City price convergence in Turkey with structural breaks

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Abstract

This paper explores relative price convergence for 18 cities in Turkey. The convergence implies stationarity in the long run. Henceforth, to observe whether price convergence occurs or not, this study conducts unit root tests following Lee and Strazicich (2003) with two structural breaks in level and/or trend. The test statistics reveal that 13 out of 18 consumer price indexes converge. The half-life measurement points out that the speed of convergence of each city is considerably high. This result indicates that the half of the cumulative shocks persists for a short time period.

JEL classification: E31, C22

Keywords: Lagrange multiplier unit root tests, structural breaks, price convergence, half-life, Turkish economy

I. Introduction

It has always been a great interest to economists to explain if international purchasing power parity (PPP) holds or not. Recently this interest has led to new idea investigating the validity of intercity PPP, across cities or across regions, as noted in Basher and Carrion-i-Silvestre (2010) and Cecchetti et al. (2000). The international PPP literature, thus, is the main motivation behind the literature of city price convergence. The intranational PPP implies the convergence in relative prices across cities in an economy in the long run. The convergence in relative prices (CPI's) of the cities in a country depends on the level of competitiveness in commodity markets and/or ability of central government to intervene in economy. The convergence in relative CPI's, therefore, gives the evidence of moving towards single market or single price index.

Throughout the literature, one may obtain several different or identical outcomes regarding convergence in prices or exchange rates or taxes. Cecchetti et al. (2000) reach convergence result in US when they employ annual panel data from 1918 to 1995. Lan and Sylwester (2009) use the monthly panel data, ranging from March 1990 to May 1999, for 36 cities' prices in China, and conclude that prices converge to relative parity in China quickly. Ceglowski (2003) employs semi-annual panel data for 25 cities spanning from 1976:2 to 1993:2 in Canada and finds that the majority of intranational retail prices of consumer goods converge in the long run. Sonora (2005) follows monthly panel data for 35 cities' prices in Mexico for the period of January 1982 to December 2000 and reaches the evidence that all city PPP holds between Mexican cities' relative prices. Burger and Rensburg (2008) consider the quarterly panel data for house prices in South Africa over the period 1967:Q1-2007:Q2 and obtain strong evidence of common trend in large middle-segment house prices. They, however, find poor evidence of convergence in medium middle-segment house prices and reach no evidence of convergence in small middle-segment house prices. Sonora (2009) investigates 20 USA metropolitan areas' annual prices over the period 1918-1997 and his research yields an outcome that the majority of relative prices converge in USA. Cheung and Lai (2000) employ annual exchange rate data for 94 countries covering period from April 1973 to December 1994 and obtain the evidence of parity reversion in developing countries rather than developed countries. Bilgili (2010) launches panel data for EU for the quarterly period 1979:1-2008:1 and reveals that oil industry tax, diesel industry tax, oil household tax and diesel household tax converge to average total taxes of members.

To understand if Turkey experiences single market, in terms of prices of weighted goods and commodities included in the basket that is used for CPI's measurement, this study carries out unit root tests considering potential structural breaks by following the methodology of Lee and Strazicich (2003), hereafter LS, and Strazicich, Lee and Day (2004). The literature of price and/or exchange rate convergence studies follows several unit root testing methods. Cecchetti et al. (2000) conduct Levin and Lin (LL) and Im, Pesaran, and Shin (IPS) panel unit root tests without considering the break(s). Ceglowski (2003) follows Fisher-Augmented Dickey Fuller (ADF) type unit root tests with no break. Sonora (2005) uses panel unit root tests without considering any structural break through LL and IPS tests. Burger and Rensburg (2008) apply unit root tests of IPS in which breaks are not taken into account. Lan and Sylwester (2009) employ panel unit root tests of Levin, Liu and Chu and Fisher-ADF with no break. Sonora (2009) follows Zivot and Andrews (ZA) test with one break and employs Clemente, Montanes and Reyes and Perron and Vogelsang tests allowing for two structural breaks. Cheung and Lai (2000) run the unit root tests of Banerjee, Lumsdaine and Stock examining structural shifts in mean or trend in the series.

There are two main issues, among others, throughout the stationary tests, as depicted by LS (2001, 2003). The first one is that commonly used ADF tests might be biased towards non-rejecting the unit root hypothesis since ADF tests do not count the existence of potential structural break(s) in the data. The common view in the literature, therefore, after the seminal paper of Perron (1989), is that regular type of ADF tests fail to reject the null of unit root if the true data is stationary and contains a break. Hence, to overcome this problem of biasedness, the related literature follows Perron (1989) by running unit root ADF tests with structural break(s). The second issue is how a unit root testing methodology determines the break. Or, should a unit root test include exogenous break dummy variable (known) or endogenous break dummy variable (not known)? Perron

(1989) employs stationary tests with one structural break determined exogenously. ZA (1992), on the other hand, follow unit root tests with one structural break determined endogenously. Lumsdaine and Papell (1997), hereafter LP, utilize the same procedure of ZA (1992) with two structural breaks included into test equation endogenously.

LS (2001, 2003) demonstrate that unit root tests of ZA (1992) and LP (1997) have the problems of size distortions and biasedness, since they conduct unit root null hypothesis with the assumption of no break against alternative hypothesis with the assumption of break in the data. LS (2001, 2003) apply a data generating process and conclude that the rejection of unit root null hypothesis assuming no break does not necessarily lead to rejection of a unit root, but results in rejection of a unit root with no breaks.

To this end, LS (2003) develop two-break minimum Lagrange multiplier (LM) unit root test in which breaks are determined endogenously and which does not suffer from size distortions and biasedness. Thus, in LS type unit root testing, the rejection of the null gives an unambiguous result of convergence. Accordingly, this paper follows LS type unit root hypothesis testing method to search the probability of random walk behavior in Turkish relative city prices. The plan of this paper is as follows. Section II presents the data and the test statistics of ADF unit root, Phillips-Ouliaris cointegration and minimum LM unit root with structural breaks. Section III yields half-life measurements to inspect the deviations of prices from their long run means.

II. Data and Convergence tests

The consumer price indexes for 19 Turkish cities are obtained from Turkish Statistical Institute (TSI). The monthly data ranges from January 1994 to December 2004. These cities are Adana, Ankara, Antalya, Bursa, Denizli, Diyarbakır, Erzurum, Eskişehir, Gaziantep, İçel, İstanbul, İzmir, Kayseri, Kocaeli, Konya, Malatya, Samsun, Trabzon and Zonguldak, respectively. The cities and the time horizon are chosen on the basis of data availability from TSI. These cities are the representative cities of their own regions of Aegean, Black Sea, East Anatolia, Marmara, Mediterranean, Middle Anatolia and South East Anatolia in Turkey.

I start with regular type of ADF unit root and cointegration tests to reveal whether relative prices have unit root or not. The unit root tests are conducted for the relative consumer price index (cpi) series by Eq. (1).

$$p_{it} = ln(cp_{it}/cp_{nt}) \tag{1}$$

where p_{it}, ln, cpi_{it} and cpi_{nt} denote the natural log of relative price of city i at time t, the natural logarithm, the natural log of cpi of city i at time t and the natural log of cpi of numeraire city Ankara[1] (the capital city of Turkey), at time *t*. The ADF tests are run by Eq. (2).

$$\Delta y_{it} = (\rho - 1)y_{i,t-1} + \sum_{J=1}^{k} \delta_j \, \Delta y_{i,t-j} + u_{it} \qquad (2)$$

where Δ, y_{it}, k and u denote difference operator, the natural log of relative price of i_{th} city at time t, the number of lagged differences and residual term, respectively. Table 1 yields the stationary test results with respect to the related three ADF equations indicated in the second, third and fourth columns, respectively. According to the findings of ADF test results, only a few relative prices are found stationary. The outcomes of two out of three ADF equations yield that Konya, Kocaeli, Eskişehir and Bursa converge to a common trend at the significance levels ranging from %1 to %10. On the other hand, Malatya, İstanbul and Erzurum relative prices are found stationary by only ADF equation with no intercept and no trend at significance levels of %5, %10 and %10, respectively. Overall, the 54 ADF tests, except 13 cases, result in stochastic trend (unit root) in relative prices.

I conduct residual based Phillips-Ouliaris (1990) cointegration tests, with the null hypothesis of no cointegration, to reveal, if it exists, the long run relationship between price of each city and price of Ankara. The cointegration tests will be conducted through the Equations (3) and (4).

$$y_{it} = x_{it}' B + DT_{it}' \vartheta + v_{it} \qquad (3)$$

$$\Delta \hat{v}_{it} = (\rho - 1)\hat{v}_{i,t-1} + s_{it} \qquad (4)$$

where x, DT, $\hat{v}$ and s denote regressors, deterministic trend, estimated residuals from Equation (3) and residuals which are used to estimate the long run variance, respectively. Table 2 gives Phillips-Ouliaris unit root tests of residuals from cointegration relationship between cpi_{it} and cpi_{nt}, where cpi_{it} and cpi_{nt}, represent the natural log of cpi of i_{th} city at time t and the natural log of cpi for the numeraire city Ankara, at time t, respectively.

[1] Ceglowski (2003) employs Toronto, the capital city of Ontario, as numeraire (benchmark) city as he tests stationarity of city relative prices for Canada. Sonora (2009) tests convergence of relative city cpi in US employing Chicago as numeraire because 'it is centrally located in US and its distance to each city is almost same'. Sonora (2005) employs numeraire city Mexico DF, Mexico's capital city, in testing relative price convergence in Mexico. Therefore, following Sonora (2009), Sonora (2005) and Ceglowski (2003), I choose Ankara as numeraire city since (i) it is almost centrally located in Turkey so that the distances of cities to Ankara are roughly same and (ii) Ankara is capital city.

Table 1: ADF unit root tests

Relative prices with respect to Ankara	with intercept	with trend and intercept	with no intercept and no trend
Adana	-2.117	-1.836	-1.198
Antalya	-2.062	-1.999	-1.423
Bursa	-2.648***	-2.699	-2.085**
Denizli	-1.359	-1.620	-0.298
Diyarbakır	-1.957	-1.728	-0.981
Erzurum	-1.704	-2.081	-1.647***
Eskişehir	-2.120	-3.392**	-1.887***
Gaziantep	-2.029	-2.062	-1.561
İçel	-1.323	-1.482	-1.282
İstanbul	-2.217	-2.213	-2.243***
İzmir	-1.946	-1.383	-1.467
Kayseri	-1.539	-1.712	-1.438
Kocaeli	-2.684***	-4.496*	-2.212***
Konya	-3.745*	-3.788**	-2.864*
Malatya	-2.519	-2.804	-2.479**
Samsun	-2.080	-1.637	-0.735
Trabzon	-2.107	-1.787	-1.176
Zonguldak	-0.927	0.334	-0.974

Note: (*), (**), (***) indicate significances at the 1%, 5% and 10% levels, respectively.

Table 2: Phillips-Ouliaris cointegration tests

cpi_{it} , cpi_{nt}	tau-statistic and (prob)	z-statistic and (prob)
Adana, Ankara	-1.766 (0.647)	-6.845 (0.575)
Antalya, Ankara	-2.052 (0.502)	-8.605 (0.441)
Bursa, Ankara	-2.997 (0.117)	-19.501 (0.052)
Denizli, Ankara	-1.580 (0.731)	-6.747 (0.583)
Diyarbakır, Ankara	-1.660 (0.696)	-5.274 (0.705)
Erzurum, Ankara	-1.915 (0.573)	-6.763 (0.582)
Eskişehir, Ankara	-2.765 (0.183)	-11.014 (0.292)
Gaziantep, Ankara	-2.434 (0.313)	-11.921 (0.247)
İçel, Ankara	-1.191 (0.860)	-3.226 (0.862)
İstanbul, Ankara	-2.119 (0.467)	-10.219 (0.336)
İzmir, Ankara	-1.396 (0.800)	-5.679 (0.671)
Kayseri, Ankara	-1.603 (0.721)	-5.578 (0.680)
Kocaeli, Ankara	-3.539 (0.033)*	-22.824 (0.024)*
Konya, Ankara	-4.082 (0.007)*	-30.624 (0.003)*
Malatya, Ankara	-2.453 (0.305)	-11.036 0.291)
Samsun, Ankara	-1.468 (0.775)	-4.301 (0.784)
Zonguldak, Ankara	-1.915 (0.573)	-6.763 (0.582)

Note: (*) denotes %1 significance level.

In Table 2, first, second and the third columns show related time series in cointegration equation, tau (t) statistics with their corresponding probability values in parentheses and normalized coefficients (z statistics) with their corresponding probability values in parentheses, respectively. Cointegration tests do not exhibit the evidence of stationarity except Kocaeli-Ankara and Konya-Ankara time series. This outcome implies that majority of relative prices have no evidence of convergence in relative prices in Turkey.

The majority of ADF and Phillips-Ouliaris cointegration tests result in nonstationarity and hence no convergences of prices in the long run in Turkey. One may need to be prudent with assumptions of the tests run above. The prosaic ADF and cointegration models do not postulate that the changes in level and/or the changes in trend might have occurred through the span of data. Perron (1989) states that a unit root test which do not allow the presence of one-time change in intercept and/or trend might bring about failing the rejection of unit root process if the true data follows stationary fluctuations around a trend with break.

Thereby the test statistics given in Tables 1 and 2 might have potential biasedness. To overcome this problem, one may conduct more powerful unit root tests which consider the presence of a break in intercept and/or trend. However, allowing the existence of a break in testing the unit root may not be sufficient to reach the desirable statistical properties. According to LP (1997) and LS (2001, 2003) ignoring two or more breaks may cause loss of power, either. The assumptions of null and alternative hypotheses separately are also another important issue in testing procedure as is explained in LS (2001, 2003). ZA (1992) and LP (1997) unit root tests follow the null of unit root with the assumption of no break against alternative hypothesis of stationarity with the assumption of possible presence of break(s). If one carries out ZA or LP type unit root test and rejects the null, this will mean the rejection of unit root on the true data with the assumption of no break. Nunes et al. (1997) and LS (2001) provide the literature with the evidence that, when the true data generating mechanism contains unit root with break(s) in fact, the test of a unit root null with the assumption of no break will result in significant rejection of unit root. Therefore, this work plan to run LS (2001, 2003) minimum Lagrange multiplier (LM) unit root tests considering the presence of two breaks on true data, determining the break point(s) endogenously and assuming the presence of break(s) under the null hypothesis of unit root. Two break LS-LM unit root tests are conducted by Eq. (5).

$$\Delta y_t = \gamma' \Delta Z_t + \emptyset \tilde{S}_{t-1} + \epsilon_t \quad (5)$$

where $\check{S}_t = y_t - Z_t \tilde{\gamma} - (y_1 - Z_1 \tilde{\gamma})$, $t = 2,3,\ldots,T$. The estimator $\tilde{\gamma}$ is a vector of coefficients obtained from the regression of Δy_t on ΔZ_t where $Z_t = [1, t, D_{1t}, D_{2t}, DT^*_{1t}, DT^*_{2t}]'$ in which D_{jt}, (j = 1, 2) represents dummy for level j, and DT^*_{jt} (j= 1, 2) denotes the dummy for trend j. The unit root null hypothesis is tested by examining the tau value $(\hat{\tau})$ given in Equation (6).

$$\hat{\tau} = t\text{-statistic for the null hypothesis that } \emptyset = 0 \quad (6)$$

In Table 3, first column gives the cities observed in Turkey. The second column is the number of lagged first differenced terms (k) to correct the serial correlation in Eq. (5). TB_1 column yields the estimated first break of level and/or trend, whereas TB_2 column shows the estimated second break of level and/or trend in the relative cpi series.

Test statistic column consists of the results from LM unit root tests for Model C. In Perron (1989), Model A, Model B and Model C denote three different unit root test equations. Model A allows an exogenous change in level of the series, Model B permits exogenous change in trend of the series and Model C allows both change. When Model C dominates the Model A (if a change in growth is found significant together with significant change in level), Model C is preferred among others. In LS methodology (Lee and Strazicich, 2003) all breakpoints are determined endogenously. In LS-Model C analysis, for instance, there are four dummies to be tested by minimum LM. Through iterations, simultaneously and endogenously, first break at level and/or trend and second break at level and/or trend are searched. By updating the data continuously '*Minimum LM program first determines the optimal lag for each of all possible cases of break points and then search for optimal break points'* as precisely indicated by Junsoo Lee (2009). I run all series by both Model A and Model C separately through RATS and Gauss programs and I find that Model C performs better than Model A does.

Table 3: The minimum LM unit root tests with two structural breaks

City	k	TB_1	TB_2	Test statistic	Critical value break points
Adana	5	1996:04(-)	1999:12(*)	-6.655(*)	$\lambda_{1,2}$=(0.2, 0.6)
Antalya	3	1995:12(*)	1999:08(*)	-4.636(-)	$\lambda_{1,2}$=(0.2, 0.6)
Bursa	8	1996:03(*)	2001:07(*)	-5.390(***)	$\lambda_{1,2}$=(0.2, 0.6)
Denizli	1	1997:02(**)	2003:03(*)	-4.593(-)	$\lambda_{1,2}$=(0.2, 0.8)
Diyarbakır	2	2000:02(***)	2001:12(**)	-6.210(**)	$\lambda_{1,2}$=(0.6, 0.8)
Erzurum	2	1999:11(***)	2001:08(**)	-6.036(**)	$\lambda_{1,2}$=(0.4, 0.6)
Eskişehir	0	1995:02(**)	1996:07(**)	-7.068(*)	$\lambda_{1,2}$=(0.2, 0.4)
Gaziantep	7	1995:02(-)	1999:12(*)	-6.390(**)	$\lambda_{1,2}$=(0.2, 0.6)
İçel	5	1999:03(**)	2002:01(*)	-4.581(-)	$\lambda_{1,2}$=(0.4, 0.8)
İstanbul	6	1999:03(*)	2002:08(*)	-6.715(*)	$\lambda_{1,2}$=(0.4, 0.8)
İzmir	6	1996:01(*)	2001:04(**)	-5.383(***)	$\lambda_{1,2}$=(0.2, 0.6)
Kayseri	1	1997:06(*)	2001:08(*)	-5.535(***)	$\lambda_{1,2}$=(0.4, 0.6)
Kocaeli	6	1998:02(**)	2000:09(*)	-6.544(*)	$\lambda_{1,2}$=(0.4, 0.6)
Konya	2	1997:01(***)	1998:07(*)	-6.397(*)	$\lambda_{1,2}$=(0.2, 0.4)
Malatya	2	1995:10(*)	1998:12(*)	-6.233(*)	$\lambda_{1,2}$=(0.2, 0.4)
Samsun	0	1999:07(**)	2001:12(**)	-5.042(-)	$\lambda_{1,2}$=(0.4, 0.8)
Trabzon	6	1995:07(*)	2000:09(*)	-5.933(**)	$\lambda_{1,2}$=(0.2, 0.6)
Zonguldak	6	2000:05(*)	2002:08(*)	-7.813(*)	$\lambda_{1,2}$=(0.6, 0.8)

Notes: (1) The critical values are obtained from Strazicich et al. (2004) and Lee and Strazicich (2003). (2) (-) denotes insignificance, and (*), (**), (***) indicate significances at the 1%, 5% and 10% levels, respectively.

The last column of Table 3, $\lambda_{1,2}=(TB_1/T,\ TB_2/T)$ produces the critical values which are symmetric around $\lambda_i = (1- \lambda_i)$, i=1,2 (Strazicich et al, 2004). Table 3 reports the rejection the null of unit root for all cities' cpi series except Antalya, Denizli, İçel and Samsun. In Table 3, the first structural breaks (TB_1) seem to cluster mostly around the second half of 1990s and the second structural breaks (TB_2) accompany with often the first half of the 2000s.

Since TB_1 and TB_2 columns of Table 3 indicate that two structural breaks in level and/or trend are significant in all cities except Adana and Gaziantep, one break tests are run for Adana and Gaziantep. Table 4, *k* column gives the number of lagged first differenced terms to correct the serial correlation in Eq. (5). *TB* column yields the estimation results for one break of level and/or trend in the cpi series. Test statistic column consists of outcomes from LM unit root tests for Model C (Perron, 1989).

Table 4: The minimum LM unit root tests with one structural break

City	*k*	*TB*	Test statistic	Critical value break point
Adana	3	1999:12(*)	-5.487(*)	λ=0.6 (=0.4)
Gaziantep	8	1997:09(**)	-2.889(-)	λ=0.4 (=0.6)

Notes: (1) The critical values are obtained from Strazicich et al. (2004) and Lee and Strazicich (2003). (2) (-) denotes insignificance, and (*), (**), (***) indicate significances at the 1%, 5% and 10% levels, respectively.

The last column of critical value break point λ = (*TB*/T) is symmetric around λ = 1- λ (Strazicich et al, 2004). According to Table 4 test statistics and critical value break points, Adana still rejects the unit root, whereas Gaziantep fails to reject the unit root null. As for the significance of one structural break for Adana and Gaziantep, Table 4, *TB* column reveals that one structural break in Adana and Gaziantep are found significant at 1% and 5% levels, respectively. Table 3 and Table 4, as a result, conclude that 13 Turkish cities converge in relative prices in the long run[2].

Before interpreting the statistics in Tables 3 and 4, one may need to know the basic economic facts about Turkish economy. Turkish economy experiences 1994 and 2001 crises through her financial liberalization steps after 1980s. In the beginning of 1994, the Turkish Lira is depreciated by 50 percent and IMF standby program is launched (Celasun, 2011). Overall, the budget deficits and thereby high inflation rates together with high interest rates and, as a result, overvalued Turkish Lira and hence capital inflows are the prominent developments of Turkish

[2] When I run LS-LM multiplier unit root tests based on numeraire city Istanbul, following the equation [(natural log of cpi_{it}) / (natural log of cpi of $Istanbul_t$)], I find also that 13 out of 18 relative prices are found stationary. These cities are Adana, Ankara, Antalya, Bursa, Diyarbakır, Erzurum, Eskişehir, İçel, İzmir, Konya, Samsun, Trabzon and Zonguldak, respectively. I conduct the same tests based on the average of 19 cities' cpi, employing the equation [(natural log of cpi_{it}) / (natural log of average cpi_t)], I reach that relative prices of Adana, Ankara, Bursa, Diyarbakır, Eskişehir, Gaziantep, İstanbul, Samsun, Trabzon and Zonguldak converge to equilibrium level in the long run.

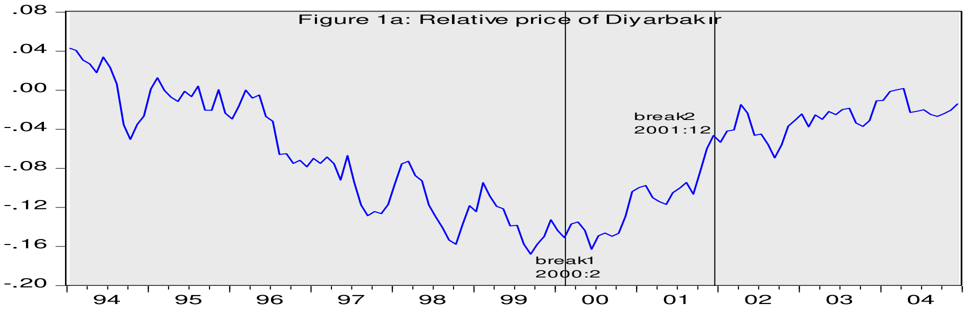
economy during 1990s. On the other hand, the potential existence of the political and economic uncertainties, and thus, the capital outflows are another movements realized in Turkish economy during the same decade. Because of these realizations in the economy, contractionary fiscal policies and disinflationary program are launched by government in 1997 (Deliveli, 2005; Cagla, 2004).

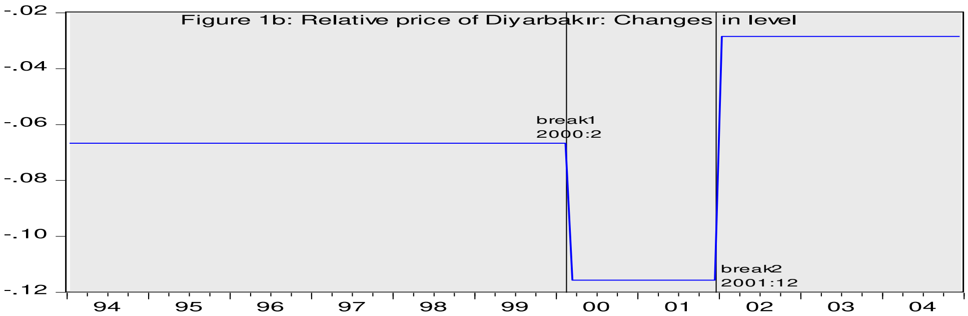
After 1994 and 2001 crisis together with huge budget deficits and government debt stock lead to new domestic and foreign borrowings especially between 1999 and 2004 (Yeldan and Weisbrot, 2004). As average, the inflation rate is 50 percent in 1980s, becomes 80 percent in 1990s, declines back to again 50 percent just before 2001 crisis.

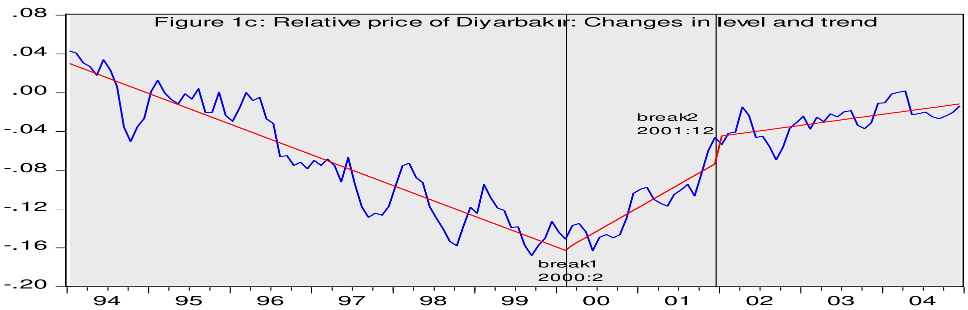
These developments in Turkish economy might have several individual or joint effects on city's structural breaks determined by LS-LM tests. The plausible reasons of the breaks, among other possible ones, can be counted as follows: (i) High inflation and high interest rates, which in turn, lead to tight budget policies and again volatility in prices. Accordingly, in the second half of 1997, due to tight budget policies, the Turkish economy experiences increases in prices of petroleum and State manufacture products by 30% and 15.2%, respectively (Parasız and Başoğlu, 1999). (ii) Capital inflows and outflows. Turkey faces capital outflows in 1994, 1997 and 2001 and has capital inflows in 1995, 1996, 1998, 1999, 2000, 2002, 2003 and 2004 (Balkan et al., 2002; SPO, 2011). (iii) The fluctuations in growth rates of agricultural, industrial and services sectors. Agricultural sector has negative growth rates in 1994, 1997, 1999, 2001 and 2003. Industrial and services sectors have negative growth rates during the years of 1994, 1999, 2001 (SPO, 2011). (iv) Public sector borrowing requirement as a percentage of GDP reaches its highest levels of 15.6 and 16.4 in 1999 and 2001, respectively (SPO, 2011). (v) The financial crises of Turkey occurred on November 2000 and February 2001. The daily interest rate increases by 210 percent at the end of 2000 and goes up by 6200 percent in the beginning of February 2001 (Uygur, 2001). Then, the February 2001 crisis induces 50 percent depreciation of national currency just after 2001 February crisis. This sharp depreciation leads annual inflation rate to increase again 80 percent in 2001 (Ertuğrul and Selçuk, 2001; TSPAKB, 2011).

Overall, the first breaks seem to capture the changes in government budget policies, short term capital movements and GDP growth rates, whereas the second breaks seem to fall in the time points of financial crisis and movements in short term capital and ups and downs of GDP growth rates over time. At this point, throughout possible common innovations listed from (i) to (v), one may observe some heterogeneity of structural break points of the cities. The differences in break time points may stem from city specific market behaviors such as possible different weights of tradable and non tradable goods in consumption and production, and/or, possible differences in city specific labor, capital and transportation costs.

One may also consider the breaks' time points which are very close to each other. It may cast doubt on presence of significant breaks identified through LM tests. When two break points of a city relative price fall into short time interval (i.e. less than one or two years), one break or two breaks might be temporary rather than permanent. On the other hand, the breaks determined by LM tests are expected to be permanent. To comprehend this issue, I check out also the plotted series of Diyarbakır, Erzurum, Eskişehir and Konya. The purpose here is to juxtapose the LM statistical evidences and visual inspections together with statistics from three split samples. To save space, I only report here Diyarbakır and Konya cases which are the first and last cities of the list for which two structural breaks are settled in a short time period.

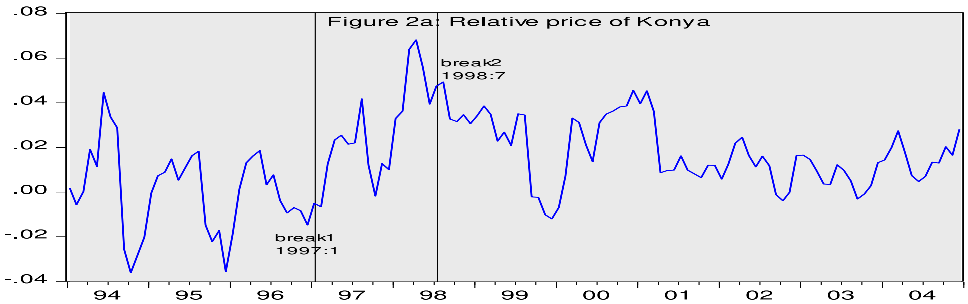


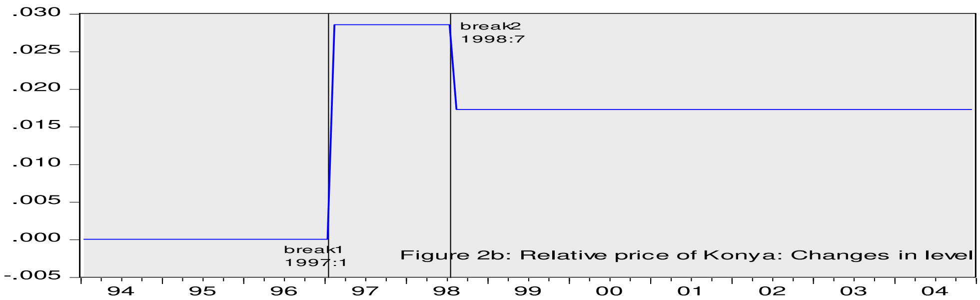




Figures 1a, 1b and 1c show natural log of relative CPI series of Diyarbakır, changes in level (mean) of natural log of relative CPI of Diyarbakır and simultaneous changes in level and trend of related series, respectively. Figure 1a presents recurrent upswings and downswings. As in GDP cycles, relative prices have also ups (or peaks) and downs (or troughs). They drop from their peaks, reach their troughs and start climbing to their peaks again. The first and second breaks correspond to a down point and an up point, respectively. Figure 1b shows the means of three time intervals of Diyarbakır's natural log relative CPI covering the periods 1994:1-2000:2, 2000:3-2001:12 and 2002:1-2004:12. Visually observed different means demonstrate marked shifts in level of relative CPI. Figure 1c graphs actual natural log relative CPI series given in Figure 1a and estimated trends for pre-break and post-break samples which correspond to time intervals of Figure 1b. Estimated lines from regressions on a trend and a constant give different slopes after the break points. One may see also sharp increase in level and a change in slope simultaneously at the 2001:12 break point on the estimated line. The first shift in level just after break1 given in Figure 1b, however, is not captured by fitted regression line where a trend and a constant are employed. Together with breaks of three split periods (prior and on February 2000, after February 2000 and on December 2001 and afterwards) the relative CPI of Diyarbakır exhibits stationarity around deterministic linear trend. One may, eventually, visualize from the figures that breaks have persistent effects and that fluctuations are stationary around a deterministic trend function. Diyarbakır figures, therefore, may give support for LS-LM tests' results in Table 3.

Figures 2a shows a plot of natural log of Konya relative price. Figure 2b gives averages of three split samples covering the periods before, at and after the breaks points. A sudden upward change occurs at one-time break of 1997:1 and a clearly observable downward change places at one-time break of 1998:7.





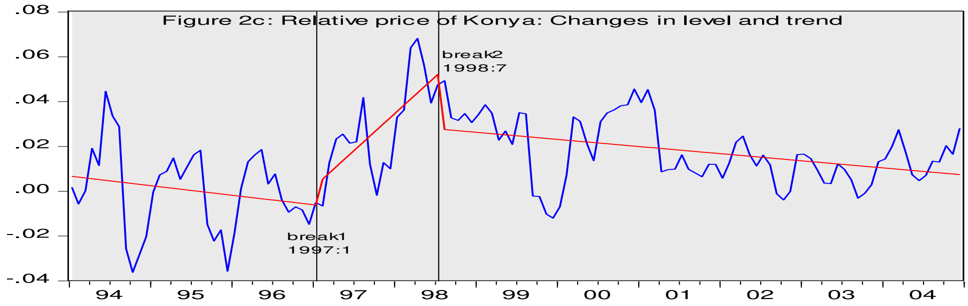


Figure 2c demonstrates the shifts in level, as are graphed by Figure 2b, through the regression lines for which trend and constant parameters are available in the estimation. Figure 2c yields changes in slope, as well. From this point of view, the outputs of Figure 1c and Figure 2c might be considered the results from Model C in Perron (1989), yet figures don't have the estimations of dummy variables for break points. LS-LM tests, on the other hand, observe full sample from its initial to the end points by including dummy variables for breaks, then first chooses optimal lag length for each break and, later, find the optimal breaks simultaneously. In conclusion, there is no conflict between figures and LM test statistics. Therefore, support of graphs and statistically significant outcomes of LM methodology indicate that the significant breaks given in Table 3 have permanent effects. In other words, the relative price of Konya converges to a steady state point in the long run as well as Diyarbakır. Though Erzurum and Eskişehir cases are not reported here, the graphs of these cities also confirm the persistent effect of break points picked by minimum LM tests.

III. Half-Lives

Zhang and Lowinger (2008) and Lee and Chang (2008) emphasize two main concerns in convergence issue. The first one is testing unit root null and the second one is, although unit root null is rejected, the Half-Life (*HL*). *HL* is the time horizon required for a temporary deviation from the long-run equilibrium path to dissipate by half. Though there are some controversies in estimation and using half-lives (Nath and Sarkar, 2007), the convergence studies employ intensively *HL* to calculate the persistence of deviations from equilibrium and compare it with related *HL* literature (Sonora, 2008). The approximate *HL* with structural break(s) can be calculated by Eq. (7).

$$HL = (ln\,(1/2))\;/\;(ln\,(1 + \emptyset)\,) \qquad (7)$$

where $\emptyset$ is the estimated value from Eq. (5) and *ln* is natural logarithm. Table 5 provides the *HL* measurements. All estimated significant $\emptyset$ values come from two structural break model whereas that of Adana is obtained from one structural break model.

According to Table 5, the *HL* of consumer price indexes ranges from 0.35 month to 1.59 months. This result, to the some extent, confirms Lan and Sywlester

(2009). They reach the outcome that prices converge rapidly in China with the *HL* between 2.20 to 2.72 months.

Crucini and Shintani (2008) find that price convergence rates are shorter in developing countries than those of developed countries. They report average *HL* of less than a year. Ceglowski (2003) concludes faster convergence of intercity prices in Canada than the international prices. He finds *HL* rate under a year. Sonora (2005) reaches *HL* rate of city relative prices in Mexico between one to two years. Burger and Rensburg (2008) conclude that *HL* of price of large middle-segment houses ranges between two to seven quarters whereas that of medium middle-segment houses spans from five to eight quarters. Sonora (2009) obtains convergence speeds of US cities' relative prices within interval of 2.25 to 2.96 years. Cecchetti et al. (2000) obtains very slow *HL* rate of 9 years in US. In comparison with Cecchetti et al. (2000), Basher and Carrion-i-Silvestre (2010) concludes slightly faster convergence interval in US with the *HL* rates from 1.5 to 2.6 years. Nath and Sarkar (2007), correcting bias due to heterogeneity in Cecchetti et al. (2000), finds 7-year *HL* rate. Cheung and Lai (2000) reveal that *HL* rates of low income, medium income and high income countries are 0.93, 1.90 and 3.15 years, respectively.

Table 5: The convergence rates (*HL*) of the LM unit root tests with structural break(s)

City	Estimated Ø	*HL* in months
Adana	-0.409	1,317
Bursa	-0.761	0,484
Diyarbakır	-0.432	1,225
Erzurum	-0.438	1,203
Eskişehir	-0.583	0,792
İstanbul	-0.598	0,761
İzmir	-0.578	0,803
Kayseri	-0.354	1,586
Kocaeli	-0.659	0,644
Konya	-0.492	1,023
Malatya	-0.409	1,318
Trabzon	-0.560	0,844
Zonguldak	-0.861	0,351

Throughout *HL* rates for 13 cities, it is observed that the deviation of each relative cpi for each city from its long run equilibrium is temporary, which is a transitory shock. As one can find some possible reasons of rapid convergence rate in Lan and Sywlester (2009), I may see the same possible reasons, as well, in the explanation of fast price convergence in Turkey.

Lan and Sylwester (2009) point out that lower degree of specialization and market differentiation in developing countries, or specifically, for instance, in China, the behavior of emerging market economy, may bring about a faster *HL* rate than the other countries' *HL* rates. Crucini and Shintani (2008) and Cheung and Lai (2000) also have identical lines to support Lan and Sylwester (2009). As a result, one may argue that the emerging market economies, including Turkey as well as China, might have more potential of faster price convergence in the long run through their market dynamics on their expansion paths. These dynamics might be possible change(s) in a country from imperfect market driven to perfect market driven conditions, or possible change(s) in weights in its consumption from non-tradable goods to tradable goods. Of course the list of parameters can be expanded and all possible dynamic parameters that are expected to have significant effects on *HL* should be estimated separately in another work.

IV. Conclusion

This paper applies minimum Lagrange multiplier unit root tests with two structural breaks and employs the data for relative prices of 18 cities spanning from January 1994 to December 2004. The 13 out of 18 relative consumer price indexes converge to their equilibrium level in the long run. The first structural breaks mostly bunch in second half of 1990s and might point (i) 1997 government intervention in energy and manufacturing products' prices, (ii) 1995, 1996, 1998 and 1999 capital inflows and 1997 capital outflows and (iii) negative growth rate in 1999. The second structural breaks seem to fall mostly in Turkish financial crises of 2000 and 2001. The capital inflows in 1998 and 1999 and negative growth rates in 1999 and 2001 can also account for second structural breaks. Besides the convergence, this paper also aims at finding the degree of persistence of deviations of each relative price in Turkey and states that the degree of deviation's of each relative price is not persistent as they all cluster around the average half-lives of 0.95 month.

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