation in the U-shaped curve



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 used in Turkey for the period of 2005-2015 is mostly not effective in keeping optimal inflation rate for RPV. As shown in Figure 8, for most cases, the gap between actual and optimal inflation rates is positive. In 92 of the total 130 cases, monetary policy is expected to be more contractionary to reduce actual inflation and RPV.

Figure 8

The gap between actual and optimal inflation rates



4. Conclusion

The main objective of this study is to empirically investigate the effects of the aggregate inflation rate on RPV by allowing the relationship being time varying. The parameter estimation of the quadratic regression is performed by using the Kalman filter estimation approach. This technique is chosen as the major analytical tool in this study because of the many advantages 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 RPV and inflation. According to 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. As the last of the finding, 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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