Wage-Productivity Relationship

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- Decomposition of value added growth in terms of employment growth and productivity growth is carried out to delineate the contribution of labour to value added growth vis-à-vis the capital intensive technology.

- Only a handful of industries are seen to have experienced a rapid productivity growth of at least 5 per cent per annum and employment growth of at least 4 per cent per annum simultaneously
- Though there is no huge trade-off (in terms of a negative correlation) between productivity growth and employment growth across industries, the positive correlation across industries is highly negligible, i.e., 0.08.
- In other words, capital intensive technology has been adopted in several industries, leading to a rapid value added growth and labour productivity growth. This is also reflected in the growth in capital-labour ratio across various groups that witnessed a growth rate of more than 4 per cent per annum

- The correlation between the average growth in workers' productivity and wages is again negligible

list the industry codes which registered a rapid growth rates in workers' productivity (value added per worker, at least 5 per cent per annum), worker (at least 4 per cent per annum) and wages (at least 2 per cent per annum). The following observations are pertinent:

- Only 182 (Dressing and dyeing of fur etc), 332 (Manufacture of optical instruments etc), 372 (Recycling of non-metal waste and scrap) and 'others' show a rapid growth in terms of all the three characteristics simultaneously
- Industries in which rapid growth took place simultaneously in terms of worker (at least 4 per cent per annum) and wage per worker (at least 2 per cent per annum) include 172 (Manufacture of other textiles), 181 (Manufacture of wearing apparel), 353 (Manufacture of aircraft and spacecraft), 369 (Manufacturing n.e.c.) and 371 (Recycling of metal waste and scrap).
- However, the correlation between the growth rate in workers and that in the wage rate per worker is not negligible (0.54).

Panel Data
Rapid Growth in the number of Workers, Productivity and Wages per Worker

Industry Group	Rapid Growth of Workers, Productivity and Wage	Rapid Growth of Workers and Productivity	Rapid Growth of Workers and Wages
20-21	HAR(1), KER(2)	AP(2), GUJ(2), PUN(1)	
22	MP(1)	BH(1), PUN(1) RAJ(2)	
23		OR(1), TN(1)	
24		GUJ(1),KAR(2),MP(1),MP(2), PUN(1), RAJ(1), TN(2)	
25		KER(1), MH(1)	GUJ(2), RAJ(1)
26	GUJ(1)	AP(1), AP(2), KAR(1), MP(2), TN(1)	AP(2), KAR(2), OR(1), PUN(1), RAJ(2)
27	UP(1)	BH(1)	BH(2)
28	PUN(1)	MH(2), UP(2)	
29	AP(1)	KAR(1), MP(1), PUN(1), PUN(2), UP(1)	MH(1)
30	RAJ(2)	AP(2), GUJ(1), GUJ(2), ALL-INDIA(2)	HAR(2)
31	AP(1), KAR(1), MP(1), MP(2), OR(2), PUN(1), UP(1)	GUJ(2), OR(1)	RAJ(1)
32	PUN(1)	MP(1), RAJ(1)	
33	MP(2)	AP(1), GUJ(2), TN(2)	
34	AP(1), BH(1), MP(1)	HAR(2), MP(2), TN(2)	OR(1)
35-36		HAR(2), RAJ(2), UP(1)	
37	HAR(2), PUN(1)	GUJ(2), HAR(1), UP(2)	AP(2)
38	BH(1), GUJ(2), MP(1), MP(2), RAJ(1)	AP(2), GUJ(1), MH(2), RAJ(2), ALL-INDIA(2)	UP(1)
TOTAL-ASI		AP(2), PUN(1)	

Employment Elasticity

Functional Specifications

- **LEMP = f (LVA, Ln EML)**
- **LEMP = f (LVA, Ln EML, LMANE)**
- **LWORK = f (LVA, LWAG)**
- **LEMP = f (LVA, LWAG, LMANW)**
  - L stands for natural log
  - EMP for employees
  - WORK for workers
  - VA for value added,
  - EML for emoluments per employee,
  - WAG for wage per worker,
  - MANE for man days per employee
  - MANW for man days per worker.

- Given the man days per worker and wages per worker, increase in value added is expected to raise the labour demand.
- However, with adoption of capital-intensive technology rise in employment may not be significant.
- On the other hand, given the value added and wages per worker, any rise in the number of man days per worker may actually reduce the number of workers.

Methodology

- The **slope dummy** with respect to value added has been introduced for the years, 1991-92 to 1997-98, to examine if the reforms changed the employment elasticity of growth.

- This equation has been estimated for each of the **industry groups** including the aggregate ASI sector, based on the panel data across fourteen major states

- **Three models** – classical regression, fixed effect and random effect –have been estimated and based on the Lagrange multiplier and Hausman test statistics the appropriateness of the model has been chosen.

Results on Employment Elasticity

- **Gross value added is an important determinant of employment across all the two digit industry groups and at the aggregate ASI level too.**

Employment Elasticity

- Estimates are indicative of a change in the employment elasticity of growth during the nineties compared to the eighties except the following:
  - 27 (wood), 28 (paper), 29 (leather), 32 (non-metallic minerals), 33 (basic metal), 34 (metal products), 37 (transport equipment), 38 (other) and the aggregate ASI

- Only in the case of 23 (cotton), 24 (wool, silk etc.) and 25 (jute) the employment elasticity declined in the reform period

- In the rest of the industry groups it showed signs of improvement compared to the eighties.

Results on Employment Elasticity

- However, the **extent of change is only nominal** and in general the employment elasticity of growth turns out to be much below unity:
  - only in 25 (jute) and 26 (textile products) the employment elasticity has been above 0.7 and 0.6 respectively whereas at the aggregate level it turns out to be only around 0.35.

- By and large **similar patterns are noted** when we estimated the employment function by replacing the employees by workers.

Wage-Productivity Nexus

Functional Specification

- **LWAG=F(LGVEM, DLGVEM, LCAPEM, LMANW)**
- **LnWAG = G(LnGVEM, DLnGVEM, LnCAPEM)**
  - L is the log transformation
  - WAG is the wage per worker
  - GVEM is gross value added per employee
  - CAPEM is capital per employee.

- **Wage per worker is taken as a function of productivity and capital-employee ratio.**

- **To allow for the change in the effect of productivity on wage in the nineties relative to eighties the slope dummy DLGVEM has been introduced.**

Wage-Productivity …

- **Higher levels of productivity are likely to raise the wages**, as part of the productivity gains may be transferred to the workers.

- The **sources of productivity rise** are rise in capital intensity, technological change or improved organization efficiency (see Tendulkar, 2000).

Capital- Labour ratio and Wages

- If higher levels of capital-labour ratio are indicative of a mere rise in capital intensity and not technological improvement, this may reduce labour demand and thus wages.

- However, if higher levels of capital-labour ratio are indicative of higher levels of technology, suggesting improved performance of labour, wages may then actually increase.

Alternative Specification

In an alternative specification man days per worker (LMANW) introduced

- Hypothesis : With a rise in the man days per worker wage per worker would go up.

Part time or piece rate basis

- higher levels of man days per worker would mean more work opportunities and hence, earnings are expected to increase.
  - In the context of labour market reforms this variable is expected to be of great importance.

Full- Time workers

- The provision for over-time remuneration would cause a positive effect of man days per worker on wages per worker.
  - Only when for the full time workers there exists no scope for over-time payment, rise in man days per worker cannot make any impact on wage per worker.
  - If full-time workers are under-utilized, strict work conditions in terms of more intensive utilization of work force may also raise the man days per worker, but this will not enhance earnings.
  - On the other hand, when full-time workers are utilized to the full extent, man days per worker can have scope for over-time payment.

Results on Wage-Productivity

- **Productivity** is a significant determinant of wage per worker across almost all the two digit industry groups.

- The **partial elasticity of wage** with respect to productivity at the aggregate ASI level turns out to be 0.27 and 0.19,suggesting that only a small fraction of productivity gains are transferred to workers in terms of wage benefits.

- Except 24 (wool), 25 (jute), 26 (textile products) and 33 (basic metals) in the rest of the industry groups **the effect of productivity on wage rose in the reform period** compared to the pre-reform period, as the coefficient of the slope dummy turns out to be significant.

- However, the magnitude of rise is only nominal. At the aggregate level, for example, it increased by 0.008 point.

The effect of capital-emp. ratio

Mixed picture

- It raised wages in a number of industries while it affected wages adversely or remained insignificant in some other, consequently showing an insignificant effect on wages at the aggregate level.
- the capital-employee ratio reveals a positive effect on wages in the following industry groups
  - 20-21(food), 22 (beverages), 24 (wool), 27 (wood), 28 (paper), 31 (rubber), 32 (non-metallic mineral), 34 (metal), 35-36 (machinery), 37 (transport)
- Only in 23 (cotton) the effect is seen to be negative and in 26 (textile) and 33 (basic metal) it is positive when man days per worker is included; otherwise it turns out to be negative with the exclusion of this variable.
- In the rest of the industry groups the effect is statistically insignificant.

Overall

- In a large number of industry groups capital-labour ratio tends to raise wages indicating improved performance of labour with higher levels of capital per head.
- However, in most of the cases the elasticity of wage with respect to capital-labour ratio turns out to be extremely low except 24 (wool) and 35-36 (machinery)

The Effect of Man-days per Worker

- Finally, man days per worker is an important determinant of wage in most of the industry groups (except 32 (non-metalic mineral) and 34 (metal)

- Interestingly the elasticity of wage with respect to man days appears to be around unity except 28 (paper), 29 (leather), 35-36 (machinery) and 38 (other).

- This confirms our hypothesis that man days per worker being a significant determinant of earnings the **decline in the rate of growth of wages in the nineties relative to the eighties could be an outcome of the decline in the rate of growth of man days per worker**, which virtually had been stagnant in the nineties.

- Unorganised manufacturing

- the establishments are more productive than the own account enterprises.
- Rural: within the establishments the trade and services sector are more productive.
- Urban: the trade sector is the most productive one followed by the services sector.
- Contrary to expectation:
- more dynamism – emergence of new activities -in the unorganised component of trade and services while unorganised manufacturing is stagnating

- **Employment Elasticity**
- **The employment elasticity defined as the responsiveness of employment with respect to value added is highest (almost unity) in the establishments in unorganised manufacturing compared to trade and services.**
- **Usually these activities are believed to be more labour intensive compared to manufacturing.**
- **Hence, this finding comes as a surprise. Perhaps the unorganised manufacturing constitutes redundant labour to a large extent.**

- Wage Elasticity
- The elasticity of employment with respect to wage per worker is negative which is as per common logic.
- In manufacturing and services the elasticity is nearly half implying a strong effect of wage rate on employment.
- On the other hand, the wage rate in the unorganised sector is much lower than its organised sector counterpart (Goldar et al 2011).
- Besides, the labour market laws are not applicable to the unorganised sector workers as they are by and large informally employed.
- In such a situation greater impact of changes in wage rate on employment holds because of the adoption of labour intensive technology and labour cost being the major component of the total cost.
- As a policy conclusion, though employment can be increased through wage reduction it can affect the wellbeing of the workers as the wage rate in the unorganised sector is already very low.

State Dummies

- We observe that most of the state dummies are statistically insignificant in the employment function, indicating that each state does not have a different profile of employment being governed by state specific factors. Particularly in the case of services more uniformity across space is perceived compared to manufacturing.

Contractualisation:

- **contractualisation does not seem to be contributing to employment generation in the establishments in manufacturing or trade activities.**
- **We may, therefore, infer that not necessarily faster industrialisation leads to ancillarisation and growth in productive employment in the small units as usually believed in the literature.**
- **The growth in petty activities could be due to sluggish employment prospects in the high productivity sector even in the so called advanced states.**
- **Capital intensive technology restricts the employment growth even when rapid industrialisation follows, which in turn leads to expansion in residual type absorption.**
- **However, services reveal a positive impact, indicating that large units get their work done by the small units in the unorganised sector.**
- **In fact, several new services have emerged in the recent years as Rakshit (2007) points out, corresponding to which large firms actually contract out work to the small firms.**

- Wage Function
- The elasticity of formal wage with respect to productivity is around half both in the manufacturing and trade activities. And in the services it is even more.
- Corresponding to the informal wage function the findings are somewhat different.
- The elasticity with respect to productivity is around 0.5 in trade and services whereas in the manufacturing it is even more.
- These estimates are very much on the high side compared to the organised manufacturing in which the responsiveness of wage to productivity is around one fifth only (Mitra, 2006b).
- However, productivity levels are much lower in the unorganised sector than the organised sector due to the use of labour intensive technology (Goldar et al 2011).
- Hence, higher wage productivity nexus does not necessarily mean better levels of living for the unorganized sector workers.
- Further, from a different angle greater transfer of productivity to workers also means lower investible resources available with the entrepreneurs in the unorganized sector.
- Higher wage share or equivalently higher wage rate to productivity ratio implies greater inefficiency.

- The most interesting point relates to the contract dummy. As regards the formal wage rate, contract tends to raise it. On the other hand, on the informal wage rate its impact is positive only in trade activity.
- The asset of the worker is a strong determinant of the informal wage rate possibly indicating that work consignments are delivered largely to those who have certain resources to pursue them.
- Hence, state support for asset creation is crucial for bringing in improvement in livelihood.

- The area dummy has a positive effect on the informal wage rate (1 for rural areas and 0 for the urban areas) except in the manufacturing activity, which is surprising indeed.
- Possibly this is because of the reason that the urban areas have the backlog of excess labour supplies partly inflated by the rural to urban migration. On the other hand, reduction in labour supplies particularly for manufacturing activity in the rural areas could be due to active participation of the rural population in NREGA (National Rural Employment Guaranty Act).

Technology Import and Employment in Industry

- The proponents of the liberalisation argument suggest that given the abundant supplies of labour in developing countries, trade liberalisation encourages producers to reallocate output toward labour-intensive goods, thus resulting in a rise in employment and/or wages.

- Ghose (2000) noted that the employment effects of trade in manufactures with industrialized countries are potentially positive and large in developing countries.

- Though the early liberalizers (East Asia) conformed to this experience, evidence from the study by Robbins (1996) and Wood (1997) does not support associations between trade liberalisation and large improvements in prospects for the typical worker.

- One of the reasons: the import of new technologies which are increasingly capital intensive and skill-based, result in increased demand for skilled workers and not for the less skilled ones (Wood, 1997)
- Hasan and Mitra (2003) noted that trade is enhancing rapidly the premium to skills in developing countries due to the skill-based production technologies embodied in imported inputs
- Rodrik (1997) further argued that while generating more employment opportunities trade may also diminish the bargaining power of workers, thus resulting in deterioration of working conditions.

- In the backdrop of these studies we propose to assess the impact of technology import and on labour demand

- KILM Data

- Countries with more than 2 per cent growth rate in industrial employment:

  Ghana, Nigeria, Namibia, Nicaragua, Mali, Lao People's Democratic Republic, Argentina, Ethiopia, Uruguay, Cambodia, South Africa, Colombia, Nepal

Turn to UNIDO data

- For the manufacturing sector information on employment, value added, wages and salaries and gross fixed capital formation have been compiled by UNIDO. The INDSTAT4 2007 ISIC Rev.3 database reports time series data for currently 113 countries. From this we picked up the South and East Asian, African and Latin American countries for the period starting from 1990 to 2004.
- The nominal variables are available both in terms of national currency and US dollars. We prefer the later as it would make international comparison easier.

- The time series of nominal variables reflect
- (a) the effect of exchange rate fluctuations,
- (b) price movements in respective countries and
- (c) the real changes, and we need to eliminate the first two effects.
- UNIDO used the average period exchange rates as given in the International Financial Statistics to convert the series in dollar terms. This way the effect of changes in the exchange rate are neutralised.
- As far as the country specific price inflations are concerned we have taken the GDP deflators from the World Development Indicators.

- The employment elasticity with respect to value added has been estimated from the following function,
- ln EMP = a+blnVA+clnW, (EMP is employment, VA real value added and W is real wage rate and Ln for logarithm transformation), for the manufacturing sector in each of the countries
- Employment elasticity estimates (with respect to value added) from the time series data for each country are not highly reliable since the number of observations are often very small.

- among the countries where the estimates are significant, only Brazil, Cambodia, Japan and Madagascar show a high employment elasticity of more than 0.7 or near unity.

- The all-country-pooled data also verifies a moderate employment elasticity of around 0.41 (from Random Effect model).

- Keeping in view the limitations of the econometric estimations employment elasticity has been estimated simply as a ratio of employment growth to value added growth from UNIDO data which again shows that in a number of countries it has been negative, implying movement in value added and employment in opposite directions.

- Only in the case of Mongolia, Japan, Vietnam, Cambodia and Korea the employment elasticity turns out to be on the high side (i.e., around 0.7 or more).

- Value added can be decomposed in terms of employment and labour productivity:

VA = (VA/L)*L,

KILM DATA: Around 40 per cent of the countries, registered a positive growth in both labour productivity and employment.

However the growth rates in both the variables are mostly negligible.

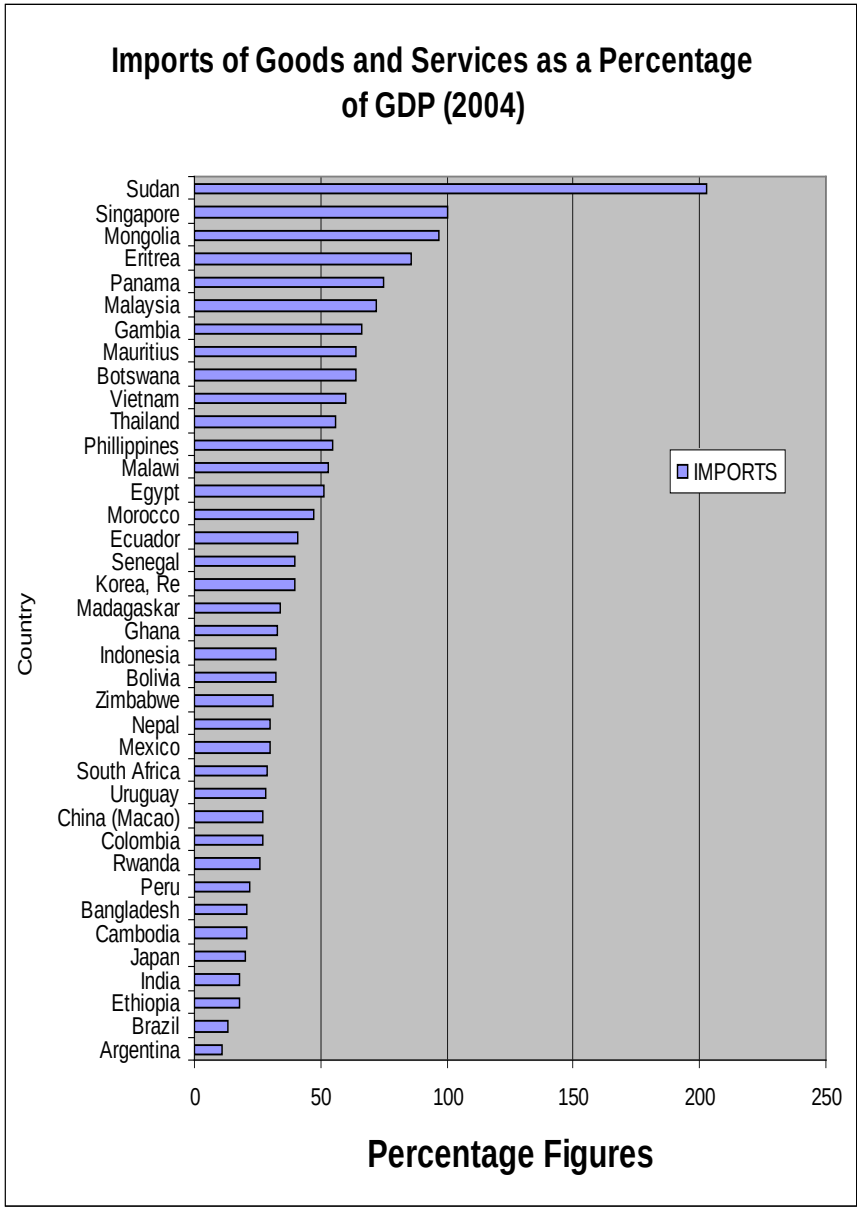
UNIDO DATA: Both employment growth and productivity growth turn out to be positive only in Cambodia, Ecuador, Indonesia, Morocco and Vietnam.

The inverse relationship between productivity growth and employment elasticity is strongly evident across many other countries.

Import of Technology and Employment

- Pack and Todaro 1969 : argued that developing countries import technology from developed countries, resulting in a mismatch between the technological requirements of the former and the available technology.
- UNIDO, 2005: Hence, it is still cheaper for a latecomer to buy the technology already invented by others than to re-invent the wheel though it is widely noted that international technology does not come cheap
- Hasan (2003), Wood (1997) and Robbins (1997), as already mentioned above, did not find any noticeable positive effect of trade reforms on employment though Ghose (2000) noted that the employment effects of trade in manufactures with industrialized countries are potentially positive and large in developing countries.

- further, imported technology may require more skilled workers than unskilled workers while developing countries are usually abundant in the latter.
- Acemoglu and Zilibotti (2001) argue that due to the difference in skill scarcity across countries, technology in developed countries which is skill intensive is indeed inappropriate for developing countries.
- Berman and Machin (2000) show that actually the skill-bias of technological change is occurring, especially in middle-income countries.
- This mismatch between skills requirement of the imported technology and the quality of available labour endowment leaves unskilled workers unemployed.


Imports of Goods and Services as a Percentage of GDP (2004)
Sudan
Singapore
Mongolia
Eritrea
Panama
Malaysia
Gambia
Mauritius
Botswana
Vietnam
Thailand
Phillippines
Malawi
Egypt
Morocco
Ecuador
Senegal
Korea, Re
Madagaskar
Ghana
Indonesia
Bolivia
Zimbabwe
Nepal
Mexico
South Africa
Uruguay
China (Macao)
Colombia
Rwanda
Peru
Bangladesh
Cambodia
Japan
India
Ethiopia
Brazil
Argentina
Country
IMPORTS
0
50
100
150
200
250
Percentage Figures

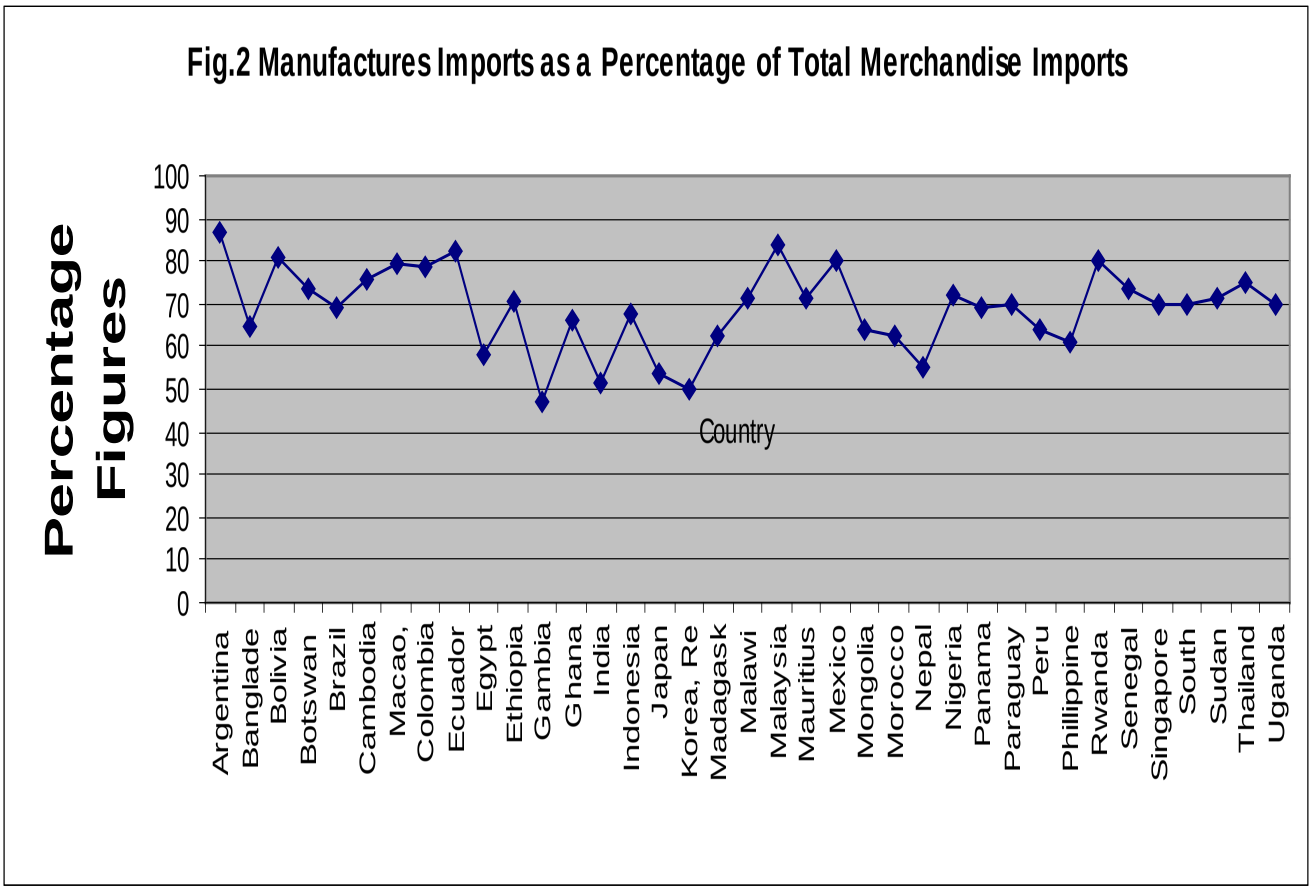


Fig.2 Manufactures Imports as a Percentage of Total Merchandise Imports
Percentage Figures
100
90
80
70
60
50
40
30
20
10
0
Country
Argentina
Banglade
Bolivia
Botswan
Brazil
Cambodia
Macao,
Colombia
Ecuador
Egypt
Ethiopia
Gambia
Ghana
India
Indonesia
Japan
Korea, Re
Madagask
Malawi
Malaysia
Mauritius
Mexico
Mongolia
Morocco
Nepal
Nigeria
Panama
Paraguay
Peru
Phillippine
Rwanda
Senegal
Singapore
South
Sudan
Thailand
Uganda

to test our hypothesis that higher imports of foreign technology reduces labour absorption, we have taken the percentage of manufactures in total merchandise imports (MFGIM) as a broad proxy for import of technology.

The quantum of labour absorption is measured as the labour engaged per unit of real value added (i.e., the ratio of labour to real value added, LPERVA).

The other variables which have been controlled for are the real wage rate per employee (REWAGR) and the real per capita gross domestic product (GDPPC).

Table 7: Panel Data Estimation for Thirty-Six Countries

Dependent Variable: LPERVA

Variable	OLS	FE	RE
REWAGR	-3.09E-07 (-3.80)*	1.09E-08 -0.14	-2.56E-08 (-0.35)
GDPPC	1.91E-07 (2.84)*	-2.29E-08 (-0.20)	-3.87E-08 (-0.49)
MFGIM	-0.00003 (-1.99)*	-0.000064 (-2.75)*	-0.00005 (-2.51)*
Intercept	0.0037 (3.11)*	0.005 (3.34)*	0.005 (3.44)*
R 2	0.13 (F= 8.95)*	0.03	0.06

- The results show distinctly that the percentage of manufactures in total merchandise imports remains statistically significant with a negative sign. This tends to support our hypothesis that with higher imports of technology, labour per unit value of real value added declines.
- The other two variables do not turn out to be significant in the FE or RE model though in the classical regression model they are significant with the right signs.
- With a rise in real wage rate labour demand tends to shrink and with a rise in per capita GDP, implying growth, employment shoots up.

Performance (Technical Efficiency) and Import of Technology

- there is a growing body of literature suggesting low level of skill-base of the work force in the developing countries while the technology imported from abroad is highly skill-intensive in nature.

- In this part of the paper based on cross-sectional data we try to empirically verify this point by examining if technical inefficiency rises in relation to technology import.

- The open economy assumption with free flow of technology across countries is a requirement. In other words, in a globalizing world we assume that invention, transfer and dissemination of technology take place without any time lag, as a result of which countries at different levels of development are able to access the same technology.

- The adverse effects of imported technology on performance are assessed in two steps.
- First, using the concept of frontier production function, we estimate technical efficiency for the aggregate manufacturing sector.
- In the second step, we examine the association between the technical efficiency of the aggregate manufacturing sector on the one hand and on the other, percentage of manufactures in total merchandise imports and per capita income.

Table 8: Value Added Function and Technical Efficiency Equation

Variable	Dep Var. lnVA (MLE Estimates)	Dep. Var. TECHEFF (OLS Estimates)
LnEMP	0.01 (0.03)	
LnGFCF	0.89 (5.23)*	
MFGIM		-0.98 (-2.12)*
GDPPC		-0.0007 (-1.21)
Intercept	4.69 (3.78)*	86.31 (2.64)*
N	30	26
Adj R^2		0.13

- Results suggest that countries with higher import of manufactures in total merchandise imports (MFGIM) are associated with lower technical efficiency.
- This may be taken to interpret that mere availability of technology does not mean better performance. If the available labour resource is poorly skilled it is natural to witness poor performance in terms of technical efficiency.
- Hence, skill up-gradation and training and research and development for technological advancement that suits the labour market conditions of these economies are two important policy conclusions that follow from our analysis.

- On the whole:
-
- Excess growth of the tertiary sector
- Mismatch between the value added composition and work force composition
- Expansion of certain less productive components within the tertiary sector not warranted by growth
- Technology import restricting the labour absorbing capacity of the manufacturing sector
- With import of technology technical inefficiency is also rising possibly because of skill-scarcity.

Labour Costs

- In the backdrop of globalization developing countries are trying disparately to reduce the cost of production in a significant manner so that it can help them achieve an edge over others in terms of competitiveness.

- **Labour costs** are usually thought to be **highly significant**. And hence, continuous efforts to pursue capital intensive methods of production are made to attain significant labour productivity gains and to reduce the labour costs.

- As labour intensive methods also involve a huge range of uncertainties due to **labour unrest**, capital intensive technological progress is thought to be an obvious solution.

- On the other hand, productive employment generation is an important challenge for most of the developing countries.

- Thus keeping in view several **rigidities** including unionisation and the lack of flexibility which pose major constraints and hamper the smooth functioning of firms, **labour market reforms** have been suggested on a large scale in order to improve the competitiveness of the countries.

- in the **Indian context** for example, the **lack of labour market deregulations** is viewed to be a major constraint in **generating productive employment** in the formal manufacturing sector and attaining other desirable goals, i.e., **attracting FDI and rapid industrialisation.**

- Also for other reforms, in the area of trade for example, to be successful, labour market reforms are considered as essential prerequisites.

- **It is generally viewed that the labour markets in developing countries are rigid in terms of work practices, wages, hiring and firing policies, etc, and all this has been attributed to the existing labour laws** (Fallon and Lucas, 1991).

- Botero, et. al. (2004) noted that countries which have tough labour-market regulations have lower rates of labour-market participation and higher levels of unemployment.

- In the case of India, findings of Amin (2008) reveal that the labour regulation has sizable and negative effects on employment growth.

- Focusing on the Indian states, Almeida and Carneiro (2008) found that inflexible labour regulations not only constrains firm size but also reduces employment.

- Ahsan and Pagés (2008) argued that employment protection diminishes output and employment without benefiting workers much.

- Findings of Connell et al. (2008) suggest that labour market reforms have several beneficial effects on employment and the quality of life of labours.

- In an important study, Hasan, et al. (2003) observed that labour demand elasticity increases with reductions in protection.

- Providing evidence from a panel of 48 developing countries, their findings suggested that trade liberalisation is more likely to have a beneficial impact when labour markets are flexible and vice versa.

- Reforms in trade sector, for example, provide reorientation in production towards exports, which is expected to have a favourable impact on employment (Krueger, 1983; Balassa, 1986.

- More regulated and rigid labour markets are associated with higher real wages, which, however, come at the expense of employment.

- While there may be a case for removing labour market rigidities by discouraging the political patronization of the unions and relaxing the strict labour laws that prohibit employment growth, attention also needs to be given to the labour welfare issues.

- There is a fear that flexibility may expand employment but affect wages and social security support to the labour adversely.

- Hence, the debate continues as to whether labour market deregulations are to be pursued aggressively or the national governments should be more careful in recommending major flexibility to the employers.

- Aspects:
- First, in a cross country framework, we attempt to examine how responsive employment is in relation to wages in the manufacturing sector.
- Second, we compare the growth and wage elasticity of employment for a set of countries.
- Third, our analysis seeks to quantify how much of productivity growth actually gets transferred to the workers.
- Fourth, in order to evaluate the case of labour market deregulation, we attempt to estimate the cost of labour in production process in a set of countries.
- Finally, focusing on India, we attempt to analyse the wage-productivity nexus in the manufacturing sector.

- Wage elasticity :

absolute value is more than 0.5 only in a few countries.

- Econometric estimation of elasticity of employment with respect to wages also confirms a high magnitude with a negative sign only in the case of Brazil, Japan, Macau, Madagascar, Malaysia, Mauritius and Philippines.
- Hence, UNIDO data like the KILM data do not provide any significant evidence to support the argument that employment expansion can take place through wage reduction.

- Wage-productivity

- Using the KLIM data, we estimate the elasticity of wage with respect to productivity in manufacturing for a set of developing countries.

- Interestingly, the elasticity turns out to be positive only in China and Korea during the nineties. In Brazil and India it is negative during the same period, suggesting no transfer of benefits to the workers.

- However, this coefficient could be estimated only for a few countries and hence, it may not be appropriate to deduce any strong conclusion.

- We, therefore, turn to the UNIDO data. The elasticity of wage with respect to labour productivity for the manufacturing sector is positive and high in a number of countries with a few exceptions: Bolivia, Senegal, India, Mongolia and Macau and Malaysia, where elasticity is less than 0.5.

- Econometric estimation also conforms to this pattern as a large number of countries reveal strong links between labour productivity and wage.

- Next, we examine if there is any connection between labour absorption in manufacturing sector and labour market regulation across countries.

- World Development Indicators report the percentage of managers indicating labour regulations (LABREG) as a major business constraint and the percentage of manager indicating labour skill as a major business constraint (LABSKILL) for various countries.

- Higher is the percentage, higher is the probability that labour market regulations and skill factor affect employment adversely.

- We have tried to relate these skill and regulation specific responses to the ratio of labour to real value added (LTORVA) estimated from UNIDO data for the aggregate manufacturing sector.
- (Results): The coefficients in the estimated equations, however, turn out to be highly insignificant.

- Even when we control for real wage rate in the manufacturing sector (RWAGE), GDP per capita (GDPPC) at the national level and the share of manufactures in total imports (MFGIM) taken as a proxy for imported technology, neither the labour skill variable nor labour market regulation turns out to be significant.

- Alternate estimate of labour absorption (or dependent variable) have been tried in the equation, i.e. the rate of growth of employment (ROGEMFG) in the manufacturing sector from UNIDO data.

- Interestingly the skill factor is seen to affect employment growth in the manufacturing sector negatively. In other words, higher is the percentage of managers who feel skill has been affecting business adversely, lower is the rate of growth of employment in the manufacturing sector.

- This implies that poor skill base of the work force in the developing countries reduces the pace of labour absorption as labour demand is possibly rising only for the high skilled variety.

- ILO’s data on the percentage of workers registered with the unions has also been tried as a proxy for labour market condition

- Interestingly higher is the percentage of work force registered with unions (WFUIN) higher is the ratio of labour to real value added in the manufacturing sector, refuting the argument for labour marker reforms.

- This is, however, based only on 13 observations and, therefore, needs to be cited with caution

- Based on the UNIDO data, we measure the average labour cost (real wage rate multiplied by total employment) as a percentage of real value added for the period 1990- 2004 in the manufacturing sector for a set of developing countries.
-
- Surprisingly, 36 countries for which this ratio could be calculated only eight countries have the labour cost more than 35 per cent (see Table 4).

- To begin with, high cost of labour argument, therefore, does not seem to have a strong basis to build a case for labour market deregulation. Therefore, these findings corroborate the argument of Gorter and Poot, (1999) that the benefits of labour market deregulation should not be exaggerated.

TFPG Measurement

Arup Mitra

- The only determinant of long run rate of growth is technological development or technical progress.
- Why? The rate of return on capital follows a diminishing pattern
- Endogenising TFPG = ENDOGENOUS GROWTH THEORY
- Rogers (2003): “Endogenous growth model - is unlike the neo-classical model where there is no prediction of a long run steady state and hence there is no immediate suggestion that countries with lower output per capita should grow faster”.

- Endogenous growth theory

Arrow (1962): modeling technical change. He considered technical change as the result of learning-by-doing, where “doing” refers to the process of investment rather than the process of producing output.

- He used the link between growth of knowledge and cumulative level of investment to model the rate of technical change that could affect the economic growth of a country.
- He viewed investment as causing changes in the environment which would stimulate learning.

- Other “knowledge-based” endogenous growth models, for example the imitation model is derived from the work by Barro and Sala-i-Martin (1995).
- The imitation model is used to explain positive long run growth and allows for costs in transferring knowledge.

- Romer (1990): another influential “knowledge-based” endogenous growth theory : it described that the growth of technological progress of a firm can be thought of as depending on the level of resources devoted to research as well as the existing level of knowledge the firm has access to.

- Concept
- The notion of TFP is interpreted as an “index of all those factors other than labour and capital not explicitly accounted for but which contribute to the generation of output.”
-
- Importance
- Debate : Sen-Solow
- Broad measure
- Components : tfpg = tp + change in te

- Cobb Douglas production function
- $\text{Log } Y_i(t) = \alpha + \beta t + \Sigma_j \gamma_j \log X_{ij}(t) + \varepsilon_i(t)$
- $\varepsilon_i(t) = V_i(t) + U_i(t)$
- $TE_i(t) = Y_i(t) / Y_i^*(t) = exp\{U_i(t)\}$
- Y^* is frontier level of output

- Differentiation of equation (1) with respect to time *t* yields:
- $\dot{Y}_i(t) = \beta + \Sigma_j \gamma_j \dot{X}_{ij}(t) + \dot{TE}_i(t)$
- [as $\dot{U}_i(t)/dt = \dot{TE}_i(t)$]

Time series data

- Only TFPG Estimation : not decomposition
- Growth Accounting Technique
- Econometric Estimation
- Vale Added Function / Output Function
- Value added function: Single/ double deflation

- Single deflation: value added is deflated by output price : assumption: output prices and material prices grow at the same rate.
- Steps: deflate value added by output price, deflate capital by capital price

- Double deflation
- Output is deflated by output price
- Material by material rice
- Fuel by fuel price
- Deflated output minus deflated material and fuel = deflated value added

Growth accounting

- Value added function : Deduct the weighted average of the rate of growth of capital and labour from the rate of growth of real value added. Weights: labour share and capital share in value added
- Output function : deduct the weighted average of the rate of growth of capital, labour, material and energy from the rate of growth of real output.

Econometric Estimation

- Constant returns to scale assumption
- Value added function or output function
- Inclusion of the term t : the coefficient of t gives the TFPG (multiply by 100: per cent per annum)

Pure cross sectional data

- Technical efficiency
- Stochastic Frontier function framework
- $Yi = F(Ei; \beta) \exp(Vi + Ui)$
- $Y* = F(Ei; \beta) \exp(Vi)$

- $Y*/ Yi = F(Ei; \beta) \exp(Vi)/F(Ei; \beta) \exp(Vi + Ui)$
- $= exp(-Ui)$

Panel Data

- TFPG=Technological progress and change in technical efficiency
- Panel method : estimation of the production function
- Residuals
- Regress residuals on t and t2 (for each unit separately)
- Calculate the predicted values of the regrassand (res hat)

- From the entire panel choose the maximum reshat and calculate exp(reshat-maxreshat) for each of the observations.
- TFPG
- $\varepsilon i\ (t) = Vi\ (t) + Ui\ (t)$
- $\varepsilon i\ (t) = \delta 0i + \delta 1i\ (t) + \delta 2i\ (t2) + Vi\ (t)$

- The fitted values of $\varepsilon i(t)s$ give an estimate of the efficiency parameter Ui (t), i.e. ;

$$\hat{} \qquad \hat{} \qquad \hat{}$$

- $Ui\ (t) = \delta 0i + \delta 1i\ t + \delta 2i\ t2$

- .
- [as d Ui (t)/dt = TEi (t)]

- . ^ ^
- TEi (t) = (δ1i + 2 δ2i t)

- TFPG= $\beta + \delta 1i + 2\ \delta 2i\ t$

TFPG CAN ALSO BE estimated using the Malmquist Productivity Index (MPI) and the non-parametric methodology, Data Envelopment analysis (DEA). MPI allows TFPG to be decomposed into two components: technical change (TECH) which is the shifting of the technical frontier and efficiency change (EFFCH) which is the catching up effect in efficiency gains.

Innovation and Employment: A Firm Level Study of Indian Industries

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Perspective

- Innovation is endemic to economic growth

- research and development (R&D) expenditures taken as a broad proxy for innovative moves contribute directly to firms' productivity enhancement, and indirectly through their industry-wide spill-over effects (Grossman and Helpman, 1990; Romer; 1986).

- the effect of innovation on employment is an important concern
- If innovation means lesser utilisatiion of all the factors of production for the same level of output to be produced, then naturally it tends to reduce employment per unit of output.
- if innovation reduces the utilization of some of the factors of production and not labour, then both innovation and employment can go hand in hand (inflexible labour contracts, labour as sunk cost, new technology is not totally automated)

- A related point is also of great interest.
- Even if innovation leads to lesser utilization of all the factors (including labour) for a given level of output, the rise in the quantum of production certainly contributes to employment generation, i.e., the scale effect.
- However, there can be a negative effect of innovation on employment. Since technological innovation largely takes place in developed countries they are made to suit these economies and their factor endowments. Incidentally these countries are primarily labour scarce and thus the new technology tends to become increasingly labour saving (Pack and Todaro, 1969).

- it is pertinent to realize that production actually takes place in stages: l) material handling, 2) material processing, 3) material handling among processes, 4) packaging, 5) storage of the finished products

- The “compensation theory” as Vivarelli (2013) points out, argues that technological unemployment is a temporary phenomenon. The labour saving effects of technology can be offset through:
- “(1) additional employment in the capital goods sector where new machines are being produced,
- (2) decreases in prices resulting from lower production costs on account of technological innovations,
- (3) new investments made using extra profits due to technological change,
- (4) decreases in wages resulting from price adjustment mechanisms and leading to higher levels of employment,
- (5) increases in income resulting from redistribution of gains from innovation, and
- (6) new products created using new technologies" (Vivarelli, 2013).

- Two working hypotheses are pertinent:
- Innovation leads to technology creation with higher efficiency and TFPG.
- The productivity gains could be more in relation to capital than labour as the former is more expensive, which means innovation and employment both are positively associated.

- Using the firm level data in the manufacturing sector, compiled by ACCEQUITY for the period 1998 through 2010, the estimation has been carried out for eleven industries. The number of firms in many of these industries is substantial covering most of the existing ones with the exception of the very small ones. However, the panel is not balanced as the information on all the variables is not available for all the firms and for each of the years.
- The number of firms is as follows : Consumer Durables (Domestic Appliances) : 15, Consumer Durables (Electronics): 12, Chemical : 119, Electric Equipment: 51, Electronics Component: 36, Engineering: 79, Engineering Construction: 46, Engineering (Industrial Equipments): 38, Household and Personal Products: 23, Leather: 18, Pharmaceuticals and Drugs: 158
- Innovation: R & D expenditure as a % of sales

- The regression results show that the R&D to sales does not have a positive impact either on technical efficiency or TFPG in any of the industries considered in our analysis (Tables 5 and 6): cross-sectional.
- Similarly the agglomeration variable also does not indicate any significant effect which could be due to the fact that we have taken the firms registration office address in the absence of plant address. Only two industries namely Engineering (industrial equipments) and Pharmaceutical and Drugs show a positive impact of population size on efficiency.

- However, based on the panel data we are able to see a positive effect of R&D to sales ratio on technical efficiency in four industries <Chemical, Engineering (Industrial Equipments), Leather, Pharmaceuticals & Drugs>), a negative effect in three other industries <Consumer durables-electronics, Electric equipment, Electronics component>, and a statistical insignificance in the rest of the four groups (Table 7).
- (In the case of TFPG the evidence is even scanty – two groups show a positive effect, i.e., Consumer Durables (Domestic Appliances), Engineering (Industrial Equipments)),

. Impact of R&D on Employment

- Employment to sales ratio perceived as a rough proxy for labour requirement per unit of output has been regressed on R&D to sales ratio, exports to sales ratio, imports to sales ratio, assets to sales ratio and efficiency (or TFPG).
- In an alternative specification employment to sales ratio has been replaced by log of employment, without changing the determinants. This is pursued mainly to capture the view that labour per unit of real output (approximated by real sales) may not increase in response to R&D though the overall employment may increase.
- The performance indicator is included to test if TFP growth, for example, results in higher output growth relative to input growth including labour or alternately employment does not drop though the use of other factor inputs may decline.

- In the equations with technical efficiency as one of the determinants the following three industry groups unravel a positive effect of R&D to sales ratio on employment: Engineering (Industrial Equipment), Household and Personal Products, Pharmaceutical and Drugs (Table 11).
- In the rest of the industries R&D to sales ratio remains insignificant.
- Technical efficiency itself shows a negative effect on employment to sales ratio in the case of Electronics Component and a positive effect in engineering (industrial equipments) and remains insignificant in the rest of the industries.

- The ratio of exports to sales is significant with a positive coefficient in three industries and negative only in one.
- Similarly the imports to sales ratio show a significant value only in three industries and among them two are positive. Based on this it is difficult to generalize that trade contributes to employment generation.
- However, some of the labour intensive sectors like Consumer Durables (Domestic Appliances) and Household and Personal Products show a positive effect of both export to sales and import to sales on employment to sales.
- While higher exports lead to increased employment, imported inputs also tend to create employment, suggesting possibilities of complementary relationship between the imported inputs and skilled labour.
- Not any major improvement in results is obtained by redefining the dependent variable as log transformation of employment

- After changing the dependent variable to log of employment Electronics Component, Engineering (Industrial Equipment) and Leather show a positive effect of R&D to sales on employment with no negative effect in any of the other industries.
- On the whole, the R&D/sales ratio is not significant in a number of industries; however the cases of positive impact are noteworthy.

- In the light of the second hypothesis we have dropped TFPG or technical efficiency from the employment equation.
- The effect of R&D/sales on employment to sales turns out to be positive and significant in the following four industries: Electric Equipment, Engineering (Industrial Equipments), Household and Personal Products, Pharmaceuticals & Drugs.
- In the rest of the industries the effect is statistically insignificant

- In several studies employment is taken to be a function of value added and wage rate to estimate the growth and wage elasticity of employment.
- Following the same logic we may regress log of employment on log of real sales, real wage rate (derived by deflating the nominal figures by the consumer price index for industrial workers), and in addition real RND (deflated by the price index for machinery). Since R&D/Sales ratio has a highly limited variation across companies and over time, log of R&D may be considered to be more suitable.
- In this specification (Table 14), log R&D turns out to be significant with a positive effect in a number of industries (seven) and the elasticity of employment with respect to R&D is seen to be highest in Consumer Durables (around 0.3). In two other industries (Leather and Pharmaceutical) it is again a little above 0.1. In Electric Equipment, Electronics Component and Household and Personal Products also the estimate is closer to 0.1.

Conclusion

- On the whole, we noted that R&D as a percentage of sales does not affect efficiency or TFPG significantly. However, in absolute terms (ln of R&D) its impact on efficiency turns out to be positive in a number of cases.
- This is indicative of the fact that given the technology firms are able to improve the performance (TE) by spending more on R&D. However, R&D is not able to contribute to overall TFPG as technology is often imported from abroad.
- After netting out the change in efficiency the TFP growth is attributed to technology up-gradation, which is sought from the developed countries.
- Hence, R&D expenditure does not enable firms to attain better performance relating to new technology procured from abroad – rather it reduces the overall performance (TFPG) possibly because of high adaptation cost of the new technology and inability to operate it and reap its potentiality instantaneously.

- The impact of R&D as a percentage of sales on employment is positive only in a few industries. This has been tested with and without controlling for the performance indicator, which does not show any strong effect on employment.
- The R&D to sales ratio is seen to have a very limited variation for which the log transformation of R&D has been tried to work out the partial elasticity of employment with respect to R&D.
- In this specification a number of industries reported a positive effect of R&D on employment in absolute sense.
- Also, some of the labour intensive industries revealed a higher elasticity of employment with respect to R&D.
- On the whole, R&D's positive impact on employment in absolute sense if not employment content per unit of output, is noteworthy even when R&D does not mean actual innovation.
- Processing of byproducts and efforts pursued to bring in an improvement in product quality and efficiency are some of the striking features of R&D expenditure, which may be resulting in employment gains.
- Even when capital intensive technology is adopted by the firms R&D expenditure has the potentiality to generate employment as it means additional activities without involving additional capital.

Determinants of TFPG: With a Special Focus on ICT

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Motivation

- The only determinant of long run rate of growth is technological development or technical progress.
- Why? The rate of return on capital follows a diminishing pattern

- The notion of TFP is interpreted as an “index of all those factors other than labour and capital not explicitly accounted for but which contribute to the generation of output.”

- Endogenising TFPG = ENDOGENOUS GROWTH THEORY
- Rogers (2003): “Endogenous growth model - is unlike the neo-classical model where there is no prediction of a long run steady state and hence there is no immediate suggestion that countries with lower output per capita should grow faster”.

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Arrow (1962): modeling technical change. He considered technical change as the result of learning-by-doing, where “doing” refers to the process of investment rather than the process of producing output.

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- Other “knowledge-based” endogenous growth models, for example the imitation model is derived from the work by Barro and Sala-i-Martin (1995).

- The imitation model is used to explain positive long run growth and allows for costs in transferring knowledge.

- Romer (1990): another influential “knowledge-based” endogenous growth theory : it described that the growth of technological progress of a firm can be thought of as depending on the level of resources devoted to research as well as the existing level of knowledge the firm has access to.

- Sena (1998) summarized with the following:
- "…a firm with low Research & Development (R&D) expenditure can draw from the high-tech technology firm a zero cost and therefore the high-tech firms' innovative efforts may explain other firm's productivity growth."

- Nadiri (1993) found a positive and strong relationship between R&D and the growth of output or total factor productivity.

- The channels of diffusion of spillovers vary considerably.

They may take the form of
intra-and inter-industry relationships,
interdependence between public and private sector investment,
supplier and purchaser connections,
and geographical location,
as well as domestic firms and firms in other countries through international technology market trade and multinational enterprises (MNEs).

- Through the study of OECD countries, Nadiri noted that the diffusion of new technology is very rapid and transmitted not only through exports but also through FDI and MNEs research operations.
- So FDI is also a determinant of TFPG

- He concluded that more than half of TFPG can be explained by R&D spillover effects and that having more R&D investments will lead to further increases in R&D spillovers.

- One important conclusion of several studies:

R&D activity is a channel for the diffusion of knowledge through innovative ideas from one firm to another and the increase in productivity growth can be translated to the market value of the firm.

- Widespread technology diffusion creates the possibility for increasing returns to investment (Arthur, 1996).

- Although most of these studies find a significant and positive effect of R&D on firms' performance, the estimated elasticity with respect to R&D varies widely (see Griliches, 1979 and 1986; Jaffe, 1986; Griliches and Mairesse, 1990; Griffith *et al*., 2006).

- Some of these recent studies for the developed countries suggested that knowledge generating activates is no silver bullet for productivity growth and '*manna from heaven'* impact is very small (see for example, O'Mahony and Vecchi, 2009).
- In India, although R&D has traditionally been negligible, the outlook of the industries has, in the recent years, changed considerably.
- Firms have started taking R&D activities more seriously and more funds are being invested in these activities. However, there are some recent studies which reported contrary results on these issues (Aggarwal, 2000 and Sharma 2012).

- Other Determinants of TFPG

- Agglomeration Economies (external to the firm):

Urbanisation and localisation economies

- In the context of agglomeration economies it is noted that some industries induce concentration of economic activity as they exhibit high economies of scale in operation and there are others which benefit from concentration because of these external economies (Mills, 1967 and Henderson, 1986).

- Concentration not only strengthens the forward and backward linkages, but also reduces the cost of operation by developing complementary services. The effective price of infrastructure services declines if there is concentration of users of these services (Mohan, 1993).

- In all, interdependence of industries in terms of input-output linkages, ancillarization and availability of infrastructure contribute to the growth of agglomeration economies.

- The benefits of concentration can be attributed to the following factors (Hermansen, 1972):
- (a) substantial economies of investment expenditure – the investment for the whole complex is less than the sum of investment for each enterprise planned and located in isolation,
- (b) efficient production due to advantages of specialization, economies of large scale operation and organization of common managerial and infrastructural facilities,
- (c) possibility of jointly exploiting of the natural and raw material resources of the area of location, and (d) opportunities for close contact, rapid diffusion of technological innovations, and rapid overall development of the economy.
- The external economies, in general are divided into two categories: (a) urbanization economies and (b) localization economies, resulting in productivity augmenting effects. Since the large cities are characterized by higher levels of productivity the real wages are also higher therein.

Evidence: Mitra (1999, 2000): large cities and productivity

TFPG = TP + Change in TE

Higher levels of urbanisation and TFPG

Concentration and TFPG : positive relationship :

SEZs, national manufacturing zones etc.

- Trade openness, particularly exports, and TFPG (Das, 2004): to capture export market one has to be more competitive

With same cost one should be producing more so that per unit cost of production comes down substantially enhancing the competitiveness

So reduction in protection (ERP) etc. may lead to higher TFPG

Mixed Evidence

- In the theoretical literature, public infrastructure appears as a key factor of productivity and efficiency enhancement through its complementary relationship with other factors of production and external economies (Lucas, 1988;Barro, 1990;Barro and Sala-i-Martin, 1995).
- Empirical findings on this issue, however, are inconsistent and often contrary to each other.
- Over the last two decades a large number of studies have focused on this issue. Most have noted that public infrastructure positively and sizably affects economic performance (Aschauer, 1989; Munnel, 1990).
- Some others, for example Evans and Karras (1994) and Holtz-Eakin (1994) havechallenged these findings on methodological ground and showed insignificant or minimal impact of public infrastructure.
- Nevertheless, with improvement in empirical methodologies, some recent studies again estimated large effects **(**Stephan, 2003; Everaert and Heylen, 2004; Kamps, 2006).
- In the case of India, Mitra*et al.* (2002), Hulten*et al.* (2006) and Sharma and Sehgal (2010) found moderate to large impact of infrastructure on the manufacturing performance.

- Mitra, Varodakis and Veganzones-Varodakis (2002) : infrastructure – physical, financial and social – social infrastructure is the most important one. Emphasis on human capital (education and health)

- **Geeta Krishnasamy and Elsadig Musa Ahmed:**

that human capital investment plays a pivotal role in driving TFP growth

- Recent studies by members of Asian Productivity Organization (APO, 2004) reported positive effects of quality change in labour on TFPG due to higher educational level for most countries.

- Catch up model of technology diffusion: mainly through better human capital formation – higher levels of educational attainments and technical skills are attained.

- Here we introduce the role of ICT in imparting higher levels of skill, improving the technical knowledge of the human capital which is supposed to operate the new technology

- Some researchers have made a case for ICT-led development based on the notion that investments in ICT can accelerate economic growth by enhancing worker productivity and increasing the returns to investment in other capital goods (APO, 1990; Mody and Dahlman, 1992; OECD, 1988, 1993).
- In addition, the ICT industry itself can be a source of economic growth and jobs.
- For these reasons, investment in ICT is believed to enhance national productivity and competitiveness, spurring economic growth.
- These findings challenge the ‘productivity paradox’ by showing that ICT makes a positive contribution to economic growth.

- Also the new technology involves ICT component : production process : several stages: through ICT technical progress is materialized
- Literature: New technology is highly skill intensive: complimentary relationship between capital and skill (ICT)
- Intangible (lack of physical substance) capital as complement to ICT

Part of the capital investment is on ICT since ICT is an indispensable component of capital investment

Investment for technological progress involves ICT

New methods or Experiments for technical progress cannot be operationalised without ICT

RND cannot be undertaken without ICT

1.Technological progress is attained with the help of ICT as an input and also as a device through which it is manifested or to be executed.
2. On the other hand, the new technology requires the knowledge of ICT for the one who operates it:

Overall: ICT as an input and also ICT at the level of yielding output

- Industries (in OECD countries and also USA) which used ICT experienced rise in TFPG
- **What caused this acceleration in the TFP of ICT-using industries?**
- **The price of ICT has declined substantially, but that cannot be the source of the productivity increase in ICT-using sectors, as input prices do not shift the production function.**

- **The fall in the price of ICT might have accelerated TFP growth in ICT-using industries through two channels:**

- firms invested in complementary intangible capital and/or

-ICT had a positive externality

- **The challenge is to infer the presence of ICT externalities while allowing for the existence of unobserved complementary investments (learning, reorganization, etc).**

- Positive externalities reduce the cost of production or the rise in output is more than the proportionate rise in cost because

firms output is a function of its own input and also the other forms' inputs; e.g. overall ICT in the economy, it's own RND and other firms' RND

- Reduced prices in ICT enable firms to undertake other knowledge oriented investment which is carried out through ICT (even if there is no externality ICT can contribute to TFPG)

- **However, we must remember that it is difficult to estimate ICT spillovers when one also allows for intangible investment that is complementary to ICT.**
- **Ram Acharya and Susanto Basu (2011)**

the impact of ICT on TFP in major OECD countries,

- **The industries with higher ICT growth may not be the ones which necessarily acquire higher TFP growth.**
- **Allowing for the intangible capital—which might otherwise be mistaken for spillovers to ICT capital—they find no evidence of ICT spillovers within countries or across national boundaries.**
- **They do find positive spillovers of R&D at the domestic level and in some specifications across boundaries.**

- Ahmed (2006):

- Information and communication technology (ICT) in the activities of Malaysia's manufacturing sector contributed significantly to its productivity growth in general and total factor productivity (TFP) growth of the sector in particular. (TFPG in ICT itself and overall manufacturing)

- This study assumes that the use of ICT in the manufacturing sector is increasing from year to year in the form of a geometric progression due to the rapid innovations of ICT around the globe.

- Labour input was subdivided into skilled, semi-skilled and unskilled, to measure the achievement of the knowledge-based economy (K-economy) through human capital involved in the sector.

- The results of this study show that the contribution of the ICT used in the sector was the highest among all the inputs.

- Achieving higher growth and TFPG through ICT is faster than achieving it through human capital and other traditional inputs.
- The impact of ICT on TFP contributions is significant and better than skilled labour as an indicator of knowledge workers (human capital) that showed a very low contribution of TFP.
- Y= f(KLME,ICT)
- But the growth rate of TFP is lower compared with the growth rate of the ICT. As a result, the achievement of the K-economy is not in a geometric progression like that of the ICT development.

- Jorgenson and Stiroh (2000) and Oliner and Sichel (2000) found that one of the most important sources of TFP growth in US in the 1990s was from ICT producing industries.
- Despite some methodological differences, these papers derive similar estimates, attributing around a quarter percentage point of the acceleration in labour productivity since 1995 to ICT (TFP growth in the ICT sector) and a half percentage point to capital deepening (all of which is attributable to the accumulation of ICT capital).

- In total, they estimate ICT has contributed three-fourth of the recent labour productivity acceleration.
- In contrast, Gordon (2000) and Bosworth and Triplett (2000) adopt the more agnostic view that the ICT "revolution" has not had the same impact as the general-purpose technologies introduced in the past century (such as electricity or transportation).

- Studies by Brynjolfsson and Hitt (1996), Lichtenberg (1995), and Dewan and Min (1997) analyzed firm-level US data and found evidence of positive and significant returns from ICT capital investment.

- Kraemer and Dedrick (1999) dictated that the empirical research at the firm level is encouraging, but not sufficient to answer the productivity paradox.
- Criticism
- The firm level research only captures gains and losses of individual firms and not net gains to the economy.

- In addition, the firm level research has focused exclusively on large corporations, and therefore might not be representative of the entire economy (Kraemer and Dedrick, 1999).

- The fact that a certain set of companies show high returns to investment in ICT does not mean that these gains are translated into productivity improvement at the national level (Kraemer and Dedrick, 1999).
- As argued by Sichel (1997), the impacts are mostly redistributional with the gains of some firms coming at the expense of their competitors.
- Hence, it is important to conduct country-level analyses and inter-country analyses.

- A study by Chen and Dahlman (2004) assessed the effects of knowledge on economic growth.
- By using an array of indicators, each of which represents an aspect of knowledge, as independent variables in cross-section regressions that span 92 countries for the period 1960 to 2000, the paper showed that knowledge is a significant determinant of long-term economic growth.
- In particular, they found that the stock of human capital, the level of domestic innovation and technological adaptation, and

- the level of ICT infrastructure all exert statistically significant positive effects on long-term economic growth.

- More specifically, with regard to the growth effects of the human capital stock, the paper found that an increase of 20% in the average years of schooling of a population tends to increase the average annual economic growth by 0.15 percentage point.

- In terms of innovation, this study found that a 20% increase in the annual number of USPTO patents granted is associated with an increase of 3.8 percentage points in annual economic growth.

- Lastly, when the ICT infrastructure, measured by the number of phones per 1000 persons, is increased by 20%, the study found that annual economic growth tends to increase by 0.11 percentage point.

- Singh (2002) discusses the possibilities for broad-based IT-led economic growth in India, including increasing value-added,

- using ‘better telecom’ links to capture more benefits domestically through offshore development (for developed country firms),

- greater spillovers to the local economy, broadening the IT industry with production of telecom access devices,

- improving the functioning of the economy through a more extensive and denser communications network, and improving governance.

- examine the question of whether IT can do more than fuel an enclave-based export boom.

- An example of IT's broader impact comes from the case of so-called IT-enabled services, a broad category covering many different kinds of data processing and voice interactions that use some IT infrastructure as inputs, but do not necessarily involve the production of IT outputs. (software versus hardware, IT-enabled services)

- Design and development of software may have characteristics of R&D, while IT-enabled services are more like manufacturing in their use of established techniques for production.

- In the light of endogenous growth theories looking at the IT sector:
- the idea of general-purpose technologies (GPTs) seems very useful.
- The idea of GPTs was introduced by Bresnahan and Trajtenberg (1995), who define them in terms of having three key characteristics: pervasiveness, technological dynamism and innovational complementarities.
- Examples of GPTs include writing and printing (both earlier advances in IT), modern digital electronic IT, steam and electricity (both advances in power delivery systems) and synthetic materials.

- Improving TFPG by moving from low value product to high value product: higher growth : as the possibility to use modern technology exists TFPG can be enhanced continually by investing on technology

- If we accept the potential theoretical benefits of moving up the value added ladder, what does this mean in practice for India's software industry?
- One possibility is offering higher value added component services, involving design and strategy – IT

- Another is offering more complete packages or bundles of services. The latter differs from the former in that a higher management component is included in the package than in particular aspects of software development, even if those require more technical skill.

- As a firm moves from LVP to HVP there will be greater scope and need to utilize ICT
- Also for the marketing of HVP greater amenities are required which are more ICT intensive.
- So HVP may experience greater TFPG due to continuous advancement in technology of which ICT is a major component.
- To the extent that IT can have significant effects on the efficiency of operations in various industries, there are strong complementarities between the IT sector itself and the rest of the economy.

- Application of ICT in units and sectors where it has not been used so far, e.g. informal manufacturing enterprises - improving the performance
- ICT use to enhance information accessibility which can reduce risk and raise the prediction capability of the entrepreneurs – reduction in wastage, losses etc. – improving performance
- Using ICT to impart training and education: cost effective

- Gr/TFPG = (x1, x2, x3…..)

Each of the inputs' productive potentiality can be enhanced by introducing ICT

Example, x3=governance

- Computer-aided registration of land deeds and stamp duties in Andhra Pradesh, reducing reliance on brokers and possibilities for corruption
- Computerization of rural local government offices in Andhra Pradesh for delivery of statutory certificates of identity and landholdings, substantially reducing delays
- Computerized checkpoints for local entry taxes in Gujarat, with data automatically sent to a central database, reducing opportunities for local corruption
- Consolidated bill payment sites in Kerala, allowing citizens to pay bills under 17 different categories in one place, from electricity to university fees
- E-mail requests for repairs to basic rural infrastructure such as hand pumps, reducing reliance on erratic visits of government functionaries47

- Innovation in ICT helps enhance factor productivity and TFPG

- Application of ICT as an input, utilising ICT to reconstitute factors and innovation possibilities in ICT all contribute to TFPG

- innovation in ICT has taken place at a rapid pace but there is still scope to carry out innovation in ICT related services

- (While conventional telephone connectivity has often proved inadequate for Internet access in rural areas, several innovations provide alternatives that are likely to be cost effective. These include wireless in local loop (WLL), fiber optic cables, and high-powered versions of Wi-Fi and Wi-Max (i.e., various versions of the 802.11 and 802.16 wireless standards).

- The Internet boom in the United States clearly played a role in pushing down costs and speeding innovation in fiber optics and wireless transmission.)

Total Factor Productivity and Technical Efficiency of Indian Manufacturing:

The Role of Infrastructure and Information & Communication Technology

- Arup Mitra
- Chandan Sharma
- Mari-Enge Veganzones

- This paper highlights the role of infrastructure, information & communication technology (ICT), RND, trade intensity and size of the unit in the context of total factor productivity growth (TFPG) and technical efficiency (TE) of the Indian manufacturing sector for the period 1994-2008

- We use advanced estimation techniques to overcome problems of non-stationarity, omitted variable bias, endogeneity and reverse causality by applying Fully modified OLS, panel co-integration and System GMM.
- Estimation results suggest that the impact of infrastructure and ICT is rather strong.
- Interestingly, sectors exposed relatively more to foreign competition (e.g.*Transport Equipment*, *Textile*, *Chemicals, Metal& Metal Products*) are more sensitive to infrastructure deficiencies.
- This finding implies that improving infrastructure and ICT would benefit these sectors to a large extent thus contributing to India's competitiveness.
- This outcome is of particular importance in the context of infrastructure bottlenecks in India.

- Data on two-digit industry groups in the Indian manufacturing sector have been gathered from the Prowess database provided by the Center for Monitoring the Indian Economy (CMIE). Annual financial statements of firms belonging to eight industries, namely
- *Food & Beverages*,
- *Textiles*, *Chemicals*,
- *Non-metallic Minerals*,
- *Metal & Metal Products*,
- *Machinery*,
- *Transport Equipments* and
- *Miscellaneous Manufacturing*

- Subsequently, the firm-level data have been transformed into industry-level data by aggregation. This has been done for each year over the sample period, 1994-2008
- The reason for taking 1994 as the initial year is that the Indian economy witnessed structural reforms in the early 1990s, which have subsequently brought in vast changes in the manufacturing sector policy
- Also a sea-change in India's ICT revolution

- In this study transportation (road, rail and air), information & communication technology (ICT) and energy sectors are considered as indicators of physical infrastructure
- These data are taken from World Development Indicators (WDI, 2011) online, and infrastructure publications of CMIE (2009)
- Instead of using all infrastructure variables separately, which is likely to lead to multicollinearity problem we construct a total (G) and an ICT infrastructure index for India by applying the principal component analysis (PCA) method to our original indicators

$$\ln(TFP)_{it} = \alpha + \beta \ln(\mathrm{G})_{it} + \delta X_{it} + e_{it}$$

$$\ln(TFP)_{it} = \alpha + \beta \ln(\mathrm{ICT})_{it} + \delta X_{it} + e_{it}$$

$$\ln(TE)_{it} = \alpha + \beta \ln(\mathrm{G})_{it} + \delta X_{it} + e_{it}$$

$$\ln(TE)_{it} = \alpha + \beta \ln(\mathrm{ICT})_{it} + \delta X_{it} + e_{it}$$

- G is overall infrastructure
- We also include a set of additional control variables (*X*): i.e. research and development intensity (R&D), trade intensity (Trade) and the size of the industry (Size) which may affect firms' productivity as well

Table A.2.1. Infrastructure and ICT Variables: Sources of Data

Variable	Sector	Indicator	Data sources
Air	Transportation	Air transport, passengers carried	WDI
Electricity	Electricity	Electricity production (kWh/per-capita)	WDI
Internet	Information and Communication	Internet users (per 100 people)	WDI
Mobile	Information and Communication	Mobile cellular subscriptions (per 100 people)	WDI
Mobile-tel	Information and Communication	Mobile and fixed-line telephone subscribers (per 100 people)	WDI
Port	Transportation	port (commodity wise traffic ,000 tones)	CMIE
Rail-goods	Transportation	Railways, goods transported (million ton-km)	WDI
Rail-pass	Transportation	Railways, passengers carried (million passenger-km)	WDI
Roads	Transportation	Roads, total network (km/1000people)	WDI
Tel	Information and Communication	Telephone lines (per 100 people)	WDI

Table 1. FMOLS Result: Effects of Total Infrastructure on ln (TFP), 1994-2008

Industry	ln (G)	Ln (Trade)	Ln (R&D)	Size ln (K)
Chemical	-0.0787 (-0.572)	0.0018 (0.083)	0.0629** (3.825)	-0.0144 (-0.6395)
Food & Beverage	0.2423** (3.259)	0.0413 (1.021)	0.006 (1.2705)	0.0056 (0.19668)
Machinery	0.1779** (2.049)	0.0402 (0.976)	0.0492** (2.055)	0.0219 (0.4401)
Metal & Metal Products	0.3291** (6.727)	0.1015** (4.467)	0.0045 (0.423)	-0.0931 (-3.003)
Non Metallic Mineral Products	0.2622** (3.668)	0.0552** (2.725)	0.0058** (2.725)	0.0129 (0.5726)
Textile	0.3079** (11.382)	-0.0371 (-1.215)	0.0023** (0.629)	0.00432 (0.2081)
Transport Equipments	0.6544** (11.478)	0.0913** (6.337)	-0.0114 (-1.547)	-0.1031** (-14.778)
Miscellaneous Manufacturing	0.56603* (1.909)	-0.1239* (-1.744)	-0.0061 (-0.1531)	-0.0329 (-0.2839)
Overall	0.315** (14.108)	0.0214** (4.4727)	0.0142** (2.9503)	-0.0248** (-6.1121)

Source: Authors' estimations.
Notes: ** and * denote significant at 5% and 10% critical level respectively. t-statistics are in parentheses

- estimated coefficients of the total infrastructure variable are found to be sizably large in several sectors and for the overall manufacturing as well.
- Results indicate that total infrastructure explains 65 per cent of TFP growth in *Transport Equipments*, 32per cent in *Metal & Metal Products* and 30per cent in *Textile*.
- In other industries, it varies from being large to moderate (except in the case of *Chemical*, where it is found to be statistically insignificant
- On an average, results suggest that the impact on overall manufacturing is around 0.32, which means that 1 per cent increase in infrastructure leads to a 0.32 per cent TFP growth.

Table 2. FMOLS Result: Effects of ICT on ln (TFP), 1994-2008

Industry	ln (ICT)	ln (Trade)	ln (R&D)	Size ln (K)
Chemical	-0.0111 (-0.265)	-0.0067 (-0.346)	0.0678** (7.891)	0.0063 (0.348)
Food & Beverage	0.0781** (1.7958)	0.0794* (1.7467)	0.0059 (0.989)	0.0515** (2.003)
Machinery	0.0095 (0.205)	0.065225* (1.777)	0.0708** (3.413)	0.051530 (1.060855)
Metal & Metal Products	0.1778** (4.014)	0.1341** (4.434)	0.0074 (0.4867)	-0.0832** (-1.9258)
Non Metallic Mineral Products	0.05662** (1.7452)	0.1037** (7.069)	0.0031 (1.0361)	0.0372** (1.7921)
Textile	0.2237** (26.435)	0.0017 (0.1311)	0.0011 (0.60934)	-0.0008 (-0.087)
Transport Equipments	0.2174** (3.603)	0.0681* (1.761)	0.0194 (1.252)	-0.0963** (-4.976)
Miscellaneous Manufacturing	0.2032 (1.217)	-0.0759 (-1.112)	0.0209 (0.565)	0.0222* (0.189)
Overall	0.1244** (12.941)	0.0462** (5.431)	0.0245** (5.743)	-0.001482 (-0.584)

Source: Authors' estimations.
Notes: ** and * denote significant at 5% and 10% critical level respectively. t-statistics are in parentheses.

- Results indicate that ICT is closely linked to manufacturing productivity as well.
- Its impact in some of the industries is substantially large, although smaller than that of the total infrastructure index (see Table 2).
- This outcome is in line with the literature which highlights that the elasticity with respect to infrastructure indicators tends to increase with the level of disaggregation.
- In *Textile*, *Transport Equipments*, and *Metal & Metal Products* industry, ICT has a positive and statistically significant effect of 18 to 22 per cent on TFP.
- The effect on the overall manufacturing is also estimated to be positive and sizable (12 per cent).

- Trade intensity is found to be positive and significant in *Metal & Metal Products*, *Non Metallic Mineral Products*, and *Transport Equipments*, which are relatively more exposed to foreign competition.

- The impact is estimated to be 6-13 per cent across industries. However the effect on the overall manufacturing is found to be around 4 per cent, which is lower than expected.

- Furthermore, the R&D variable explains only 2 per cent of TFP growth, which is not very surprising as Indian manufacturing is known for its low R&D intensity.

- Nonetheless, in research intensive industries, (*Chemical* and *Machinery)*, the effect is found to be 6 per cent and 7 per cent respectively, which is quite encouraging, knowing that these sectors are most productive in our sample (see section 4)**.**
- As for the size, the impact is noticeable in *Food & Beverage* and *Non Metallic Mineral Products*, which are characterized by small firms with low productivity growth. This result implies that a policy of concentration would generate higher productivity gains in these sectors.

- Next, we test the effect of ICT on TE
- Estimation results suggest that ICT has a positive, statistically significant and sizable impact on all industries
- The effect still varies among the sectors.
- It is again *Transport Equipments*, followed by *Textile*, which show the highest sensibility to ICT limitations (with an elasticity of 0.16 and 0.12 respectively).
- The elasticity of the overall sector is estimated to be 0.08.
- As for the size, it still plays a role in the efficiency of the *Food Industry* in particular, as seen previously

- On the whole, while the estimated coefficients vary, both in terms of magnitude and statistical significance, various constant effects are perceivable across industries.
- *Transport Equipments*, *Textile* and *Metal & Metal Products* are found to be highly associated with infrastructure provisions, including ICT, as far as their productive performance is concerned.
- This is also the case with *Chemical* industry (which is the most productive sector in our sample, both in terms of TFP and TE), along with *Transport & Machinery* (in terms of technical efficiency, TE).
- This may be due to the fact that these sectors are relatively more exposed to foreign competition and need a more supportive environment in terms of infrastructure to be able to compete efficiently.

- Enhancing total infrastructure and ICT, especially in the sectors more sensitive to infrastructure deficiency, can constitute a powerful engine of competitiveness and industrial growth.

- Singh (2006) : ICT playing a crucial role in the context of Infrastructure

This monograph compares the methodologies and progress of the different existing models of information and communication technology (ICT) use for broad-based development and economic growth in India.

The focus is chiefly on the rural economy, where the developmental needs are the greatest, and the use of ICTs presents the most challenges.

It examines the nature of benefits in areas such as education, health, market efficiency, and democratic participation, the channels through which impacts can be realized, and the practical means for realizing potential benefits, including organizational innovations and government policy as well as structural changes.

- Indeed, two points to be brought out in this piece are the catalytic role of ICTs in spurring complementary innovations,
- and the special nature of ICTs, distinguishing them from other types of modern technologies, even others that have a general purpose, infrastructural nature, such as electric power.

- In abstract, there are two types of potential economic gains from the use of ICTs.
- First, there are both static and dynamic efficiency gains. Static gains are one-time, and come from more efficient use of scarce resources, allowing higher consumption in the present.
- It is useful to distinguish two kinds of static efficiency gains.
- One kind pertains to increases in operating efficiency, while the other comes from reduced transaction costs, where the latter can be interpreted broadly to include costs of opportunism and rent-seeking.
- In both cases, the channel for gains is through more effective and lower cost information storage, processing and communication – the last of these including wider networks and richer information exchange.

- Dynamic gains come from higher growth (TFPG), potentially raising the entire future stream of consumption.
- Reductions in transaction costs can increase growth rates as well as providing static efficiency gains.

- ICTs can also spur innovation, which is a key factor in economic growth.

- Development can also include improvements in the capabilities of the population, such as education, health and nutrition, independently of any direct or indirect economic impact.
- The ability to participate in democratic decision-making also falls into this category.
- Broad-based improvements in capabilities can also have positive impacts on long-run economic well being (TFPG)
- The role of ICTs in effecting improvements along non-economic dimensions is ALSO important.

- Experience with Internet use in developed countries suggests that information exchange related to the completion of market transactions is especially valuable.
- The ability of IT-based communications (combined with storage and processing) to bring together buyers and sellers more effectively represents major potential gains.
- These gains can come about through lower search costs, better matching of buyers and sellers, and even the creation of new markets.

- On the whole,
- TFPG is a function of several variables including innovation, trade intensity, infrastructure, ICT, human capital, agglomeration economies and size of the firm/industry
- ICT is key to several of these determinants of TFPG
- Non-economic factors (education, health), governance, prediction/forecast impacting on TFPG and long run growth
- ICT's importance in the context of non-economic factors is also enormous.