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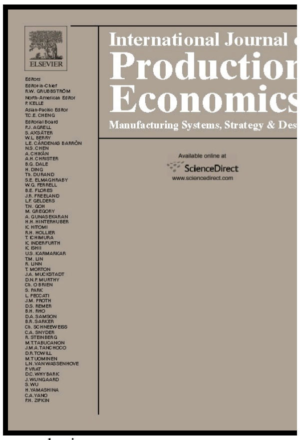

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Output and Labor Productivity in Organized Manufacturing: A Panel Cointegration Analysis for India[1]

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Keywords: labor productivity; real wages; panel unit root tests; cross-sectional dependence and Indian manufacturing

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ABSTRACT

One of the policy puzzles faced in India during the last two and half decades has been the weak association between output and labor markets, particularly in the manufacturing sector. In this research, we investigate the long-run relationship between output, labor productivity and real wages in the case of organized manufacturing. We adjust the measure of labor productivity incorporating bottlenecks, such as lack of infrastructure, access to external finance, and labor regulations, which all may influence labor market outcomes. Using panel data from seventeen manufacturing industries, we establish long-run dynamics for the output-labor productivity-real wages series over a period of nearly three decades. We employ recently developed panel unit root and cointegration tests for cross-sectional dependence to incorporate heterogeneity across industries. Long-run elasticities are generally found to be low for labor productivity compared to real wages due to the changes in manufacturing output. There are variations across industries within the manufacturing sector for the effects of the labor market on manufacturing output. In some industries, lower wages are associated with higher output, and the reason for the positive relationship in other industries could be due to workers' bargaining power.

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1. Introduction

Starting from a low growth rate of 3.5% per annum between 1950 and 1980, the Indian economy grew at a remarkable rate of over 9% per annum since 1991 until recent time. Most industries were highly regulated, subject to licensing and rigid capacity controls. The transition to higher growth rates coincided with 'pro-market' economic reforms initiated in the 1980s. This has gained momentum in the early 1990s since the economic reform programs started. Rodrik and Subramanian (2004) identify the 'attitudinal shift' by government towards pro-business and private sector in 1980s.

Within the manufacturing sector, the 1991 liberalization had a strong unequal effect on productivity growth across industries and states as emphasised by Aghion *et al.* (2003). Ahluwalia (2002) and Unel (2003) report a manufacturing productivity surge in the 1980s. Research by Topalova (2004) and Pattnayak and Thangavelu (2010 and 2014) note an increase in manufacturing productivity particularly after the economic reforms.

On the other hand, Balakrishnan and Pushpangadan (1994), Rao (1996) and Hulten and Srinivasan (1999) establish little evidence of total factor productivity improvement in manufacturing after the reform period. Goldar (1986, 2004) identifies a decline in manufacturing growth in India during the post-reform period. Kathuria and Sen (2013) review the recent literature on total factor productivity in case of India and highlight the differences between the formal and informal sectors in total factor productivity growth.

While the reforms have been primarily focused on increasing manufacturing growth and productivity, growth has so far been service-led as identified in recent studies (e.g. Kochhar *et al.* 2006; Mitra and Ural 2008). Findings from the studies are mixed and varied due to the econometric techniques, time period and data considered in the studies.

Like China, India has potential to be a global manufacturing hub. Rigid labor regulations can be a major barrier to the decision-making process for global sourcing as suggested by Holweg *et al.* (2011). 'Make in India' is a major initiative by the current government, promoting the role of manufacturing sector for development. We explore here the major reasons behind the rather lacklustre performance of the manufacturing sector in India.

The labor market is one of the key channels by which the effects of globalization can influence the productivity differences amongst various industries within organized manufacturing. The organized manufacturing sector, despite its impressive growth in the 1980s and 1990s, failed to expand employment opportunities (see Nagaraj 2000; Kochhar *et al.* 2006 and Panagariya 2008). This has been referred to as 'jobless growth' in literature (Nagaraj 1994, Balhotra, 1998). To quote from a survey on India by the OECD (2007):

"India has a much smaller proportion of employment in enterprises with ten or more employees than any OECD country. The number of workers has also fallen in the manufacturing sector where the share of labor income in value added is low compared to other countries and the capital intensity is relatively high. Such developments indicate that India is not fully exploiting its comparative advantage as a labor-abundant economy."

In spite of its importance in understanding the links between labor and product markets, there has been scant empirical research on the impact of labor market changes on output, productivity, and labor income particularly for developing economies. In the case of India, most of the literature covers only the initial periods of liberalization in the 1980s and early 1990s (see Nagaraj, 2000 for a review).

Besley and Burgess (2004) investigate the effects of labor regulations on manufacturing performance for various Indian states over the period 1958-1992. Their findings show that the states with pro-worker labor laws experienced lower growth in manufacturing output, employment, investment, and productivity during the pre-reform period. In a recent study, Ahsan, and Pagés (2009) identify job security and the cost of labor disputes being the two major elements in reducing registered output and employment.[2] Das and Kalita (2009) analyse the decline in labor intensity in Indian manufacturing using survey data from twenty-two export-oriented manufacturing firms. Weak infrastructure, lack of trained skilled workers and rigid labor regulations are identified as constraints on generating employment. Kathuria *et al.* (2010) indicate that labor productivity has increased for the organized sector over time, but has declined in the unorganized sector during 2000-2001. Bollard *et al.* (2013) report significant improvement in labor productivity in manufacturing, while employment remains more or less stagnant between 1983 and 2007. Plant efficiency is identified as a determinant in productivity improvement instead of factor movement across the sector due to economic reform.

Our overview identifies quite a few studies focusing on manufacturing productivity and assessing the impact of different aspects of labor regulations on economic and social outcomes. However, there is no study integrating labor and product markets together in an industry panel framework.

Over the past two decades, the heterogeneous panels have attracted a great of deal of attention in applied econometrics literature. To our knowledge, Bhattacharya *et al.* (2011) is the only study analysing the effects of wages and employment on labor productivity using industry panel data. Our contribution here is to extend this research and relate this with the product market in a panel of all manufacturing industries in India. In this context, we explore the panels of manufacturing as heterogeneous and cross-sectionally dependent. The linking of product with labor market is important to analyse the indirect effects of labor market outcomes on manufacturing output for a heterogeneous panel of manufacturing industries.[3] The panel-based econometric techniques analyse both time-series and cross-sectional

[2] An excellent survey by Djankov and Ramalho (2009) discusses employment laws and their effects on economic and social outcome for various developing countries including India.
[3] Most of the reform programs are related to organized (formal) manufacturing. In India, 80% of employment occurs in unorganized (informal) sector, while only 17% of manufacturing output is from this sector (NCEUS, 2007).

dynamics between labor and product markets, allowing for more reliable statistical inferences for heterogeneous industries.

Our contribution in this research is three fold. First, we estimate adjusted labor productivity netting out the role of labor regulation, infrastructure, and access to external finance, which can hinder labor productivity for each industry panel and use this measure in our final model for estimation purposes. Second, we establish the long-run dynamics between output, adjusted labor productivity and real wage. The labor market might have differential effects across industries, and their effects might be more beneficial among sectors with a higher dispersion of within-industry shocks. For this purpose, we use panel tests with cross-sectional dependence. Third, given the heterogeneity across the panel of industries, we find elasticity values are less than one for the adjusted labor productivity measure with respect to output, while elasticity values for real wages are greater than one for some industries. Both estimates are inelastic for the overall panel.

The remainder of the paper is organized as follows. Section 2 presents a brief overview of manufacturing output growth while identifying the constraints. Section 3 describes our empirical model and data sources. Section 4 explains the econometrics steps we follow and the empirical findings. The final section summarizes the major findings with indicative policy implications.

2. Constraints on Indian Manufacturing Output Growth: A Brief Overview

2.1. Labor regulations, labor productivity and real wages

The Indian labor market is complex and characterized by an array of institutional arrangements, incentives, and disincentives both from employer and employees' side. Labor regulations created a stringent environment for business, productivity and output of manufacturing. Labor regulations may increase the cost of hiring, for example via minimum wage legislation and compulsory benefits to the workers. Workers in organized manufacturing enjoy bargaining power. The Industrial Disputes Act (1947) is the major piece of framework regulating industrial relations in the organized manufacturing sector. Labor laws were very rigid and labor market institutions have gradually evolved particularly since the mid-1980s. There is large heterogeneity across the states in labor regulations particularly after the reform period.

2.2 Infrastructure, access to external finance and labor productivity

Nadiri and Mamuneas (1994) examine the effects of infrastructure on the cost structure and productivity for U.S. manufacturing industries. The productive effects of infrastructure vary across industries and have a positive effect on labor productivity growth. Poor infrastructure with weak transport, telecommunications, roads and power shortages have created barriers to business investment in case of India. This has been emphasized by Gupta *et al.*(2008).

Firms with high labor productivity are less likely to face credit constraints. Financial development can be associated with 'jobless growth'. Easing financial constraints may allow industries to invest in more capital-intensive technologies. This helps in increasing output but not employment in manufacturing. In addition, the effects of financial development may be different across industries. With access to external finance, job relocation may happen from weak to profitable industries. With inelastic labor supply due to labor regulations, the effect will be more on wages and the labor productivity.

3. Empirical Specification and Data

3.1 Empirical specification

We specify a production function as follows:

$$Y_{it} = f\,(K_{it}, L_{it}) \quad (1)$$

where Y_{it} is real output for industry i is time period t, K_{it} is the capital formation, L_{it} represents the labor employed.

Being a labor abundant economy, manufacturing output is predominantly driven by labor. Moreover, shifts in the production possibility frontier happen primarily due to changes in labor productivity and flexible labor market conditions along with investment in capital and technology.[4] Our empirical data comprises the organized manufacturing. We argue the price of labor (real wages) determines the level of employment (and hence output) in this sector.[5]

Labor productivity is a major influence on the output level particularly after the reform period. To incorporate the role of technology and substitution of capital for labor in organized manufacturing, we include labor productivity as the control variable.[6] This variable reflects the differences in labor productivity between the organized and unorganized manufacturing occurring due to improvement in technology after the reform and capital substitution in the organized sector.

There is much debate in the literature establishing the relationship between real wages and output (hence employment). Despite the apparent simplicity, the relationship between real wages and output has remained inconclusive both theoretically and empirically. Any increase (decrease) in real wages leads to an increase (decrease) in cost of production and

[4] Substitution between capital and labor involves moving along an isoquant, while a shift in isoquants may happen due to changes in capital, technical progress, innovation or combination of all factors. We assume any change in the capital-labor mix is reflected in differences in labor productivity (and in real wages) particularly in organized labor markets.

[5] There is major imbalance of employment and output generation between organized and unorganized manufacturing. Per capita real wages has been stagnant for manufacturing production workers. The Indian reform program did not help in absorbing unskilled workers from unorganized sector. The distortion between product and labor markets is a major concern in Indian reform program and is a source of 'jobless' reform particularly in manufacturing.

[6] It is extremely difficult to find a proper estimate of capital consumption for our data set. An increase in manufacturing output due to an improvement in capital, technology or innovation is assumed to be reflected through improvement in labor productivity. The absence of detailed capital data at the two-digit level leads to this assumption.

hence less (more) manufacturing output (employment). Employment in organized manufacturing witnessed a significant drop due to structural reform in recent years.

In capturing the effects of labor regulation and other control variables which may have effects on labor productivity (*labprod)*, we assume that labour productivity depends on labor regulations (*lr)*, infrastructure (*infra)* and access to external finance (*fin*).

$$labprod_{it} = g(lr_{it}, infra_{it}, fin_{it}) + e_{it} \quad (2)$$

where e_{it} is error term. From the estimation of equation (2), we retrieve the labor productivity for each industry and use this adjusted labor productivity (*adj_labprod*) as a control variable over our time period in estimating output. This adjusted measure of labor productivity nets out effects that labor regulations, infrastructure and external finance have in influencing labor productivity.

Our final equation for output is as follows:

$$output_{it} = h(adj\_labprod_{it} , realwage_{it}) \quad (3)$$

For empirical purposes, we consider the logarithmic (natural) version of equation (3)

$$\ln output_{it} = \gamma_{0i} + \gamma_{1i} \ln adj\_labprod_{it} + \gamma_{2i} \ln realwage_{it} + \eta_{it} \quad (4)$$

where, η_{it} is an error term. γ_{1i} , γ_{2i} are the elasticity of adjusted labor productivity and real wage with respect to output for each industry. For estimation purposes, we consider equation (4) as a long-run equilibrium relationship.

3.2 Data

The present study uses annual data from 1973-74 to 2000-2001. The data are collected from Annual Survey of Industries (ASI, published by the Central Statistical Organization). The ASI considers only registered manufacturing sectors. The manufacturing industries are classified into 17 sectors at the two-digit industrial classification level.[7] For the period of the study, two National Industrial Classification (NIC) codes have been used for data collection.[8]

Following Goldar (1986), we consider gross value added as an index of output instead of net value added, as depreciation charges in Indian industries are known to be highly arbitrary. This is determined by the income tax authorities, and seldom represents actual consumption. To convert nominal gross value added to real, the yearly current value has been deflated (single deflation) by the wholesale price index (WPI).[9] The data on the WPI have been collected from the Handbook of Statistics on the Indian Economy. The sector-specific WPI has been employed for the corresponding manufacturing industry. In the case of textile, machinery and equipment, and other manufacturing industries where sector WPIs are not available, the WPI for aggregate manufactured products has been used as a proxy.

Labor productivity is defined as real gross value added per employee. Employment is defined as the total employees of an industry. Similarly, real wage is defined as money wage deflated by the consumer price index (CPI) for industrial workers (base 1982-83 = 100). The money wage is estimated as the ratio of nominal wages to the number of workers in an industry.

[7] The ASI consists of 26 sectors at two-digit classification and 19 sectors in manufacturing, i.e., code 20 to 38. We have established that codes 20-21 and 35-36 are the same by definition, which leaves us with 17 manufacturing sectors.
[8] The details of NIC codes (1987 and 1998) of the industries covered in this study can be obtained from the authors.
[9] Goldar (1986) explains that the use of single deflation method based on product prices for estimation of real value added may not be appropriate. Due to the difficulty of compiling a materials price index needed for the double deflation method, most of the studies in the literature employ a single deflation method. In assuming the single deflation method, we assume the price of material inputs does not change relative to output.

We construct an adjusted measure of labor productivity considering the effects of labor regulations, infrastructure, and access to external finance, on labor productivity. For this purpose, we rely on classifying the industries following the findings from Gupta *et al.* (2008). In this research, they calculate the dependence of each industry on infrastructure, on external finance and labor-intensity in measuring the performance of industries. Following the same procedure, we estimate the differences in labor productivity across industries considering these bottlenecks. This adjusted measure of labor productivity (*adj_labprod*) is calculated from estimates of equation (2) as discussed earlier.[10]

4. Model Estimation and Empirical Findings

To start with, we use the Generalised Least Square (GLS) estimation techniques in estimating Equation (2). The effects of infrastructure, access to external finance and labor regulation (reflected through labor-capital mix) on labor productivity are found to be significant for the panel.[11]

In estimating the final version of our model in Equation (4), we apply recent panel econometric techniques. These techniques improve the statistical reliability of our tests by incorporating cross-industry heterogeneity and cross-industry dependence. For heterogeneous industries, assuming cross-sectional independence across panels may distort the findings as suggested by Banerjee *et al.* (2004) and others.

Breitung and Pesaran (2008) review the unit root tests and cointegration test in the context of panel data. To estimate Equation (4) as a panel cointegration model, we first check the non-stationarity of the variables with panel unit root tests. In this context, we consider both first and second generation panel unit root tests.

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[10] In mapping industries with our sample, we use Appendix B1 (Gupta *et al.* 2008, pp 38).

[11] $labprod_{it}$ = 5.891 +8.86lr_{it} +6.814 $infra_{it}$ + 10.45 fin_{it} with *p-values* less than 0.005. We find estimated labor productivity from the equation for each industry and then construct the adjusted productivity variable for use in further estimation.

4.1. Panel unit root tests

The first generation unit root tests (viz. Levin and Lin, 2002, Maddala and Wu, 1999, Im, Pesaran and Shin, 2003) and others assume that the cross sectional units are independent, while the second generation tests viz. Bai and Ng (2004), Phillips and Sul (2003), Pesaran (2007) and others reject this hypothesis and assume that the cross-sectional units are interdependent. Moreover, heterogeneity among the panels needs to be considered here. In this regard, our focus is to consider the stationarity of the variables using the first and second generation panel unit root tests.

Amongst the first generation models, first we consider the Im, Pesaran and Shin (2003) test. This allows heterogeneity of the first order autoregressive parameters, but assumes cross-sectional independence across panels. This test performs well for small sample size.

In addition, we perform an alternative test by Maddala and Wu (1999) from the first generation group. This test combines the *p*-values p_i from unit root test-statistics for each cross-sectional unit. This test performs better results when T is larger than N.[12] In both IPS and MW tests, the null hypothesis assumes the presence of a unit root.

From the second generation group, we perform the Pesaran (2007) test. Pesaran considers an Augmented Dickey-Fuller model by introducing a cross-section average of lagged levels and first-differences of individual panel. With average individual statistics, he develops a panel root t-statistic defined as cross sectional augmented IPS (CIPS). This test considers both heterogeneity and cross-sectional dependence across panels. Table 1 presents the findings from both the first and second generation panel unit root tests. All unit root tests support non-stationarity under the null hypothesis.

[12] The detail discussion on various panel unit root tests is not considered here to conserve the space.

Insert Table 1 near here

4.2. Panel cointegration tests

In establishing long-run relationship among variables, we use Kao (1999) and Pedroni (2004) panel cointegration tests. Table 2 shows the outcomes of cointegration tests for our model. Kao (1999) presents Dickey Fuller and Augmented Dickey Fuller types of cointegration tests in the panel data. In each case, the test statistic rejects the null hypothesis of no cointegration.

Following Pedroni (2004), we use four within-group tests and three between-group tests to check whether the panel data are cointegrated. For all seven tests, test-statistics show that the null hypothesis of no cointegration can be rejected at the 1% significance level. Therefore, the output, labor productivity and real wage variables have long-run associations for our sample period. This leads us to conclude that the variables we consider both from the product and labor markets series are cointegrated for the panel of 17 manufacturing industries and share a long-run equilibrium relationship.

Along with Kao (1999) and Pedroni (2004), we use the four panel cointegration tests by Westerlund (2007). These tests have good small-sample properties and high power relative to popular residual-based panel cointegration tests. We consider asymptotic *p*-values for inference purposes. The G_t and G_a test statistics consider the null hypothesis of no cointegration for all cross-sectional industries against the alternative that there is cointegration for at least one cross-sectional industry. Rejection of the null implies evidence of cointegration of at least one cross-sectional industry. The P_t and P_a test statistics pool information over all the cross-sectional industries in testing the null of no cointegration against the alternative of cointegration for all cross-sectional industries. Rejection of null implies that there is evidence of cointegration for the panel as a whole.

The computed values of the Westerlund (2007) panel cointegration statistics are presented in Table 3. Using asymptotic *p*-values, the no cointegration null is rejected at the

1% level of significance. Rejection of null hypothesis implies variables are cointegrated at least for one panel and for all panels of the industries.

Insert Tables 2 and 3 near here

4.3. Test for cross-sectional independence

We check cross-sectional dependence (CD) using the Pesaran (2004) CD test. This test is based on the average of pair-wise correlation coefficients of the ordinary least squares (OLS) residuals from the individual regressions for panel, and is used to test for cross-section dependence where no priori ordering of the cross-section units is assumed. The CD test statistic for all variables rejects the null hypothesis of no cross-sectional dependence at least at the 1% level of significance.

We check these findings using two additional tests by Frees (1995) and Friedman (1997). Both the Frees and Friedman tests reject the null of cross-sectional independence.[13] Thus, we conclude that our 17 panels of manufacturing industries are cross-sectionally dependent.

Insert Table 4 near here

4.4. Panel long-run estimation

Heterogeneity and persistence in short-run dynamics can create substantial variability in single-equation cointegration vector point estimates. These estimators can be quite sensitive to the particular time span of the observations and to the particular industry (cross-sectional unit here) being studied. This small sample fragility can be encountered in spite of the super consistency of these estimators.

[13] Frees' test statistic for cross sectional independence is 0.249. This is greater than 0.172 at the 1% level of significance. Freedman's test statistic for cross-sectional independence is 73.865, with a *p*-value of 0.000.

Panel DOLS can provide more precise estimates and is straightforward to compute. The relevant test statistics have standard asymptotic distributions. In examining the finite-sample properties for the OLS, fully modified OLS (FMOLS) and DOLS, Kao and Chiang (2000) establish the DOLS to be superior method compared to the OLS and FMOLS techniques. We apply the panel DOLS method to estimate the long-run output function using a panel of 17 industries for the considered time span. The DOLS parameter estimates for each industry and the fixed effect panel DOLS estimates are reported in Table 5.

The estimates of elasticities with respect to output of *adj_labprod* and *realwage* are reported for each of the 17 industries in last two columns of the Table 5 along with their respective *t*-statistic. We also present the findings for the panel of 17 industries in the last row for these two series.

Insert Table 5 near here

We find that for 5 out of 17 industries *realwage* variable is negatively related to *output*. These are Food, Paper, Rubber, Metal and Machinery. Only for Food and Rubber, the findings are statistically significant and the elasticity value is greater than 1, suggesting that an increase in *realwage* variable reduces *output* more than proportionately. For 12 out of 17 industries the *realwage* variable has a positive sign. However, only 4 industries (viz. Wool, Jute, Chemical and Transport) have significant positive elasticity for *realwage* variable on *output*. Estimates of wage elasticity to output vary between 1.45 and 7.46. The higher values of elasticity can be due to the differences in skills, and heterogeneity across manufacturing.[14] Meanwhile, for the panel of 17 industries the *realwage* variable is found to be statistically significant with a positive value of 0.128.

We find that *adj_labprod* is positively related to output for 12 out of 17 industries, and the findings are statistically significant for 4 industries. These are Textile, Chemical, Mineral and Basic Metal. Estimates of labor productivity elasticity to output vary between 0.01 and 0.556. For the panel as a whole, we find that a 1% increase in *adj_labprod* increases *output* by 0.006% and this result is statistically significant at the 1% level.

In summary, our findings from the industry panel suggest both *adj_labprod* and *realwage* variables have a long-run influence in generating manufacturing output and employment. However, our findings are mixed across industries. This suggests that the mechanisms that link labor productivity and real wages to output and employment are complex with dependence on the specific circumstances of the industry. Market power and labor regulations are likely influences, but these influences need to be considered for each industry individually.

5. Conclusion and Policy Implications

The Indian government has been undertaking policy reforms since 1980. Enhancing the efficiency and international competitiveness of manufacturing industries are amongst the primary objectives. Unlike the East-Asian countries, Indian reform has not substantially shifted labor from agriculture into the manufacturing sector. The process of structural adjustment is slow.

We posit a simple model in analysing manufacturing output and in doing so we attempt to establish long-run dynamics between product and the labor market. We use relatively new econometric panel techniques in establishing the long-run dynamics between

[14] Inter-industry differences in real wages are a source of involuntary unemployment and lower output (Krueger and Summers ,1987).

these variables across our panel of heterogeneous industries. In this respect, our findings are robust. Long-run dynamics is established among output, real wages and labor productivity. We establish cross-sectional dependence across the heterogeneous panel of industries. Policy reforms in the economy, specifically in the labor market (as an exogenous shock) will have varying effects across the heterogeneous panel; and the effects are interdependent across industries.

In the recent history of the manufacturing sector in India, various economic reforms eased the bottlenecks to the supply of essential inputs, which had been responsible for the low utilization of capacity for a long time. For organized manufacturing, firms have shifted to a more capital-intensive technology with fewer workers. Contracting and sub-contracting are more common for the post-reform period, reducing employment in formal manufacturing. In a recent survey, Kotwal *et al.* (2011) identify poor infrastructure, restrictive labor laws and small-scale production as barriers to manufacturing exports. We consider some of these bottlenecks from the literature which may affect labor productivity and use these in establishing an adjusted labor productivity measure in analyzing output growth. Long-run elasticities of the adjusted labor productivity measure with respect to output are found to be low for most of the industries and for the overall panel. Compared to the labor productivity, elasticities for real wages are relatively high with respect to output in most industries.

From a policy viewpoint, our findings indicate that there is a need to remove the bottlenecks in infrastructure and finance in order to increase labor productivity and overall manufacturing output. In this respect, we emphasise fixing infrastructure bottlenecks, access to external finance and flexible labor regulations are necessary along with other factors as suggested in the literature. The mechanism linking labor productivity-real wages-output is complex and depends on the specific nature of the industry.

On a final note we emphasise, the effect of labor market outcome on output is a complex process, disentangling the exact mechanisms by which firms improve their labor productivity remains a challenge for researchers due to non-availability of data for a longer time period. Exploring the dynamics is important in understanding the entire adjustment processes that firms within industries follow in response to changes in the labor market environment. We expect future research in this area will expand along this direction subject to the availability of the data.

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Table 1: Panel Unit Root Tests

	Im-Pesaran-Shin (2003) test		Maddala and Wu (1999) test		Pesaran (2007) CIPS test	
Variables	t-statistic	p- value	χ^2-statistic	p- value	t-statistic	p- value
output (level)	-6.251	0.000	606.550	0.000	-17.348	0.000
output (first difference)	-3.447	0.000	191.125	0.000	-9.310	0.000
adj_labprod (level)	-6.581	0.000	646.088	0.000	-16.588	0.000
adj_labprod (first difference)	-1.932	0.050	452.677	0.000	-12.145	0.000
realwage (level)	-5.797	0.000	498.143	0.000	-17.458	0.000
realwage (first difference)	-2.794	0.002	192.635	0.000	-8.388	0.000

Note: All variables are measured in natural logarithm. The *p*-values are the probabilities of rejecting the null of no unit root. The Im-Pesaran-Shin and Maddala and Wu tests assume cross-sectional independence, whereas the Pesaran test allows for cross-sectional dependence. The Akaike information criterion (AIC) is used in selecting the lag lengths.

Table 2: Panel Cointegration Tests

	test-statistic	*p*-value
Kao (1999)		
ADF t-statistic	-2.335	0.009
Pedroni (1999)		
panel v-statistics	6.276***	0.000
panel rho-statistics	-13.443***	0.000
panel pp-statistics	-16.882***	0.000
panel adf-statistics	16.836***	0.000
group rho-statistics	-11.738***	0.000
group pp-statistics	-24.209***	0.000
group adf-statistics	-19.545***	0.000

Note: ***, **, *, indicates 1%, 5% and 10% level of significance respectively. The critical value at 1% level of significance for panel v-stat = 2.33; while the 1% critical value for the rest of the tests is -2.33.

Table 3: Panel Cointegration Test: Westerlund (2007)

	adj_labprod		*realwage*	
	value	*p*-value	Value	*p*-value
G_t	-3.789	0.000	-4.381	0.000
G_a	-35.090	0.003	-24.474	0.000
P_t	-12.583	0.000	-15.699	0.000
P_a	-27.112	0.000	-28.479	0.004

Note: The Westerlund (2007) tests assume no cointegration for null hypothesis. The test regression is fitted with a constant and one lead and lag. The kernel bandwidth is considered according to the rule 4 $(T/100)^{2/9}$. The *p*-values are for a one-tailed test based on the normal distribution.

Table 4: Cross-Sectional Independence Test: Pesaran (2004)

	CD-test	*p*-value	Absolute value of correlation
output	9.13	0.000	0.193
adj_labprod	50.05	0.000	0.811
realwage	-0.88	0.000	0.408

Notes: The null hypothesis assumes presence of cross-sectional independence.

Table 5: Panel DOLS Long-run Elasticity Estimates for Individual Industries and Overall Panel

Industries	*Leads and lags*	*adj_labprod*	*Realwage*
Food	2	0.556***	-1.1694**
		(2.764)	(1.936)
Beverage	2	0.008	0.721
		(0.593)	(0.676)
Cotton	2	-0.004	1.982
		(0.291)	(0.772)
Wool	2	0.011	2.56***
		(1.501)	(2.627)
Jute	2	0.047	7.466**
		(1.637)	(2.684)
Textile	2	0.032*	2.223**
		(1.686)	(2.541)
Wood	2	-0.010	0.087
		(1.205)	(0.204)
Paper	2	0.0009	-0.061
		(0.070)	(0.081)
Leather	2	0.014	0.767
		(1.34)	(1.268)
Chemical	2	0.010*	1.451*
		(1.678)	(1.854)
Rubber	2	-0.082***	-8.014**
		(3.636)	(2.344)
Mineral	2	0.04**	1.815
		(2.658)	(0.847)
Basic metal	2	0.033**	0.140
		(2.306)	(0.220)
Metal	2	0.004	-0.648
		(0.435)	(0.572)
Machinery	2	0.007	-0.556
		(1.136)	(0.491)
Transport	2	-0.028	3.722***
		(1.337)	(3.141)
Other	2	-0.027**	1.627
		(2.205)	(0.980)
Panel estimates	2	0.006**	0.128**
		(2.215)	(1.864)

Notes: *, **, *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. *t*-statistics are in parentheses.