Causal Relationship Between Relative Price Variability and Inflation in Turkey: Evidence from Panel Data

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This study investigates the causal relationship between inflation and relative price variability in Turkey for the period of January 2003-January 2014, by using panel data. In the study, a Granger (1969) non-causality test in heterogeneous panel data models developed by Dumitrescu and Hurlin (2012) is utilized to determine the causal relations between inflation rate relative price variability. The panel data consists of 4123 observations: 133 time observations and 31 cross-section observations. The results of panel causality test indicate that there is a bidirectional causality between inflation rate and relative price variability by not supporting the imperfection information model of Lucas and the menu cost model of Ball and Mankiw.

Keywords: Variability Hypothesis, Inflation Rate, Relative Price Variability, Panel Causality.

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1.INTRODUCTION

The positive relationship between inflation and relative price variability (RPV), called variability hypothesis, has been an important issue in monetary economics because of welfare cost of inflation and credibility of monetary policy. The variability hypothesis has been theoretically developed by two main theories. The first theory is called the imperfect information model or island model established by Lucas (1973). This model asserts that the unexpected inflation creates RPV because of suppliers' misperception about relative and general price changes. The essential idea of the Lucas imperfection information model is based on the suppliers' inability to distinguish price movements due to 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. The second theory on the relationship between inflation and RPV is the menu cost model theoretically developed by Ball and Mankiw (1994). This model also predicts that the positive relationship runs from expected inflation to RPV because of firms' sluggish price adjustment process.

In the empirical literature, there have been numerous studies investigating the validity of the variability hypothesis. However, most of studies have only concentrated on the sign of the relationship, by implicitly assuming that inflation rate is exogenous. In other words, these studies examined the validity of the hypothesis by regressing RPV on the inflation rate. If the coefficient of the inflation rate is found to be positive and statistically significant, it is then concluded that there is a positive link between RPV and inflation rate. Primarily, this kind of approach is necessary but not sufficient to test the validity of the hypothesis for two main reasons. First, linear or non-linear regressions used by the previous studies demonstrate only the presence or lack of the statistical association between the two variables, but have no bearing on the causal relationship. Second, according to both imperfect information and menu cost models, the validity of the hypothesis requires not only the presence of the statistically significant correlation between RPV and inflation rate but also the causality running from inflation rate to RPV but not vice versa.

The purpose of this paper is to investigate the validity of the variability hypothesis for the case of Turkey by employing Dumitrescu and Hurlin panel Granger causality approach for the panel data. In the study, the panel data consists of 4123 observations: 133 time observations and 31 cross-section observations.

2.BRIEF LITERATURE REVIEW

Following the pioneering studies of Vining and Elwertowski (1976) and 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), 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), Dabús (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 Dabús (2000) demonstrate that the relationship between two variables depends on the regimes of inflation or monetary policy.

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. Thus, one of the major critics on the subject has especially focused on 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), Ukoha (2007) use 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) employs a panel data, combination of cross-sectional cities and commodities.

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 Caglayan and Filiztekin (2003) and Baglan et al. (2015) use nonlinear function form while the early works by Yamak (1996) and Yamak and Tanriover (2006) assume the linear relationship between inflation and RPV.

3.DATA AND METHODOLOGY

As known, panel data is a combination of cross-sectional and time-series data. This kind of data has some extra information in comparison with individual cross-sectional or times series. In the context of panel data, it is possible to efficiently test the causal relationship between variables under consideration. In this study, a Granger (1969) non causality test in heterogeneous panel data models developed by Dumitrescu and Hurlin (2012) is utilized to determine the causal relations between inflation rate and RPV for the case of Turkey.

Dumitrescu and Hurlin panel causality test is an extended version of standard Granger causality test under heterogeneous panel data. This causality test which is based on the stationary fixed-effect panel model considers both the heterogeneity of the regression model and the heterogeneity of the causal relationship from one variable to another. In terms of regression heterogeneity, this method allows for the heterogeneous slope parameters in the panel regression model. If the number of non-causal relationships in the model is at least one and at most N -1, it means that the heterogeneity deals with causality from one variable to another. Dumitrescu and Hurlin Panel Granger causality test has some advantages over alternatives. The most important one of them is the use of Wald statistics. In the causality test, the standardized average of Wald statistics has a standard normal distribution and does not require any particular panel estimation. In the presence of cross sectional dependence, Wald statistics will be both efficient and consistent. Even if models have different lag order, K, for each individual, causality test can be easily applied.

The linear model between inflation and RPV, which are observed for N individuals on T periods and also assumed to be stationary, follows as below:

$$INF_{i,t} = \alpha_i + \sum_{k=1}^{K} \gamma_i^{(k)} INF_{i,t-k} + \sum_{k=1}^{K} \beta_i^{(k)} RPV_{i,t-k} + \varepsilon_{i,t} \qquad (1)$$

$$RPV_{i,t} = \alpha_i + \sum_{k=1}^{K} \gamma_i^{(k)} RPV_{i,t-k} + \sum_{k=1}^{K} \beta_i^{(k)} INF_{i,t-k} + \varepsilon_{i,t} \qquad (2)$$

where INF is inflation rate and RPV is relative price variability. i and t represent expenditure group and time, respectively. In both equations, α_i's are the intercepts of the regression, $\gamma_i^{(k)}$'s are the coefficients of lags of the dependent variable, and $\beta_i^{(k)}$'s are the regression coefficients. The regression coefficients are assumed to be time invariant while the intercepts are allowed to differ across the expenditure groups. K is the lag length which is identical for all-cross-section units of the panel. Thus, equations (1) and (2) are fixed coefficients models with fixed individual effects.

The null and alternative hypotheses of Dumitrescu and Hurlin panel Granger causality test are as follows:

$$H_0: \beta_i = 0 \qquad \forall_i = 1, \ldots., N$$

$$H_1: \beta_i = 0 \qquad \forall_i = 1, \ldots., N_1$$

(3)

$$\beta_i \neq 0 \qquad \forall_i = N_1 + 1, N_1 + 2, \ldots \ldots . N$$

The null hypothesis states that there is no causal relationship for any of the units of the panel. The alternative hypothesis consists of two subgroups of cross-section units. For some of the individual vectors, β_i can be equal to 0. This means that there is no causal relationship for a subgroup of individuals. On the other hand, it is accepted that RPV Granger causes INF for the other subgroup of individuals. If N_1

equals to 0 or $\beta_i = 0$ is not rejected, it is decided that RPV Granger causes INF for all the individuals of the panel. In this case, it is concluded that the causality is homogenous. Otherwise, if N_1 is greater than 0, it means that there is a causal relationship at least for a subgroup of individuals. For this case, the causality is heterogeneous.
The above hypotheses are generally tested by using the average of standard Wald statistics computed for each individual of the panel as follows.

$$W_{N,T}^{Hnc} = \frac{1}{N} \sum_{i=1}^{N} W_{i,T} , \qquad (4)$$

The distribution of the average statistics $W_{N,T}^{Hnc}$ is determined for both the asymptotic case and the semi-asymptotic case. The standardized version of Wald statistics has a standart normal distrubution called $\check{Z}_N^{Hnc}$ which is computed as below:

$$\tilde{Z}_N^{Hnc} = \sqrt{\frac{N}{2 \; x \; K} \; x \; \frac{(T-2K-5)}{(T-K-3)}} \; x \left[\frac{(T-2K-3)}{(T-2K-1)} W_{N,T}^{Hnc} - K \right] \xrightarrow[N \to \infty]{d} N(0,1) \qquad (5)$$

If the value of $\check{Z}_N^{Hnc}$ is superior to the corresponding normal critical value, the null hypothesis is rejected, otherwise, the null hypothesis cannot be rejected against the alternative hypothesis.

In panel data analysis as in traditional time series analysis, stationary tests must be performed for each of the variables to determine whether the series had unit root. Unit root tests in panel data are divided into two groups as first and second generation. The first generation unit root tests assume that all cross sections are independent while they are assumed to be dependent in second generation. So, initially it is important to test the presence of cross sectional dependence across individuals for applying the appropriate unit root test. In this study, cross-sectional dependence in the series is separately examined by using Breusch and Pagan (1980) LM test and Pesaran (2004) test. In case of panel data models where time series dimension (T) is sufficiently larger than cross section dimension (N), the reliable estimates of pair-wise correlations can be obtained with CD_{LM1}. If both time series dimension (T) and cross section dimension (N*)* are large enough, the presence of cross-sectional dependence can be investigated with CD_{LM2}. In the presence of cross-sectional dependence, stationarity properties of variables must be determined with second generation unit root tests. Therefore, in this study, Cross-Sectionally Augmented Dickey-Fuller panel unit root test developed by Pesaran (2007) is employed for implementing stationarity test.

The purpose of this paper is to examine the causal relationship between inflation rate and relative price variability on the basis of expenditure groups in Turkey by employing Dumitrescu and Hurlin panel Granger causality test. The data used in this study are monthly and cover 31 expenditure groups for the period of 2003:01-2014:01. The panel data consists of 4123 observations: 133 time observations and 31 cross-section observations. Expenditure groups are given in Table A1 in appendix. All data come from State Institute of Statistics and were seasonally adjusted by using the Census X12 method. Aggregate and sub-aggregate inflation series are defined as the monthly log difference of series. Finally, the RPV variable is constructed by using the aggregate and sub-aggregate inflation series as follows:

$$RPV_t = \sqrt{\sum_{i=1}^{31} (INF_{it} - INF_t)^2} \qquad (6)$$

where $INF_{it} = lnP_{i,t} - lnP_{i,t-1}$, $INF_t = lnP_t - lnP_{t-1}$, lnP_t is the logarithm of the consumer price index level at time t and $lnP_{i,t}$ is the logarithm of the price index level of expenditure group i at time t.

4.EMPIRICAL RESULTS

As discussed above, before applying the unit root and thus causality tests, the cross-section dependence tests must be performed for each of the relevant variables. Table 1 presents Breusch and Pagan (1980) LM test (CD_{LM1}) and Pesaran (2004) test (CD_{LM2}) results.

Table 1

The Results of Cross-Section Dependence Test

	INF		**RPV**	
Tests	**Intercept**	**Intercept and**	**Intercept**	**Intercept and**
CD_{LM1}	1456.626 ***	1381.338 ***	36678.09 ***	57.939 ***
CD_{LM2}	18.10807 ***	16.62075 ***	177.823 ***	230.3085 ***
Note: *** denotes statistical significance level of 1%.				

The third row in Table 1 reports the CD_{LM1} statistics for both variables. Based on the computed CD_{LM1} statistics, the null hypothesis of no cross sectional dependence is easily rejected at the 1% level for the series. According to CD_{LM1} statistics, expenditure groups which constitute cross section units of panel data are dependent on each other. In this study, since both T and N are sufficiently large, CD_{LM2} statistics can be also used to determine cross section dependence across the expenditure groups. The fourth row of Table 1 records CD_{LM2} test statistics. These statistics indicate strongly the presence of cross-sectional dependence as well as CD_{LM1}. The results based on two alternative statistics imply that a shock to either inflation rate or RPV in any expenditure group totally or partly spillovers to other expenditure groups. This is actually an expected situation because each commodity in the expenditure groups is subject to commodity-specific and economy-wide shocks. Since economy-wide shocks are common to all expenditure groups, all commodity prices will change in the same rate, and there will be no change in the relative prices. However, different characteristics of each commodity have different impacts on the pass-through commodity prices depending on the flexibility degree of other prices and the relative importance of the commodity. The findings on the cross-section dependence across the expenditure groups in terms of inflation and RPV indicate that there exists more or less a pass-through mechanism of commodity-specific shocks. Under the assumption of cross section dependence, cross-sectional augmented Dickey-Fuller (CADF) panel unit root test must be applied to determine whether both series have a unit root in their levels. The results of CADF unit root test for inflation rate and RPV are reported in Table 2.

Table 2

The Results of CADF Unit Root Tests

Variables	**Without Trend**	**With Trend**
INF	-4.739 ***	-4.871 ***
RPV	-2.658 ***	-2.925 ***
Note: *** denotes statistical significance level of 1%.		

As seen from Table 2, the calculated CADF test statistics reject the null hypothesis which implies the presence of the unit root in inflation rate and RPV at the 1% level. For both variables, the absolute value of the calculated CADF statistics is greater than the critical value. Finally, according to CADF unit root test, each of the variables is stationary in its levels. Thus, panel Granger causality tests must be applied to the variables in their levels.

Panel Granger causality test results are given in Table 3. Even though the asymptotic properties of Dumitrescu and Hurlin panel Granger causality test do not significantly vary when the lag-order is different across individuals, the causality test in this study is separately performed for lags one, two and three.

Table 3

Dumitrescu and Hurlin Panel Granger Causality Test Results

H_0 Hypothesis	**K**	**W-Stat.**	**Z Stat.**	**Result**
INF $\nrightarrow$ RPV	1	2.33530	5.05266 ***	$\longleftrightarrow$
RPV $\nrightarrow$ INF		1.75060	2.81361 ***	
INF $\nrightarrow$ RPV	2	3.37755	3.62507 ***	$\longleftrightarrow$
RPV $\nrightarrow$ INF		3.96277	5.20231 ***	
INF $\nrightarrow$ RPV	3	5.08013	4.44569 ***	$\longleftrightarrow$
RPV $\nrightarrow$ INF		4.84397	3.92854 ***	

Note: *** denotes significance level of 1% level. The symbols of $\nrightarrow$ and $\longleftrightarrow$ present no causality and bidirectional causality, respectively. K denotes lag length.

As seen from Table 3, the null hypothesis of no-causality running from inflation rate to RPV is rejected at the 1% level for one, two and three lags. In all specifications with different lags, the computed Z-statistics is greater than the normal critical value. Up to now, causality results seem to support the imperfect information and menu cost models. As expected, causality runs from inflation to RPV. However, another null hypothesis of no-causality from RPV to inflation rate is also rejected at the 1% level for all lag lengths. It means that RPV also Granger causes inflation rate. This finding is actually not predicted by both models. RPV should not Granger cause inflation rate. Thus, the overall results of panel causality test indicate that there is a bidirectional causality between inflation rate and RPV in Turkey. A two-way causality is running from inflation rate to relative price variability and also from relative price variability to inflation rate. Thus, the empirical evidence does not validate the variability hypothesis in the context of imperfection information and menu cost models. The existence of the causation from RPV to inflation means that RPV may also cause some welfare losses by disrupting allocative efficiencies. Therefore, aggregate demand policy may be necessary but not sufficient to fight inflation. In order to control RPV, aggregate supply policies must be also implemented for handling commodity specific shocks.

5. CONCLUSION

The hypothesis that there is a positive relationship between inflation rate and RPV, called variability hypothesis, is recently attracting considerable interest. Most of empirical studies find a statistically significant and positive association between the two variables. Significant and positive relationship between inflation and RPV is the necessary condition, but not sufficient condition to validate the variability hypothesis. The sufficient condition is the existence of the causality running from inflation to RPV but not vice versa, according to the imperfect information model of Lucas and the menu cost model of Ball and Mankiw.

In this study, in the context of causality, the variability hypothesis was examined for the case of Turkey. The data used in this study are monthly and cover 31 expenditure groups for the period of January 2003-January 2014. The panel data consists of 4123 observations: 133

time observations and 31 cross-section observations. In the empirical analysis of the study, it was found that there is a strong cross-sectional dependence across all expenditure groups. This finding implies that the cross-sectional dependence across commodities is probably originated from commodity-specific shocks. After detecting the dependence among the commodities, Dumitrescu and Hurlin panel Granger causality test which takes into account the heterogeneity across individuals in the definition of the causal relationship was applied to inflation and RPV. According to the causality test results, there is a two way causal relationship between inflation and RPV for the case of Turkey. The empirical evidence presented in this paper finds no support for the variability hypothesis produced by the imperfect information of Lucas and menu cost model of Ball and Mankiw because it was found that RPV Granger causes inflation.

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