

Investigation co Integration with Structural Breaks in Inflation, Real Wages and Productivity

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Abstract

This document shows the research of real wages, inflation and labor productivity interrelationships using co integration, Granger-causality and, most of all, and structural break tests. Tests for assessments to variable's over the period of 1973-2007 time corroborate the presence use of a structural break in 1987 and states that a 1 percent improvement in manufacturing sector real wages led to a rise in manufacturing market productivity of between 0.5 and 0.8 percent. Very similar quotes for the result of inflation on manufacturing market productivity have restricted precise significance. Granger causality results recommend that real income and inflation both Granger-cause productivity in the long run.

Introduction

The Relation among the macro variable's i.e. real wages, inflation and productivity can be hypothesized because of many reasons for dependency as Barden stated in 2007. A negative relation between inflation and productivity is in the basics of economics theoretical literature as motivation and effort depends on the individual's purchasing power (real wages). In contrast to that inflation can also bring changes firm future decisions about investment, production techniques, and also the rate of capital depreciation.

There are two main arguments where the relation between real wages and productivity can be hypothesized, first is opportunity cost of job loss which will increase with an increase in the real wages. So worker will put an extra effort to avoid joblessness (an efficiency wage hypothesis) (Jordan, 1987). Most of the economists draws that there is a relationship between real wages and productivity Wake ford, (2004).

Second is that if there is an increase in real wages that will also increase the production cost, and then the firm will obviously substitute labor for capital which reflects a increase in the marginal productivity of labor. Gordon, (1987); added that substitution of labor with capital will give the result of unacceptable increase in real wages.

Hendry,(2001) concluded precisely that an increase in demand for production inputs (labor) will increase the labor cost; which will put an upward pressure on consumer price index, so real wages and inflation are also related.

Evidences and acknowledgments are being presented regards the interrelationships of real wages, inflation and productivity. Most of the former studies conducted; have used co integration technique to check the interrelationships of the variables without having structural breaks that happened along the time. Therefore the results provided may not be efficient for policy making like productivity enhancement and controlling consumer price index. This paper analyzed the interrelationships of relationships of real wages, inflation and productivity with using a set of co integration tests i.e. granger casualty test and structural break test. These tests will be applied to Pakistan data for the period of 1973 to 2007.

The main aim of this paper is to study the empirical relation of real wages and inflation on productivity of Pakistan's economy for the period of 1973 to 2007.

The data has been taken 1973 onwards for some major reasons the first one was the division of Pakistan into west Pakistan (Bangladesh) and today's Pakistan in 1971, the second reason was the era before 1970's Pakistan has a high level of income inequalities according to 1965 statistics only twenty two families has eighty percent of total country's resources under their hands. Pakistan was listed in few of the developing countries to keep 5% of average growth rate for four decades till 1988-89, poverty rate declined by 40 percent from 1947-1990. 1990's was the period where Pakistan has started with downfall in its growth rate, revenues, and GDP. On the other hand an increase in the international debts, inflation rates, and domestic debts happens to be there in democratic era. In the first five years of the president Musharaf military government came up with the structural adjustments that offered with best results of increase in growth rate, stability of the stock market, empowerment of the labor organizations, and increase in revenues of the sales tax. But after the emergence of democratic government into military government in 2003 again turned back the country into crises till 2007 with many other phenomena's involvement in this, the first one the energy crises dropped down in the level of production as well as labor productivity per hour, law and order situation in the state, NATO war in Afghanistan and non stable political situation in and outside the country till 2007.

A broad set of tests will be used to find the empirical results. Johansson, (1988, 1991) vector error correction method (VECM) will be adopted for the parameter estimates of co integration vector and causality between the variables.

Gregory and Hanson's (1996a, 1996b) technique will be used to illustrate co integration relationships

in structural breaks. To confirm the long run estimates we compared results with other time series techniques including (Engle and Granger), autoregressive distributed lag (ARDL) to estimates the consistency and stability of result, structural change test for investigating the long run relationships.

This procedure is done by Kumar, Webber, and Perry for Australia and now it has been applied to Pakistan's economic variables.

Literature review

With the help of given literature on the topic it will not be difficult to analyze the variables empirically. The relationship between real wages, inflation and productivity has got much attention in the economic literature. Variables from a number of economies have been tested, so we are trying to get together the information about their techniques and data sets.

Inflation and productivity

Many evidences from the studies are there to support a negative relation between inflation and productivity (Jaret and Salody,1982; Clark. 1982; and Hendroyianis). The negative relation is there because increase in inflation will decrease the worker's effort and interest. The indirect constraints presented for inflation and productivity are Inflation decreases motivation to work, which make the relative prices ambiguous that results in inefficient investment decisions. That leads to affect the tax decrease for depreciation and causes an increase in the prices of capital by Christopoulos and Tsionas; (2005). Narayan and Smith, (2009) puts some more arguments about negative relation of inflation and productivity, of which some are (1) inefficient combination of production factors, (2) decrease in research and development expenditures (3) increase in product stock to supply it after increase in prices to control prices (buffer stocks).

The Greek manufacturing industries in the period of 1964 to 1980 were examined for inflation and its effect on labor productivity (Bitras and Panas 2001). The results got were an increase in inflation from 1964 - 1972 and 1973-1980 for 16 out of 20 industries have a slowdown in total factor productivity. Negative relation of inflation and productivity was summarized by Tsionas in 2003; for 15 European countries over the period of 1960-1997. Bayesian technique was used that resulted in no co integration, while the VECM technique was given with negative relation between inflation and productivity for most of the countries. The causality test came up bidirectional causality between inflation and productivity for five countries and two countries with unidirectional causality.

Panel co integration method is applied to Western 15 countries for period of (1961-1991) which also implied for long run adverse relation between inflation and productivity for seven out of fifteen countries (Christopoulos and Tsionas, 2005). Relation between inflation and mineral product price were analyzed for causality for mining of Australia, it was observed that there is a long run negative causality relation moves from prices to productivity (Mahadevan and Asafu-adjye, 2005). Karrar hussain (2009) checked inflation and labor productivity for Pakistan over the period of (1960 to 2007), his paper implies a unidirectional negative causality ran from inflation to labor productivity and also bidirectional negative causality. Both are due to changing capital to labor ratio. Me hra, (1993); observed as bidirectional relationship between inflation and product price. He also argued in (1991) that long run increase in inflation has a positive relation with productivity adjusted wages.

Real wages and productivity

The relation between real wages and productivity is positive because higher opportunity cost of the job loss will increase the work incentive and effort from wake ford, 2004. An increase in the real wages will also put an up word pressure on production cost so the firm will change the production technique by substituting labor with capital, which increases the worker's marginal productivity

(Wake ford, 2004). Mora, (2005); examined the relationship of real wages and productivity for twenty years of data and found the similar results with wake ford, 2004; and so did Ehrenburg, 1998).

Ehrenburg, (1998); reviewed the long run partnership between real wages and productivity in the US from 1948-1990 and recognized a extensive run, counter-cyclical partnership between actual income and productiveness once the test position had handled for capital stocks. Their major results suggest that if the public funds stock had remained constant then both actual income and productiveness would have greater. However, using panel co integration methods Mora, (2005) reviewed the unity in wages and productivity for 12 Europe for the amount time 1981-2001 and discovered discounts in the distribution of small income and model labor expenditures, but did not discover identical distribution discounts in productivity or actual wages

Inflation, real wages and productivity

Panel co integration technique has been applied on inflation, real wages and productivity by Narayan and Smyth, (2009); for seven European countries for the period 1960-2004, they found that there is positive statistical relation between real wages and productivity but inflation growth and productivity growth was not

empirically evidenced. 249 united states manufacturing companies were observed by Wohar, (2004) for wages inflation and productivity with time period from 1956 to 1996, he got the conclusion that for long run inflation Granger causes productivity, while in two way Granger causality is their between real wages and productivity. Hall, (1986); and Alexander, (1993); draws that there is a co integration relation between real wages, inflation and productivity in United Kingdom; with the efficiency wage hypothesis i.e. higher real wages motivates productivity. With the 29 manufacturing units over the era from 1980 to 1996 ; Gunay, (2005); in turkey observed relation of inflation, wages and profit margins, results obtained were real wages and inflation are positively related with profit margins.

Empirical concerns

From this overall literature we got the three main points for our paper. The first thing in notice is that many researchers used time series or panel data techniques in their paper with no structural break which leads to misleading results. As the whole world went through many changes in past few decades so did Pakistan, so it is really important to test co integration in the structural breaks. Second is that using of small sample size which obviously affects the efficiency of test. The last one that most of these studies haven't recognized the importance of real wages affects on relation between inflation and productivity. Other than these discussed studies this paper investigates the empirical relation of real wages, inflation and productivity for the 34 years with application of set of tests with explicit test for structural breaks.

Data

Hondroyiannis, Papapetrou,(1997); Strauss, Wohar,(2004); used variables as hourly compensation in the manufacturing sector represents wages which are then deflated by consumer price index to get real wages, consumer price index for inflation, and out per hour in production sector is proxied for productivity. Productivity measures are total output in manufacturing sector (in money terms) in divided by total employment level for the period of 1973 to 2007 for Pakistan.

Methodology

The following linear is used by (HP), 1997 and (SW), 2004 for the same variables, (Real wages, Inflation and Productivity)

$$\ln Y_t = \alpha + \beta_1 \ln W_t + \beta_2 \ln \pi_t + \varepsilon_t$$

In the given equation β_1 and β_2 are the respective elasticity's of wages and inflation on productivity. $\ln y$ Implies productivity, $\ln \pi$ is the natural log for inflation and $\ln w$ represent log of wages, and ε_t is used for error term.

Structural breaks with co integration

The last three decades of 20th century went with some significant changes in the economies of the world so same happened to Pakistan, so it is necessary to test structural breaks in co integrating vector. Gregory and Henson, (1996a and 1996b); are used to find the break dates for the long run relationship among real wages, inflation and productivity. Gregory and Henson proposed four situations for the structural break that are (1) shift of level, (2) shift of level with trend, (3) regime change (with change in slop of coefficients and intercept). VECM technique is used while Vector Auto regressive model (VAR) is at maximum likelihood for this (VECM) technique where null hypothesis; no co integration with structural breaks against co integration with the structural breaks Johansson, 1988 and 1991.

$$\Delta y_t = C + \sum_{i=1}^k \theta_i \Delta y_{t-1} + \pi y_{t-1} + \varepsilon_{1t}$$

Here y_t represents the non stationary level form variables and is a vector of 1(1). C is constant and π shows the coefficient matrix between stock prices. The concerned elements of the metrics are coefficients of adjustments while δ implies co integrating vector. It is important to test the variables for unit root properties, the variables are being considered endogenous, and therefore the confirmation of exogeneity is done with formal tests.

Schwarz Bayesian criteria and Akaike information criterion is used to test the specification of the lags for VAR model. Second step to be followed is test for co integration.

To determine the co integration vectors, trace and value Eigen tests statistics are being proposed by Johanson and Juselius, (1990). These tests are used for restricted/unrestricted intercept, if it's restricted there will be no trend option for VAR, then the third step is measurement of co integration vector.

Estimation of endogeneity and identification test through the different short run adjusted equations.

The null hypothesis of the Granger non causality i.e. the lag of dependent variable's are insignificant with the independent one's that is for exogeneity test. The first difference of each variable is regressed with one period lags whom are normalized with their respective variables to check the identification. If then the error term are significant with the negative signs of their respective variables, identification will be confirmed.

Granger causality

The granger causality can give the result for co integration, but doesn't show the direction of the causality either the variable's are moving in same direction or opposite. Wages inflation and productivity are being arranged in VECM equation and augmented with the one lagged period error correction term by (Engle and Granger, 1987). The VAR estimation at the first difference will give under\over estimated results if the series are integrated with one.

$$\Delta \ln Y_t = \alpha + \sum_{i=1}^n \theta_i \Delta \ln Y_{t-1} + \sum_{i=1}^n k_i \Delta \ln W_{t-1} + \sum_{i=1}^n m_i \Delta \ln \pi_{t-1} + \varphi_1 ECT_{t-1} + \varepsilon_{1t}$$

$$\Delta \ln W_t = \alpha + \sum_{i=1}^n k_i \Delta \ln W_{t-1} + \sum_{i=1}^n \theta_i \Delta \ln Y_{t-1} + \sum_{i=1}^n \mu_i \Delta \ln \pi_{t-1} + \varphi_2 ECT_{t-1} + \varepsilon_{2t}$$

$$\Delta \ln \pi_t = \alpha + \sum_{i=1}^n m_i \Delta \ln \pi_{t-1} + \sum_{i=1}^n \alpha_i \Delta \ln W_{t-1} + \sum_{i=1}^n \omega_i \Delta \ln Y_{t-1} + \varphi_3 ECT_{t-1} + \varepsilon_{3t}$$

ε_{1t} , ε_{2t} and ε_{3t} shows the independent errors. Their means are equal to zero, while covariance is finite. The long run co integrating vector error is being showed by ECT_{t-1} . By regressing the depending variables against their values at their previous time and the other variables we will get the results of causality. SBC is applied to find the lag length "n" and chi square from the causality results i.e. for the rejection of null hypothesis.

Unit root test

The first step followed as we mentioned in methodology is checking of the unit root properties of the data, for that we are first going for augmented dickey fuller test (ADF) cause it has the space for the extra lagged terms that helps eliminating autocorrelation problem. We applied this test using e views software; results are being shown in the Table 1.

In this table CPI represents inflation rate, P is used for productivity and W is used for real wages. Table shows that augmented dickey fuller values are greater that the critical values for each of the variables at level and lag (1) so it is concluded that data is non stationary because of the rejection of null hypothesis i.e. there are unit root properties. Then again testing with the first difference we got that the critical values are greater than ADF-values for each variable. That showed the stationary of the data at its first difference.

Co integration with structural break

To illustrate the long run empirical relationship and structural break date in the co integrating vector Gregory and Hanson, (1996); models are being used. Model (1) level shift, (2) represents trend with level shift, Model (3) intercept and slope of coefficient changes with regime shift and model (4) is for model (3) with trends. The results are being presented in table 2. All these four models are being applied to the data and one year was selected where the ADF value was at maximum. The null hypothesis of co integration was rejected for the first model.

That was level shift, 1987 was selected as endogenously determined break that gives an option of yes in the table for evidence of one co integrating vector. Model implies that there is a long run corresponding relation between real wages inflation and productivity in case of Pakistan. 1987 refers to a changing year of economy for Pakistan. It is important to use sub samples of data for co integration analysis to remove the biasness but as our small sample w are applying it, for monthly bases data we must use subsample in co integration.

Gregory and Hansson, (1996a); method is used for tabulation of the critical values while for unknown breaks we used Engle and granger test.

Long run elasticity's and comprehensive tests

This section includes the long run estimated elasticity's of inflation and real wages on productivity. The GH first model of level shift is applied with EG technique and VECM technique for co integrating to normalize productivity. To compare and confirm our results we used a set of tests, and results are being shown in Table 3. The results of these test shows different relation among the variables among which one is relation of real wages to productivity is significant in all the four results. These entire tests results in rejection of the null hypotheses of no co integration in wages and productivity. Real wage ($\ln W$) elasticity for all tests remains in the range of

0.5 to 0.7, it implies that there if wages are increased by 1 unit, productivity will increase in between the range of 0.5 to 0.7. So we came to the conclusion that there is a positive relation between real wages and productivity. CPI shows the inflation in the Table 3, (lnCPI) shows a negative sign with its test value shows that the relation is negative between inflation and productivity, but that is not significant for all of test results. Researches as usual argue that there is a negative weak relation between inflation and productivity but it has been sought out that the relation is ambiguous. So for Pakistan it can be concluded that inflation has weak negative relation with productivity.

Some other tests were also held to check co integration in the VECM technique. Most favorable lag lengths of VAR were tested with the fourth model that intercept, slope of the coefficient, trend and regime shift. AIC and SBC criterion both came up with lags of two periods their maximums values were 284.239 and 282 so for the second order respectively.

To examine for co integration we used the “unrestricted indentify and no trend option” where the optimum Eigen value and trace test research for null hypothesis that there is no co integration are 21.787 and 38.241 respectively, which are increased than the “95% critical principles 21.120 and 31.540 respectively. For the null that there is one co integrating vector, the corresponding calculated principles (critical principles in the parentheses) are 11.859 (14.880) and 16.459 (17.860) respectively. Therefore, the zero speculation that there is no co integration is rejected but the null that the amount of co integrating vectors is one is not declined. Thus, the co integration success from the “GH” examine corroborate with those from the VECM.

Granger causality

As the earlier results concluded that there is a long run relationship between inflation, real wages and productivity. By applying the Granger causality test in VECM we got the long run estimation as well as the short run. The results are reported in Table 4.

Three equations were presented in methodology for real wages, inflation and productivity. That gives us each of the variables unidirectional causality for the other. In short run Inflation has a no significant statistical effect on productivity, while real wages are positively significant in productivity equation, and productivity is also significant in wages equation at 95 percent level of significance.

The long run estimates for lagged error term ECT_{t-1} at level of significance 95%, and as it has a negative sign in the productivity equation so it shows the same our here. So the whole interpretation came to the conclusion that real wages and inflation causes granger causality for production.

So keeping our objectives mind we get to conclusion that targeted inflation may have a positive impact on output per labor in a year, and policies could well be implicated that an increase in real wages will successfully lead to productivity growth. It could also be used to discourage the production of a specific product that is considered to be socially, religiously essential.

Obviously productivity can be achieved through some other financial and labor sector reforms and it might be the case of the first break 1987. Further studies can confirm the conclusion of structural break.

Conclusion

Real wages, inflation and productivity are the three important macro variables in a country’s economic policy making, as our aim is to provide best results for policy making for productivity growth. These variables are studied empirically in case of Pakistan for the period of 34 years (1973-2007) with structural breaks.

Gregory and Hansen technique is for structural breaks in the co integrated vector that found the structural break date 1987 and level of significance 95%. To confirm the co integration, a set of four tests has been used that includes Engel and granger, vector error correction method, auto regressive distributed lag, all these estimators provide a constant result. Granger causality is applied to check the elasticity’s and causality if real wages and inflation on productivity results shows that there is a bidirectional relationship between real wages and productivity (wage efficiency argument) and (substitution of labor for capital). Results show that one unit increase in real wages will cause 0.5 to 0.7 changes in productivity. While inflation has a negative insignificant relation with productivity, that shows a weak negative relation with productivity. As a whole it is concluded that granger causality moves from real wages and inflation to productivity.

Table 1

“UNIT ROOT TEST”		
“For unit root properties” (at level)		
	ADF-value	Critical value
$\ln CPI$	2.501083	-2.9241
$\ln P$	0.625367	-2.9241
$\ln W$	3.352446	-2.9241
The data on the first difference		
	ADF-value	Critical value
$\ln CPI$	-3.836422	-3.5162
$\ln P$	-3.362987	-2.7382
$\ln W$	-6.349475	-3.4329

Table 2

Model	Break date	GH statistics	Critical value	Evidence of Co integration
(1)	1987	-5.5432	-3.603	Yes
(2)	1987	-2.8741	-3.603	No
(3)	1999	-2.0052	-3.190	No
(4)	2003	-1.6883	-3.190	No

Table 3

	EG	ARDL	VECM	GH
Constant	4.292 (6.88)*	4.763 (5.33)*	-	1.067 (2.06)*
$\ln W$	0.573 (3.41)*	0.695 (3.44)*	0.554 (2.11)*	0.608 (2.95)*
$\ln CPI$	-0.793 (1.87)*	-0.604 (1.80)*	-0.771 (1.12)	-0.586 (1.37)

Table 4

Dependent variables	$\Delta \ln P_t$	$\Delta \ln W_t$	$\Delta \ln CPI_t$	ECM_{t-1}
$\Delta \ln P$	-	0.234 (2.16)*	-0.138 (0.21)	-0.372 (2.66)*
$\Delta \ln W_t$	0.039 (3.52)*	-	-0.749 (1.44)	-
$\Delta \ln CPI_t$	0.015 (0.21)	0.162 (1.54)	-	-

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