Routledge
Taylor & Francis Group

Economic Research-Ekonomska Istraživanja

ISSN: 1331-677X (Print) 1848-9664 (Online) Journal homepage: http://www.tandfonline.com/loi/rero20

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Economic Research-Ekonomska Istraživanja, 2015
Vol. 28, No. 1, 85–103, http://dx.doi.org/10.1080/1331677X.2015.1022401

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Zekeriya Yildirim*

Faculty of Economics and Administrative Sciences, Department of Economics, Anadolu University, 26470 Eskisehir, Turkey

(*Received 12 August 2013; accepted 6 February 2015*)

The main purpose of this paper is to examine the interrelationships among productivity, real wages and inflation in the Turkish manufacturing industry for the period of 1988:1 to 2012:2. To that end, this paper employs both cointegration analysis and a Granger causality test. This paper finds that inflation has a greater effect on labour productivity than do real wages. Furthermore, the Granger causality test shows that there is a strong feedback between labour productivity and inflation, suggesting policy makers targeting inflation should follow labour productivity. This test suggests that there is no causal link running from productivity to real wages in the Turkish manufacturing industry. This absence of a link is largely due to lower bargaining power and structural problems, including high unemployment, a huge tax burden on wages and the large share of the informal sector.

Keywords: labour productivity; real wages; inflation; cointegration; Granger causality

JEL Classifications: C50, E23, J24

1. Introduction

Productivity growth has played a crucial role in maintaining country competitiveness and long-term economic growth while also controlling inflation. Therefore, inflation-targeting central banks and governments aiming to improve the competitiveness of their economy closely follow movements in labour productivity and the affecting factors of labour productivity. From the macroeconomic perspective, changes in productivity have been associated with movements in real wages and inflation in the theoretical and empirical literature. In this framework, an analysis of the interrelationships among productivity, real wages and inflation is critical for authorities who plan structural reforms to enhance productivity and for policy makers who aim to control inflation.

On the theoretical side, economists provide several mechanisms to explain the dynamic linkages among the variables. The theoretical literature suggests that inflation may have a negative impact on productivity because it may decrease worker purchasing power and may disrupt price signals and investment plans. Conversely, the literature stresses that an increase in real wages may positively affect productivity by increasing the costs of job loss and labour. Further, the literature also provides theoretical forecasts on the direction of causality among productivity, real wages and inflation. Several theories examine the direction of causality between productivity and real wages. First,

*Email: zekeriyayildirim@anadolu.edu.tr

efficiency wage theory argues that causality runs from real wages to productivity. Second, marginal productivity theory and bargaining theory state that causality runs from productivity to real wages. There are also two theoretical views that attempt to explain the causal ordering between productivity and inflation. The basic theoretical view suggests that causality runs from productivity to inflation. The alternative theoretical view argues that causality flows from inflation to productivity.

On the empirical side, there are many studies analysing the relationship between productivity and real wages. Similarly, several studies have analysed the linkage between productivity and inflation.[1] However, there are a few studies that examine the interrelationships among productivity, real wages and inflation. Most of these studies were focused on developed countries. Strauss and Wohar (2004) and Narayan and Smyth (2009) examined these relationships within a panel cointegration framework. The former study focused on the causal links at the industry level for a panel of 459 US manufacturing industries, while the latter study centred on panel estimates of the long-run elasticities of productivity with respect to real wages and inflation for G7 countries. Two other studies investigated the linkages among the variables using time series cointegration techniques. First, Hondroyiannis and Papapetrou (1997) studied both the short-run and long-run interrelationships among the variables within a time series cointegration framework in Greece. Second, Kumar, Webber, and Perry (2012) analysed the relationships using a comprehensive set of cointegration techniques for the Australian manufacturing sector. These researchers focused on both the long-run relationship and the causal links. Overall results from the studies focusing on developed countries show that there is a positive and strong relationship between productivity and real wages, while there is a negative relationship between productivity and inflation. Nonetheless, there is no strong consensus regarding the direction of causality among productivity, real wages and inflation in the empirical literature.

Due to the lack of available labour market data, there are only two studies that examine the interrelationships among productivity, real wages and inflation in the context of emerging markets and developing countries. By focusing on how policy makers consider wage and productivity growth in evaluating inflation, Mihaljek and Saxena (2010) analysed these relationships for emerging market economies, while Tang (2014) studied the linkages employing both cointegration analysis and a Granger causality test for Malaysia. The aim of this paper is to contribute to the extant empirical literature by investigating the relationships among productivity, real wages and inflation for a fast-growing emerging market economy, Turkey, a country that exhibits relatively strong productivity growth (Figure 1).

For an international comparison, recent developments in productivity, real wages and inflation in major emerging market economies are presented in Figure 1. Turkey demonstrates the second largest productivity growth rate among the emerging market economies after China, although real wage growth in Turkey is negative. In other words, productivity growth substantially exceeds real wage growth and thus underpins a relatively large decrease in inflation (Figure 1). In contrast, productivity gains are compensated by strong real wage growth in some emerging markets, such as China, the Czech Republic and Hungary.

To analyse the interrelationships among the variables, the history of labour productivity, real wages, inflation and interest rates in Turkey is indicated Figure 2. In the post-1980 era (1988–2001), there were two political decisions and several economic developments affecting the interrelationships among productivity, real wages and inflation in the Turkish manufacturing industry. The decisions were the rapid real wage

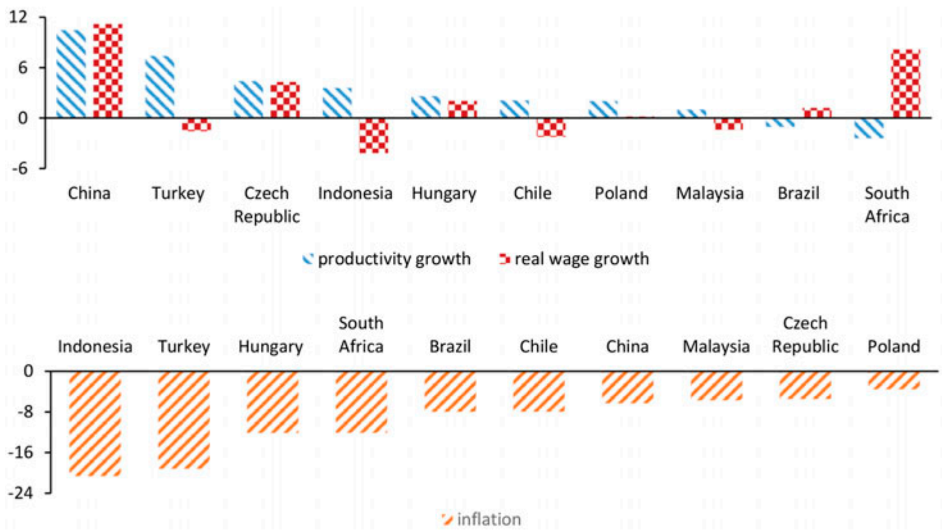

Figure 1. Productivity, real wages and inflation in emerging market economies (average annual percentage changes, 2005–2007).
Sources: Mihaljek and Saxena (2010), International Monetary Funds (IMF).

hikes between 1988 and 1993 and the Custom Union (CU), which took effect between Turkey and the European Union in 1996. Real wages and salaries in the public sector were substantially increased by the government from 1988 to 1993 (Figure 2). Consequently, the average real wages in the manufacturing industry were raised by 132%. The government-driven real wage hikes caused an unprecedented increase in labour productivity over the same period (Yilmaz, 2012, p. 359). Conversely, Turkey experienced two domestic-driven serious crises (1994, 2001), and high and chronic inflation triggered chronic fiscal deficits. The high inflation and interest rates negatively affected the productivity growth by distorting price signals and firms' investment plans. Many firms in the manufacturing industry invested in high-interest yielding government securities instead of investing in basic research. In this period, especially after 1993, the causal link between productivity and real wages weakened.

During the past decade (2002–2012), labour productivity in the Turkish manufacturing industry has risen sharply. This growth has been driven primarily by an unprecedented decrease in both inflation and interest rates (Figure 2). The persistent disinflation trend has contributed significantly to the strong productivity growth through several channels (e.g., a mix of factor inputs and investment plans) whereas the unprecedented decline in interest rates has played an important role in achieving this by inducing manufacturing firms to invest in long-term basic research. Consistent with this pattern, Erzan and Filiztekin (2005) find that decreases in interest rates boost labour productivity for large firms in the Turkish manufacturing industry. In contrast, the link between labour productivity and real wages has been broken, and hence, the wage-productivity gap has widened during this period (Figure 2). Some authors associate the widening of this gap with the already low and continually decreasing bargaining power of workers and certain structural problems, including high unemployment, huge tax burdens on wages and a large informal sector (Bildirici & Alp, 2012; Elgin & Kuzubas, 2012). The widening gap has helped the central bank to

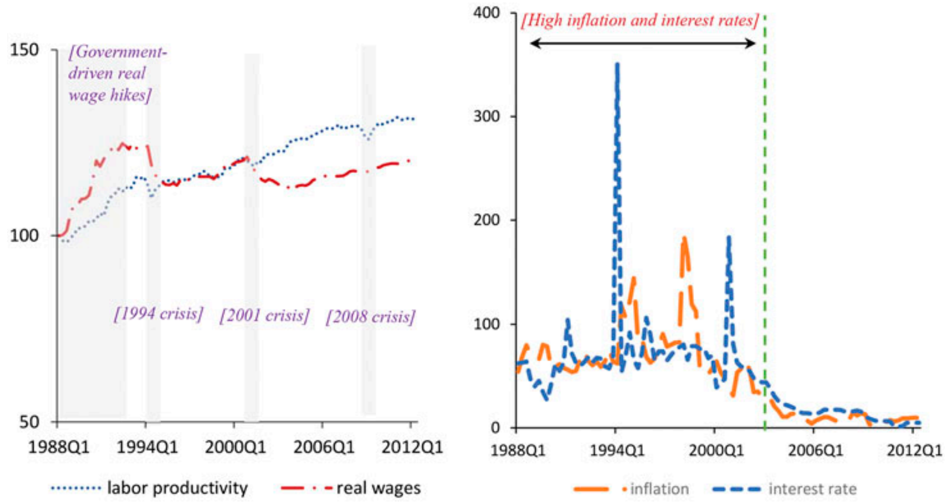

Figure 2. Labour productivity, real wages (1988Q1 = 100), inflation and interest rates in Turkey. Sources: International Monetary Funds' International Financial Statistics (IMF's IFS), the Turkish Statistical Institutes (TUIK) and State Planning Organisation (SPO).

reduce inflation to single digits by limiting recovery in domestic demand and by enabling firms with cost-advantages (Basci, 2005). Thus, recent developments in labour productivity and inflation clearly show that there is a strong relationship between labour productivity and inflation.

This paper examines the interrelationships among productivity, real wages and inflation in the Turkish manufacturing industry by considering the main literature and political and economic developments in Turkey. This paper is important for two reasons. First, the interrelationships among productivity, real wages and inflation have not been examined in the Turkish manufacturing industry. Second, there is no study that examines the causal linkages among the variables in the Turkish manufacturing industry using the methodological framework in this paper.

This paper is structured as follows. Section 2 explains the theoretical background. Section 3 describes data and methodology. Section 4 presents the empirical results. Finally, Section 5 concludes.

2. Theoretical background

It is accepted in the theoretical literature that inflation may adversely affect productivity growth. Economists suggest three mechanisms by which inflation may have a negative effect on productivity (Freeman & Yerger, 2000; Hondroyiannis & Papapetrou, 1997; Jarrett & Selody, 1982; Kumar et al., 2012; Narayan & Smyth, 2009; Papapetrou, 2003; Tsionas, 2003). The first mechanism depends on worker purchasing power while the others rely on firms' investment plans and mix of factor inputs. These mechanisms are as follows.

Worker purchasing power

Inflation leads to a decrease in worker purchasing power that reduces motivation and effort. Thus, inflation may negatively affect productivity through the worker purchasing power mechanism.

Mix of factor inputs

According to this proposed mechanism, inflation influences productivity in three ways. First, inflation may reduce productivity because it gives rise to an inefficient mix of factor inputs. Second, it may adversely affect productivity because of the choice of sub-optimal factor input mixes stemming from the distorted information content of price signals. Third, inflation reduces capital accumulation because it decreases tax reductions from deprecation and it raises the rental price of capital. Because of decreasing capital accumulation, productivity may decrease.

Investment plans

Firms generally respond to increasing uncertainty about inflation by raising inventories of buffer stock and decreasing expenditures on long-term basic research that leads to a reduction in productivity. Thus, increasing uncertainty about inflation may negatively affect labour productivity.

Changes in productivity may also stem from changes in real wages. In the theoretical literature, there is a consensus regarding a positive relationship between productivity and real wages. In this framework, there are two basic arguments. The first argument depends on efficiency wage theory. According to this theory, higher real wages imply a higher cost of job loss for workers. When firms pay higher wages, workers exert greater effort to avoid being dismissed (Storm & Naastepad, 2007, p. 5). Therefore, a rise in real wages will improve labour productivity by causing an increase in the cost of job loss. The second argument explains the positive relationship between productivity and real wages within a macroeconomic framework. This argument suggests that an increase in real wages will lead firms to substitute capital for labour by raising the cost of labour. This substitution stemming from an increase in real wages will also raise marginal productivity (Wakeford, 2004, p. 113).

Causal relationships among productivity, real wages and inflation are also addressed by different theoretical models. These models and their forecasts regarding the direction of causation for the variables are summarised in Table 1. There are some theories that attempt to explain the direction of causality between productivity and real wages. The theories agree there is a unidirectional causality, but they have different views on the direction of the causality. First, efficiency wage theory asserts that the causality runs from real wages to productivity. This theory is based on the main hypothesis that productivity depends positively on real wages. Thus, it suggests that real wage increases (decreases)

Table 1. Causality issue.

Real Wages → Productivity	Efficiency Wage Theory
Productivity → Real Wages	Marginal Productivity and Bargaining Theory
Productivity → Inflation	Standard Theoretical View
Inflation → Productivity	Alternative Theoretical View

Sources: Wakeford (2004); Saunders and Biswas (1987).

precede productivity increases (decreases). Second, marginal productivity theory and bargaining theory state that the causality runs from productivity to real wages because wages are determined with respect to productivity, that is, higher productivity will cause higher real wages and lower productivity will cause lower real wages. Hence, this theory asserts that productivity increases precede real wage increases (Yusof, 2008, p. 392).

Table 1 shows that there are two theoretical views regarding the direction of causality between inflation and productivity. First, the standard theoretical view depends on the assumption that productivity growth is exogenous and increases in worker productivity bring about decreases in the rate of inflation by raising the economy's aggregate supply. Therefore, this view argues that inflationary pressure may be reduced by productivity growth and therefore suggests a unidirectional flow of causality running from productivity to inflation. In other words, according to this view, changes in productivity precede changes in inflation rate. In contrast, the alternative theoretical view suggests that inflation may adversely influence productivity growth by decreasing worker purchasing power, distorting information content of price signals, disrupting investment plans and decreasing capital accumulation. Dependent on these factors, this view argues that the causality flows from inflation to productivity (Freeman & Yerger, 2000, p. 317; Saunders & Biswas, 1987, p. 1).

3. Data and methodology

This paper uses quarterly seasonal adjusted data for productivity, real wages and the rate of inflation for the 1988:1–2012:2 period. Productivity represents average labour productivity (production index/employment index) in the Turkish manufacturing industry while the rate of inflation represents the growth of the GDP deflator. Real wages are obtained by deflating the nominal wage index with the GDP deflator. All data are obtained from the Turkish Statistical Institutes (TUIK), State Planning Organisation (SPO) and International Monetary Funds' International Financial Statistics (IMF's IFS). The variables are transformed into logarithmic form.

Following Kumar et al. (2012), the long- run empirical model is specified as follows:

$$pr_t = \alpha_0 + \alpha_1 rw_t + \alpha_2 in_t + \varepsilon_t \tag{1}$$

where *pr* is the labour productivity, *rw* represents real wages, *in* is the rate of inflation and ε_t is the serially uncorrelated error term. The coefficient of rw_t, α_1, indicating the elasticity of productivity with respect to real wages, is theoretically expected to be positive whereas the coefficient of in_t, α_2, indicating the elasticity of productivity with respect to inflation, is theoretically expected to be negative.

There are various time series cointegration tests to examine whether there exists a long-run relationship among variables, such as those in equation (1). In the applied literature, the most commonly used tests are the Engle and Granger (1987) cointegration test (hereafter EG), the Gregory and Hansen (1996) cointegration test with an endogenous break (hereafter GH), the ARDL bounds testing approach developed by Pesaran, Shin, and Smith (2001) and the Johansen approach proposed by Johansen (1988) and Johansen and Juselius (1990). The first three tests are referred to as the single equation cointegration tests because they depend on single Ordinary Least Squares (OLS) estimation. The other test is referred to as a system-based cointegration test because of its dependence on multivariate estimation techniques. There are several differences among these tests. EG and GH are based on residuals, the ARDL bounds testing approach is based on an unrestricted error correction model (UECM) and the Johansen approach is based on Vector Autoregression (VAR). In addition, the ARDL bounds testing approach does not require that variables are the same order of integration, which is a prerequisite for others. Considering that each of these tests has particular advantages and disadvantages, this paper employs all four approaches to inquire into the existence of a long-run relationship among productivity, real wages and inflation. This section briefly explains each approach.

3.1. Cointegration tests

EG is carried out in two steps. First, the potential long-run relationship in equation (1) is estimated using OLS and residuals $(\hat{\varepsilon}_t)$ are obtained. Second, an Augmented Dickey-Fuller (ADF) test is performed on the residuals to determine whether they are stationary or not. Here, the null hypothesis is that the residuals are non-stationary $(\hat{\varepsilon}_t \sim I(1))$, implying no-cointegration, while the alternative hypothesis is that they are stationary $(\hat{\varepsilon}_t \sim I(0))$, implying cointegration. To test the null hypothesis, an ADF t-statistic on the residuals is used. The statistic is calculated by estimating the following ADF test equation:

$$\Delta\hat{\varepsilon}_t = \rho\hat{\varepsilon}_{t-1} + \sum_{i=1}^{p} \alpha_i \hat{\varepsilon}_{t-i} + \eta_t \tag{2}$$

The calculated statistic is compared with critical values tabulated by Mackinnon (1991) to decide whether the null hypothesis is rejected. Rejecting the null hypothesis implies cointegration.

The Johansen approach employs the error correction representation of VAR (p) model to test cointegration. This representation is as follows:

$$\Delta y_t = c + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + \pi y_{t-1} + u_t \tag{3}$$

where y_t = (productivity, real wages and inflation), $\Gamma_1 \cdots \Gamma_{p-1}$ and π are unknown parameters and u_t is the error term ($u_t \sim N(0, \sum)$).

This approach focuses on the rank of π, which shows stationary linear combinations of productivity, real wages and inflation. If π has a zero rank, there are not any stationary linear combinations of the variables. Thus, there is no long-run relationship. In contrast, if π has a reduced rank, there exists a long-run relationship. Thus, to test whether the variables are cointegrated, the rank of π is determined by testing whether the eigenvalues of π are significantly different from zero in the Johansen approach. There are two test statistics to test the rank of π (i.e., the number of cointegration vectors): the trace (λ_{trace}) and the maximum eigenvalue $(\lambda_{\max})$ statistics. A decision regarding cointegration among the variables can be made by analysing results from both tests.

The ARDL bounds testing approach necessitates estimating the following unrestricted error correction model:

$$\begin{aligned}\Delta pr_t = \alpha_0 + \sum_{i=0}^{p} b_{1i}\Delta rw_{t-i} + \sum_{i=0}^{p} b_{2i}\Delta in_{t-i} + \sum_{i=0}^{p} b_{3i}\Delta pr_{t-i} + b_4 rw_{t-1} + b_5 in_{t-1} \\ + b_6 pr_{t-1} + \varepsilon_t\end{aligned} \tag{4}$$

The ARDL approach includes a two-step procedure. First, testing is required for the existence of any long-run relationship among the variables (equation (1)). In this step, an F test is used to determine whether cointegration exists. Here, the null hypothesis of no-cointegration is H_0: $b_4 = b_5 = b_6 = 0$. Pesaran et al. (2001) report two sets of critical values (CVs) for the F test with and without time trend. If the estimated F statistics are higher than the upper bound critical value, then there exists a unique long-run relationship in equation (1). Second, the order of the lag in the ARDL model is selected and the long-run coefficients are estimated. The optimal lag order is selected using information criteria, such as AIC and SBC. To obtain long-run coefficients, the selected ARDL model is estimated by OLS.

The above three techniques have a common assumption: that the long-run relationship does not change during the sample period. It is inconsistent in some situations because there might be various developments such as policy regime shifts and economic crises that may cause considerable changes in the long-run relationship. If there exists such a structural break within the sample period, the techniques reject the null hypothesis of no-cointegration too often. Thus, using the techniques may cause a spurious cointegration problem in the presence of a structural break (Cook, 2004; Leybourne & Newbold, 2003; Perron, 2007). To avoid the problem, this paper also uses the GH cointegration approach.

Gregory and Hansen (1996) extend the EG test with an endogenously determined structural break. They accommodate the single structural break in the long-run relationship (equation (1)) by incorporating suitable dummy variables in equation (1). The GH technique depends on three models. Each of the models is an adjusted version of equation (1) with dummy variables. They are as follows:

Model C (level shift)

$$pr_t = \alpha_0 + \delta D_t + \alpha_1 rw_t + \alpha_2 in_t + \varepsilon_t \tag{5}$$

Model C/T (level shift with trend)

$$pr_t = \alpha_0 + \delta D_t + \beta t + \alpha_1 rw_t + \alpha_2 in_t + \varepsilon_t \tag{6}$$

Model C/S (regime shift)

$$pr_t = \alpha_0 + \delta D_t + \alpha_1 rw_t + \alpha_2 in_t + \alpha_3 D_t rw_t + \alpha_4 D_t in_t + \varepsilon_t \tag{7}$$

where α_0, α_1 and α_2 are, respectively, the intercept and cointegrating slope coefficients before the shift, and δ, α_3 and α_4 denote changes to the intercept and slope coefficients at the time of the shift. The dummy variable (D_t) is defined as

$$D_t = \begin{cases} 1, & \text{if } t > \tau \\ 0, & \text{if } t \leq \tau \end{cases}$$

where τ is a structural change point in the sample period.

The GH procedure is similar to the EG procedure. First, the long-run relationships displayed in models (5)–(7) are estimated by OLS for each possible break date and residual sequences $(\hat{\varepsilon}_{it})$ are obtained from each of the three models. Therefore, there are three residual sequences $(\hat{\varepsilon}_{1t}, \hat{\varepsilon}_{2t}, \hat{\varepsilon}_{3t})$. Second, an ADF test is performed on each of these estimated residual sequences. Using the smallest values of the ADF *t*-statistics on the residuals, the null hypothesis of no-cointegration is tested. The test statistics are calculated by estimating equation (2) for each of the three residual sequences. The smallest values are $ADF^* = \inf_{\tau \in T} ADF(\tau)$. Gregory and Hansen (1996) report asymptotic critical values for the ADF *t*-statistics.

3.2. Granger causality

If there is a long-run relationship among productivity, real wages and inflation, then a causal relationship among the variables exists. However, the existence of such a long-run relationship does not provide any evidence about the direction of causality. The Granger causality test allows analysis of the causality direction in both the short and long-run. In the presence of cointegration, the test depends on the following error correction models (ECMs):

$$\Delta pr_t = \mu_1 + \alpha_{pr}\hat{\varepsilon}_{t-1} + \sum_{i=1}^{p} \phi_{rwi}^{(1)} \Delta rw_{t-i} + \sum_{i=1}^{p} \phi_{ini}^{(1)} \Delta in_{t-i} + \sum_{i=1}^{p} \phi_{pri}^{(1)} \Delta pr_{t-i} + \varepsilon_t^{pr} \tag{8}$$

$$\Delta rw_t = \mu_2 + \alpha_{rw}\hat{\varepsilon}_{t-1} + \sum_{i=1}^{p} \phi_{rwi}^{(2)} \Delta rw_{t-i} + \sum_{i=1}^{p} \phi_{ini}^{(2)} \Delta in_{t-i} + \sum_{i=1}^{p} \phi_{pri}^{(2)} \Delta pr_{t-i} + \varepsilon_t^{rw} \tag{9}$$

$$\Delta in_t = \mu_3 + \alpha_{in}\hat{\varepsilon}_{t-1} + \sum_{i=1}^{p} \phi_{rwi}^{(3)} \Delta rw_{t-i} + \sum_{i=1}^{p} \phi_{ini}^{(3)} \Delta in_{t-i} + \sum_{i=1}^{p} \phi_{pri}^{(3)} \Delta pr_{t-i} + \varepsilon_t^{in} \tag{10}$$

where $\hat{\varepsilon}_{t-1}$ is the lagged residual term generated from the long-run relationship and is referred to as the error correction term.

The short-run, long-run and strong causality are used to analyse the causal relationships in the applied time series literature. The long-run causality depends on a *t*-test, while the others rely on a joint *F*-test. The significance of the *t*-statistics related to the coefficient of the error correction term implies the long-run causality. If the *F*-statistics from the coefficients of the first difference of the variables are statistically significant, then there is short-run causality between the variables of interest. Strong causality is also determined by the significance of *F*-statistics on both the coefficients of the respective explanatory variables and the respective error correction term.

4. Empirical results

4.1. Unit root tests

The cointegration tests, except for the ARDL technique, require the variables to have the same order of integration. Therefore, pretesting the variables to learn their order of integration is the first step of the analysis. To perform the pretest, this paper employs the two conventional unit root tests: the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests. For both tests, the null hypothesis is that there is a unit root. Table 2 presents the test results for the variables in this paper. The results show that two test statistics for the log level of the variables (productivity, real wages and inflation) are less than the critical values in absolute terms. This implies that the null hypothesis cannot be rejected. However, the test statistics, for their first difference, exceed the respective critical values, implying a rejection of the null hypothesis. Thus, both tests clearly show that productivity, real wages and inflation have the same order of integration, I (1).

Table 2. Unit root tests.

	Level			First difference	
Variables	ADF statistic	PP statistic	Variables	ADF statistic	PP statistic
pr	2.62 (4)	1.86(4)	Δpr	**4.53(4)***	**9.57(2)***
rw	2.81(4)	0.95(5)	Δrw	**7.59(0)***	**7.80(5)***
in	0.79(4)	1.71(2)	Δin	**7.51(3)***	**13.62(6)***

Notes: Both tests consist of a constant. Figures in parenthesis are lag lengths. ADF and PP critical values at 1% and 5%, respectively, are 3.50, 2.85 and 3.49, 2.89.
Source: Author's own calculation.
*denotes statistical significance at the 1% level; bold emphasises statistical significance.

4.2. Cointegration

The first aim of this paper is to probe the existence of a long-run relationship in equation (1).[2] For this purpose, all the single equation techniques (EG, GH, ARDL bounds testing) and the system-based technique (Johansen) are employed.[3] All the cointegration tests depend on a comparison of the test statistics against the respective critical values. Thus, the calculated test statistics and the respective critical values are reported in Table 3.

Panel A of the table shows the results of the single equation techniques. The panel consists of three parts (a, b, c). The first part of the panel indicates the results of the EG test. The test rejects the null of no-cointegration because the calculated ADF statistics (from the estimates of equation (2)) exceed the critical value. The second part relates to the GH test results. The two models (C, C/S) in the test suggest there is cointegration with a structural break. The break date endogenously determined by the GH procedure is 1993 in both models. That date is the starting year of highly volatile periods in the Turkish economy.

The final part of panel A in Table 3 reports the results of the bounds testing for cointegration. The first step of the test is the lag order selection. To determine the optimal lag order, this paper considers two lag order selection criteria (AIC and SBC) as well as employing diagnostic testing on the residuals. These criteria values and the LM test with p-values are reported in the last part of panel A. The results show the optimal number of the lags selected by AIC and SBC to be 6 and 3, respectively. The residuals of the unrestricted error correction model (equation (4)) do not exhibit serial correlation for the lag order selected by AIC. Nonetheless, the model selected by SBC does not pass the residuals diagnostic test for serial correlation. To ensure robustness of the results, this paper reports the bounds tests results for lag orders (6,3) selected by AIC and SBC. For both lag orders, the calculated F-statistic is higher than the upper bound critical value at both the 1% and 5% significance levels. This indicates that the test also rejects the null hypothesis of no-cointegration.

Panel B of Table 3 includes the results of the system approach. The first part of panel B shows the optimum lag order of the VAR model and the results of the residual autocorrelation test. It reveals that the suitable model for the cointegration test is VAR (5), which passes the residual diagnostic test for autocorrelation. The second part of panel B reports the results from the Johansen cointegration tests for VAR (5). Both the test statistics reveal that there is no stationary linear combination of the variables. Consequently, with the exception of the Johansen approach, all tests clearly show that there is a long-run relationship among productivity, real wages and inflation.

Table 3. Results for cointegration tests.

Panel A. Single equation cointegration tests

(a) *EG cointegration test*

Model	ADF statistic [lag]	Critical values 1% (5%)
Eqs. (1) and (2)	**4.39 [0]****	−4.44 (–3.82)

(b) *GH cointegration test*

Model	ADF* -statistics [lag]	Critical values	Break date
C	**6.09 [0]***	5.44 (4.92)	1993:4
C/T	5.10 [0]	5.80 (5.29)	1991:3
C/S	**6.44 [0]***	5.97 (4.50)	1993:4

(c) *Bounds testing approach*

(*c1*) *Statistics for choosing the optimal lag length*

p	AIC	SBC	$\chi^2_{SC}(1)$	*p*-val	$\chi^2_{SC}(4)$	*p*-val
1	−4.004	−3.712	1.866	0.171	8.595	0.072
2	−4.020	−3.646	3.151	0.075	8.458	0.076
3	−4.195	−3.738	6.965	0.008	9.753	0.044
4	−4.186	−3.645	8.417	0.003	9.310	0.053
5	−4.178	−3.552	7.671	0.005	7.875	0.096
6	−4.207	−3.494	5.124	0.023	13.19	0.010

(*c2*) *Bounds test for cointegration*

Model	Calculated *F*-statistics [lag] (number of regressor)	Critical value bounds of the *F*-statistics	
		Lower bound I(0)1% (5%)	Upper bound I(1)1% (5%)
Eq. (4)	**7.44*** [6] (2), **8.23***[3] (2)	3.17 (3.79)	4.14 (4.85)

(Continued)

Table 3. *(Continued).*

Panel B. System based cointegration test (Johansen approach)

(I) *VAR model residuals autocorrelation test*

Model	Lag	LM (1) [*p*-v.]	LM (4)	LM (8)
Eq. (3)	5	9.19 [0.41]	11.28 [0.25]	6.24 [0.71]

(II) *Johansen cointegration test*

Hypotheses		Trace test		Hypotheses		Max. eig. val. test	
H_0	H_A	λ_{trace}	C. V. (5%)	H_0	H_A	$\lambda_{\max}$	C·V. (5%)
$r = 0$	$r > 0$	27.85	42.91	$r = 0$	$r = 1$	15.16	25.82
$r = 1$	$r > 1$	12.68	25.87	$r = 1$	$r = 2$	9.29	19.38

Note: Critical values for the EG test are obtained from Enders (2010, p. 490) for three variables.
The lower and upper bound critical values for the bounds test are derived from Pesaran et al. (2001, p. 300), table CI(iii) case V: unrestricted intercept and unrestricted trend ($k = 2$).
Critical values for GH (1996) are obtained from Gregory and Hansen (1996, p. 109), Table 1.
Source: Author's own calculation.
*and
**denote statistical significance at the 1% and 5% levels, respectively; bold emphasises statistical significance.

Table 4. Long-run elasticities.

Mod.1	EG	GH(C)	GH(C/S)	ARDL[a]	DOLS	FMOLS
rw	0.16* (8.56)	0.19* (4.98)	0.20* (5.62)	0.14* (3.92)	0.18* (5.61)	0.16* (5.35)
in	−0.95* (4.61)	−1.55* (5.64)	−1.38* (4.83)	−2.20* (4.81)	−1.91* (5.03)	−1.44* (4.57)
Mod.2						
rw	0.15* (7.90)	0.15* (3.32)	0.14** (2.71)	0.19* (4.01)	0.20* (4.85)	0.16* (4.94)
in_1	−0.61** (3.15)	−1.74* (5.75)	−1.80* (5.42)	−2.01* (4.01)	−1.96* (3.89)	−1.14* (3.53)
Mod.3						
rw	0.15* (7.52)	0.23* (5.07)	0.12** (1.97)	0.17* (2.79)	0.15* (3.97)	0.14* (4.19)
in_2	−0.39** (2.36)	−0.95* (4.17)	−1.26* (4.51)	−1.08* (2.27)	−1.69* (3.51)	−0.75* (2.69)
Mod.4						
rw	0.15* (7.53)	0.13* (2.13)	0.12** (1.96)	0.17* (2.93)	0.16* (3.95)	0.14* (4.21)
in_3	−0.42* (2.50)	−1.28* (4.84)	−1.33* (4.94)	−1.22* (2.58)	−1.70* (3.47)	−0.78* (2.78)

[a]The estimates of the coefficients depend on the ARDL model (1, 3, 2) selected by AIC.
*and
**denote statistical significance at the 1% and 5% levels, respectively.
Source: Author's own calculation.

Table 5. Causality.

	Source of causation							Direction of causality (conclusion)		
	Short-run causality			Long-run causality	Strong causality			SR	LR	Strong
D. Var.	Δpr F-st.	Δrw	Δin	$\hat{\varepsilon}_{t-1}(t-st.)$ t-st.	$\Delta pr, \hat{\varepsilon}_{t-1}$ F-st.	$\Delta rw, \hat{\varepsilon}_{t-1}$	$\Delta in, \hat{\varepsilon}_{t-1}$			
Δpr	–	**3.14***	**3.62***	**−0.18 (3.06)***	–	**7.14***	**4.44***	$rw \rightarrow pr \mid in \rightarrow pr$	rw, in → pr	$rw \rightarrow pr \mid in \rightarrow pr$
Δrw	0.20	–	0.50	−0.11 (0.81)	1.36	–	1.49	$pr \nrightarrow rw \mid in \nrightarrow rw$	$pr, in \nrightarrow rw$	$pr \nrightarrow rw \mid in \nrightarrow rw$
Δin	**5.06***	**5.23***	–	0.01 (0.31)	**4.05***	**4.38***	–	$pr \rightarrow in \mid \mathrm{rw} \rightarrow \mathrm{in}$	$pr, rw \nrightarrow in$	$pr \rightarrow in \mid \mathrm{rw} \rightarrow \mathrm{in}$

*denotes statistical significance at the 1% level; bold emphasises statistical significance.
Source: Author's own calculation.

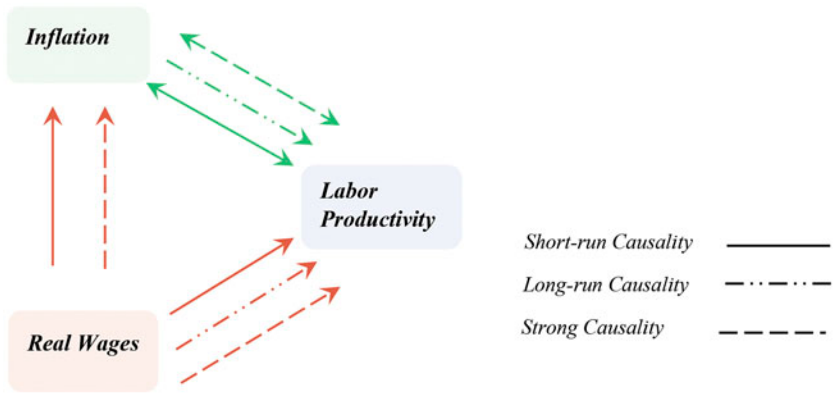

Figure 3. Graphical summary of causality tests.
Source: Author's own calculation.

4.3. Long-run estimates

The long-run relationship (equation (1)) is estimated using the EG, GH and ARDL techniques. In addition, to ensure robustness of the results, DOLS and FMOLS are also used to estimate the long-run coefficients in equation (1). Table 4 reports the results from the five techniques. The table clearly shows the long-run relationship is consistent with theoretical expectations. The results reveal that real wages positively affect productivity. This result is statistically significant and consistent with the theory. The estimates of the elasticity of real wages are between 0.14 and 0.20. That is, a 1% increase in real wages causes an increase in labour productivity of between 0.14% and 0.20%. Consequently, this result suggests that real wages have a positive impact on productivity. However, the effect of real wages on productivity is relatively small in the Turkish manufacturing industry.

Table 4 also shows the estimates of the coefficient of inflation. All techniques suggest that there is a negative and statistically significant long-run relationship between inflation and productivity. Compared with real wages, the effect of inflation on productivity is large. To analyse whether this is due to the measure of inflation or not, the paper also uses different measures of inflation that obtained three different price indexes.[4] Thus, the models (2, 3 and 4) in Table 4 include the different measures of inflation. The first measure of inflation (in_1) represents the growth of consumer price index. The other measures (in_2 and in_3) are the growth of the producer price index and wholesale price index, respectively. Overall, the results imply that inflation has a larger effect on productivity than do real wages for each measure of inflation. Comparison of this effect with the main literature reveals that inflation has a relatively large impact on productivity in the Turkish manufacturing industry.[5]

4.4. Causality

Because there is a long-run relationship among productivity, real wages and inflation, the Granger causality test is employed to identify the direction of causality in both the short-run and long-run. For this purpose, the error correction term is initially obtained from the ARDL (1, 3, 2) model. Next, the ECM models (as indicated in equations (8), (9), (10)) are estimated with four lags. The results of the test for causality are presented in Table 5 and Figure 3.

In the short-run, the results suggest that the causal relationship between productivity and inflation is bi-directional. However, there exists a unidirectional causality running from real wages to productivity (Figure 3 and Table 5). This result is consistent with the pattern of a widening wage-productivity gap and several studies (Bildirici & Alp, 2012; Elgin & Kuzbas, 2012; Taymaz et al., 2010). Turkey has an economy facing structural problems such as high unemployment, a huge tax burden on wages and the large share of the informal sector. In addition, the workers in the Turkish manufacturing industry have lower and decreasing bargaining power. The structural problems and lower bargaining power have caused a weakening of causal links running from productivity to real wages. Thus, it is expected that the productivity-real wages link is weaker in the Turkish manufacturing industry. This result is also consistent with this expectation.

Table 5 clearly shows that only the error correction term (–0.18) in the productivity equation is significant with the expected negative sign. This implies that real wages and inflation affect productivity in the long-run. Furthermore, the coefficient reveals that convergence to equilibrium is relatively small in the Turkish manufacturing industry. The result of the strong causality analysis is consistent with both the short-run and long-run causality analyses (Figure 3).

5. Conclusion

The effects of inflation and real wages on productivity are well-documented in the theoretical literature. The literature reveals that there exists broad consensus with respect to the existence of strong interrelationships among real wages, productivity and inflation. The recent growing empirical literature focusing mainly on developed countries provides evidence to support this consensus. However, there has been little empirical research that tests this general agreement in the context of emerging market economies. The main purpose of this paper is to contribute to the existing empirical literature by providing evidence on both the effects of real wages and inflation on productivity and the causal linkages among the variables for the manufacturing industry in Turkey, which is one of the fast-growing emerging economies.

The results reveal that the dynamic interactions among real wages, inflation and productivity in Turkey are consistent with the theoretical expectations, the empirical findings in the literature for developed and developing countries, and the stylised facts of the Turkish economy. Some of the findings are summarised as follows.

(1) Inflation has a greater effect on labour productivity than do real wages.
(2) There exists a feedback effect between labour productivity and inflation.
(3) There is unidirectional causality from real wages to productivity, thus implying a broken link between productivity and wage.

Overall, the results of this paper provide various important policy implications. First, the findings imply that Turkey's central bank may contribute considerably to productivity growth and, hence, to long-term economic growth by controlling inflation and thereby maintaining the historically low interest rate. In addition to the positive effects of disinflation on labour productivity, there is some evidence suggesting that decreases in interest rates may boost labour productivity, especially in large firms, within the Turkish manufacturing industry. Therefore, keeping interest rates low is necessary for boosting productivity growth. Second, the results suggest that some wage adjustments might provide further productivity gains. Hence, authorities aiming to enhance productivity should seek adjustments that do not create inflationary pressures from the labour market. Furthermore, in Turkey, there exist several structural impediments to productivity growth, including the significant size of the informal sector, the high regulatory labour costs, the low human capital, and the small share of institutionalised firms. To reduce these impediments, the government should design reforms and policies that (i) attract FDI inflows to boost productivity growth via technology spillover; (ii) facilitate the institutionalisation of firms; (iii) provide improvements in human capital; and (iv) reduce the tax burden on wages, thereby reducing the informality phenomenon.

This paper covers the period during which Turkey experienced high and chronic inflation for the most part. However, Turkey has recently succeeded in reducing inflation to single digits. In other words, Turkey has existed in a lower inflationary environment since 2005. In this environment, the relationship between inflation and productivity may be different. Therefore, further investigation is necessary to identify whether the effect of inflation on productivity is different in a lower inflationary environment.

Acknowledgement

The author would like to thank an anonymous referee for helpful suggestions and comments.

Notes

1. An incomplete list includes Jarrett and Selody (1982), Ram (1984), Buck and Fitzroy (1988), Alexander (1993), Erenburg (1998), Freeman and Yerger (2000), Bitros and Panas (2001), Papapetrou (2003), Tsionas (2003), Dritsakis (2004), Wakeford (2004), Mahadevan and Asafu-Adjaye (2005), Hsu (2005), Mora, Lopez-Tamayo, and Surinach (2005), Christopolous and Tsionas (2005), Yusof (2008), Taymaz, Voyvoda, and Yilmaz (2010), Aslan, Aslan, and Yalama (2009), Bildirici and Alp (2008, 2012), and Kim, Lim, and Park (2013).
2. The cointegrating equations in ARDL, EG and the Johansen approach include constants and deterministic trends.
3. To consider the effects of the government-driven real wage hikes and the economic crises (1994, 2001 and 2008) and to avoid any spurious cointegration among productivity, real wages and inflation, four dummy variables are included in the test equations, except for the GH test. The first covers the period 1988Q1–1992Q4 and represents the government-driven real wage hikes. The others represent the economic crises in 1944, 2001 and 2008. They cover the periods 1994Q1–1994Q2, 2001Q1–2001Q1 and 2008Q4–2008Q4, respectively.
4. The price indexes are obtained from the IMF's IFS database.
5. The result supports the argument that inflation has a substantially negative impact on productivity in countries with high and chronic inflation, such as Turkey. By the end of the 1990s and the beginning of the 2000s, Turkey had experienced chronic and high inflation that triggered chronic fiscal deficits. The high inflation caused a distortion in price signals and firms' investment plans. In this process, many firms in the manufacturing industry invested in high interest yielding government securities instead of investing in basic research. Consequently, a strong negative link between inflation and productivity has arisen.

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