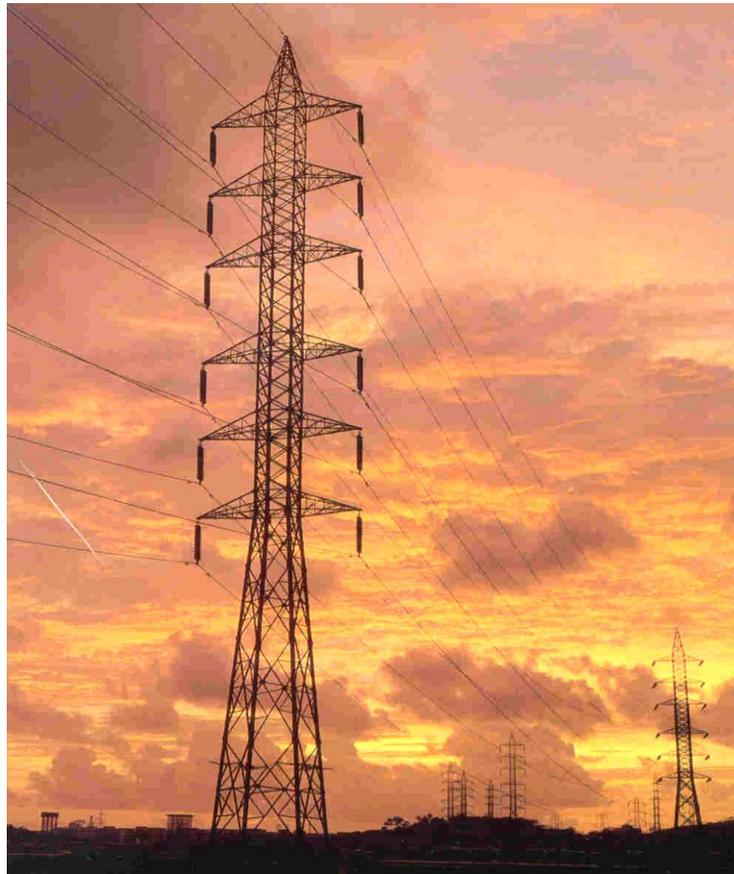


**ESTIMATING EMPLOYMENT EFFECTS OF
POWERLINKS TRANSMISSION LIMITED
PROJECT IN INDIA & BHUTAN**



IFC Development Impact Department

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EXECUTIVE SUMMARY AND KEY FINDINGS

In 2003 IFC committed a loan of US \$75 million to Powerlinks Transmission Limited (PTL) a joint venture company, to construct power transmission lines that helped evacuate hydropower from Bhutan to a number of States in north and east India.

Unlike most studies which tend to focus on jobs created through construction and O&M (Category 1 jobs) of power projects, this study looks at employment effects more comprehensively and also estimates Category 2 jobs that are created- i.e. those jobs that are created as the increase in power supply brought by PTL helps firms expand their output and hence create more jobs. We also specifically focused on the impact of increased reliability in power supply through reduced power outages, on job creation.

The study uses a mix of methodologies including Input Output models, econometric time series models and step-by-step estimation for estimating the different types of employment effects.

- *Large indirect and induced effects:* In terms of Category 1 jobs created during construction and O&M through direct, indirect and induced channels, we find that the PTL project will create a total of 243,000 persons-year employment (roughly about 9,700 additional jobs) over the 25 year life of the project.
- *Significant impact on poverty:* Besides, the jobs created during construction added Rs 47,000 lakh (US\$94 million) to household income, which has special implications for poverty reduction as the transmission lines were constructed through some of the poorest states in India. Besides, a large portion of induced jobs are created in the agricultural sector, creating employment and income for rural low skilled population.
- *Significant second order growth effects:* Category 2 jobs created by this project are much more significant as power supply is a significant constraint for firms in India. An increase in power supply from Bhutan's Tala hydropower plant transmitted through PTL's transmission lines created about 75,000 new formal jobs in India over the period 2006- 2012 , of which about 4,600 new formal jobs were created in West Bengal. The effects on informal jobs is expected to be much larger than that on formal jobs, however, it could not be estimated due to data limitations. Reliability of power supply

is a very important issue for firms in India. The increase in power supply helped reduce power outages in West Bengal which created 1589 formal jobs (out of 4,600) attributable to the incremental power brought by PTL. Again, the effect on informal jobs is expected to be much higher than the above.

- *Development impact in Bhutan:* Additionally, this vital transmission link that enables cross border trade of power from Bhutan to India, also has a significant development impact in Bhutan through GDP growth, increase in government revenues, which further enables the Bhutanese government to spend more on social sectors like health and education- which in turn improves the quality of life and also the employability of the people of Bhutan.

Category 1 jobs (created during construction and O&M)			Methodology used
1	Direct	44,000 person years	Input-Output models
2	Indirect	55,000 person years	
3	Induced	144, 000 person years	
	Total	243, 000 person years (about 9,700 jobs over 25 years)	
Category 2 jobs (created as increase in power supply relieves a constraint for firms)			
1	Impact of power supply	75,000 jobs in 6 years	Econometric time series (VECM model)
2	Impact of reliability of power supply (subset of 1)	1600 jobs in 6 years in West Bengal	Step by Step estimation model using Enterprise Surveys and primary data from interviews.

EMPLOYMENT EFFECTS OF INFRASTRUCTURE PROJECTS:

Infrastructure provides the foundation for economic growth, improving quality of life and generating employment. While creating jobs is not the sole objective of investing in infrastructure, literature shows that infrastructure investments generally have high employment multipliers, which work through several channels. At present, IFC's systems capture information on *direct* jobs that are being provided in client companies. For example in calendar year 2010, IFC's infrastructure investment clients provided 332,567 jobs, of which 89,327 were women. However these numbers refer only to the *direct jobs* that were created. Studies show that calculating only the direct jobs ignores the various other channels through which infrastructure projects create jobs, and grossly underestimates the employment impact.

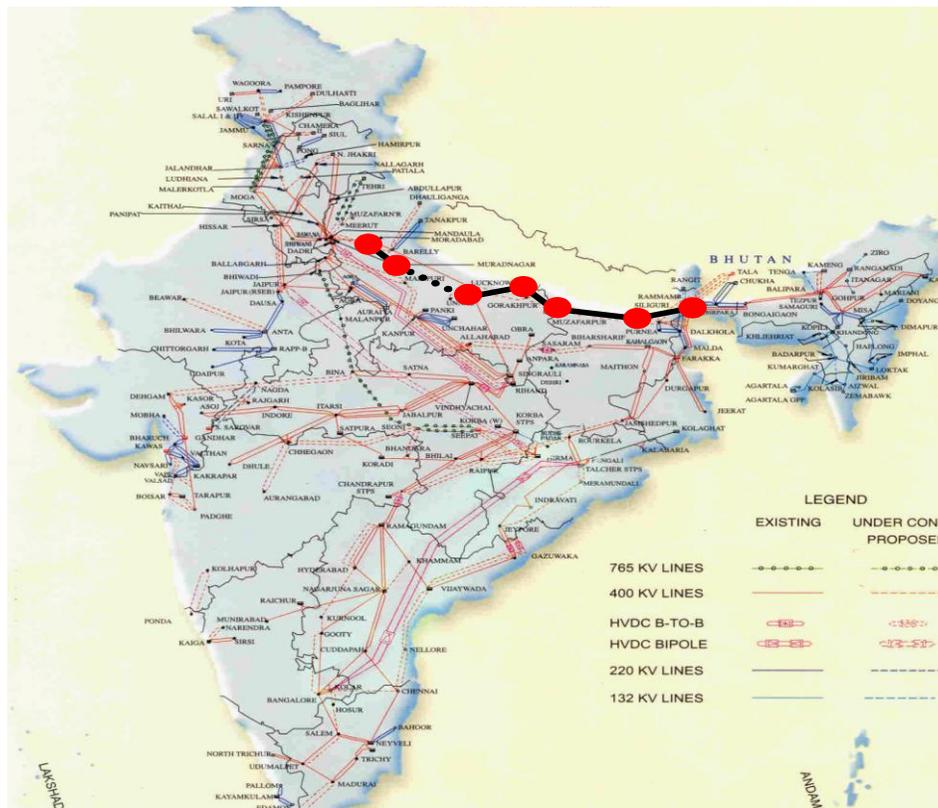
OBJECTIVE OF THIS STUDY:

In 2003 IFC committed a loan of US \$75 million to Powerlinks Transmission Limited (PTL) a joint venture between the private utility Tata Power Company Limited (51% of PTL), and the Government of India (GoI) owned Power Grid Corporation of India Limited (PGCIL, - 49% of PTL) to establish the Powerlinks Transmission Project. The Project involved construction of five 400 kV and one 220 kV double-circuit transmission lines of about 1,200 km from Siliguri (West Bengal) to Mandaula (Uttar Pradesh, near Delhi), with a capacity of about 3,000 MW on a build, own, operate, maintain and transfer - BOOT basis. The term of the BOOT is 30 years, during which PTL will make available its entire capacity to PGCIL. The purpose of the transmission system is to expand the capacity of the Indian grid, connecting the power surplus regions of east and northeast India with the power deficit region of north India. PTL commenced construction in November 2003 and achieved commercial operation in 2006. This is the first private sector transmission project in India as well as in a developing country in Asia.

An interesting feature of the project is that it enabled evacuation of power from the 1,020 MW run-of-the-river Tala Hydropower Project (Tala HEP) in Bhutan, which is currently operated by Druk Green Power Corporation Limited (DGPCL), a Government of Bhutan company. Power from Tala would not have been evacuated without PTL as it required specialized 400KV double circuit transmission lines, which were not available. PTL won the tender to build these much

needed transmission lines. The PTL transmission lines are now a vital part of the Indian transmission network and bring in much needed power from a power surplus Bhutan to a power hungry India, *contributing to both Bhutanese and Indian growth.*

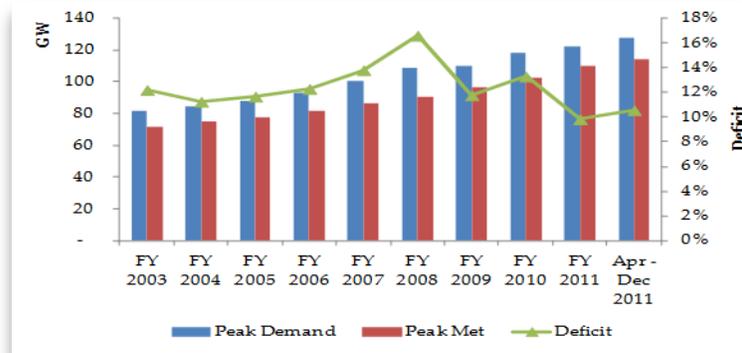
The objective of this study is to assess the employment effects of the Powerlinks project in both India and Bhutan. Wherever possible, an effort was made to assess over development impact on welfare of people in India and Bhutan.



THE POWER SECTOR IN INDIA:

India has faced a serious imbalance in its power requirements and supply since 1980s. It is characterized by shortage and supply constraints. Although the total supply of power in India has risen at approximately 10% during 1970 -2008/9, the demand for power, particularly commercial power, has been growing even more rapidly. As India faces severe peak load deficit, hydropower is especially valuable as it can cater to peak load demands during summer

and is also a cleaner source of energy. The Indian government imports power from Bhutan (which has surplus hydropower) in order to meet its peak load demand and reduce power deficits. The transmission sector plays a vital role, as it enables seamless flow of power to the various distribution entities across the country.



CONCEPTUAL FRAMEWORK:

By facilitating the setting up of the transmission lines IFC helped generate *two* main categories of employment.

Category 1: The first category of employment effects are created in the *process of construction and maintenance* of the new transmission lines. Category 1 jobs are created through 3 main channels

a) Direct effect: jobs that were created by PTL employing additional labor and professional staff (permanent and temporary) to build (over 5 years) and later operate the transmission (over project life for 20 years).

b) Indirect effect: The construction and O&M of the power transmission lines in India requires supplies from other sectors like cement and cables. The additional jobs created in the supply chain (backward linkage) are the *indirect* effects.

c) Induced effect: The additional workers in PTL and also in firms supplying to it, now spend more on household consumption items like groceries, curtains, furniture etc. –which creates additional employment in various other sectors throughout the economy, creating a multiplier of further demands. This spillover effect is called *induced* effect.

Category 2: of employment effects come from jobs that are created due to an increase or improvement in power supply: i.e. by removing or reducing an existing constraint on production of various sectors. This employment effect, that we call “**second-order growth effects**” is the most crucial channel through which infrastructure projects help create jobs. Power is an important factor of production. An increase in supply of power induces an increase in power consumption which stimulates industrial production, growth and hence employment. Secondly, an increase in power supply helps improve its reliability, which is a very critical constraint on industrial output and growth. Data from Enterprise Surveys across the developing world reveal that the private sector lists unreliable power supply as one of its top constraints. This is particularly true in India, where power outages cause considerable losses for the private sector. A large proportion of firms in India buy generators to mitigate such losses from erratic power supply. Therefore any improvement in reliability of power supply will help firms reduce their losses, (due to power outages) and increase their output and jobs.

Most studies that assess employment impacts of infrastructure often focus only on Category 1. Further, within Category 1, policy makers often tend to focus only on direct employment. One of the reasons for this is that it is methodologically challenging to assess employment effects of power supply, especially transmission networks, which explains why there is very little literature at the project level.

The study tries to provide a comprehensive assessment of the different types of employment effects of the PTL project. In summary, the study examines the following:

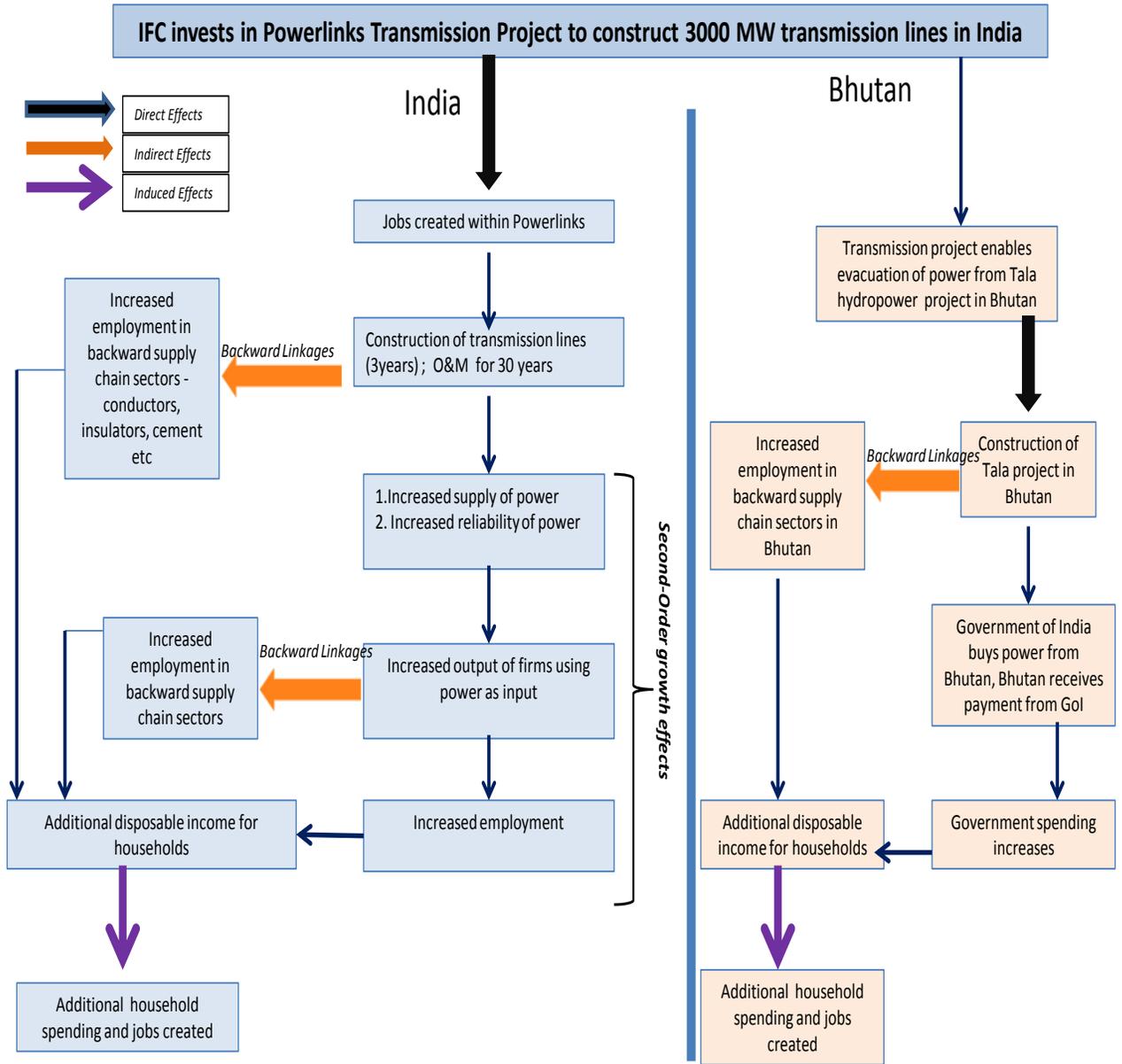
a. Category 1 job effects

- a) Direct
- b) Indirect
- c) Induced

b. Category 2 job effects: second order growth effects

- a. Effect of increase in power supply on employment
- b. Effect of increase in reliability of power supply on employment

Figure 1: Chain of effects on employment of the Powerlinks Transmission Project



METHODOLOGY AND DATA

To estimate the different channels of employment effects we used a mix of 3 main methodologies.

1. To estimate Category 1 job effects (jobs created in the process of construction and maintenance of the power transmission system) – direct, indirect and induced job effects we used the *Input-Output* approach.
2. To estimate Category 2 second order growth effects of increased power supply we used a time series *VECM econometric model* - that models the direction and magnitude of the relationship between electricity consumption and employment using data over 1970-71 to 2008-09.
3. For measuring the effect of reliability of power supply on employment we used a *step by step estimation model* with data from 2005 Enterprise Survey of India. This analysis is a subset of the overall Category 2 job effects to especially focus on how important reliability of power is for firms.

In India we used data from the Planning Commission, Annual Survey of Industries, Central Electricity Authority, power statistics from state governments., and also supplemented the secondary data with primary interviews with a variety of stakeholders like Central Electricity Authority, PTL, Ministry of Power, the distribution and generation utilities of state governments, representatives of the private sector through the Confederation of Indian Industries (CII) of Delhi, West Bengal and Bihar. In Bhutan we used data from National Bureau of Statistics, Ministry of Hydropower, Ministry of Labor, Bhutan Power Corporation Limited, and also data collected through interviews with the government. Besides we also conducted interviews with various government officials in the Ministry of Hydropower, Druk Power Corporation Limited, Ministry of Employment and Labor, National Statistics Bureau, Ministry of Economic Affairs etc to get a better perspective of the issues involved.

LIMITATIONS OF THE STUDY

The employment effects are estimated based on the incremental 1020 MW which comes from Tala Hydroelectric plant in Bhutan. These results are conservative estimates as the PTL transmission line has a capacity of 3000MW. Second, in 2004-05 the informal sector employment was six times that of the formal sector. Due to limited data on informal employment, this study only analyses the effects on formal employment. Hence, the results of this study, i.e. the effects on employment are conservative estimates which in most cases only bring out the effects on formal employment. Third, the category 1 employment effects are based on a simplistic assumption of a static relationship with a constant production function which does not allow the analysis of dynamic relationship between the outputs of one sector to that of others. Additionally, as improvement in power reliability is likely to shift the static production function relationship upwards, the category 1 estimates are also conservative. Last, although, the incremental government revenue for Bhutan is likely to have induced employment effects in Bhutan, however, due to the lack of Input-Output Tables for Bhutan this effect has not been analyzed. Overall, the results of this study are based on certain simplifying assumptions, which make the estimates of employment effects fairly conservative. Finally, the assessment of reliability of power on employment is built on data from Enterprise Surveys, and uses assumptions to move from one step to the next. Even though the numbers may not be very precise, it does give us a sense of the magnitude of the effect- which from qualitative interviews with the private sector is quite significant.

CATEGORY 1 EFFECTS: *Jobs created during construction and O&M* To estimate the direct, indirect and induced employment effects created through construction and O&M of the transmission lines of PTL, we developed an Input-Output model.¹ A detailed technical note explaining the Input-Output approach is given in Annexure 1. The Input-Output model was used to assess the employment effects during (i) construction- 2003-2007 and (ii) O&M of the system-2008-2028. The employment effects include the following:

Our analysis used the 2006 Input Output tables for India obtained from Central Statistical Office in India. We supplemented the Input-Output table with other data on project investment and also PTL's forecasted data on projected revenues and expenditure during the BOOT period that the company shared with us.

Employment effects during construction:

The employment effects during construction are given in Figure 1. Since we could not get detailed breakdown of data for direct employment during the construction phase from PTL, we estimated it using employment to output ratios of the sectors which directly supplied labor for construction of this project. The estimated figure shows that construction of the transmission system created 18,657 person-years² employment directly during the 2003-2007 period. The construction of the transmission line also led to another 39,144 person-years of indirect jobs in industries that supplied goods and services. In addition, the induced effect of incremental income led to an additional 52,630 person-years of employment during the construction phase. The induced employment effect is high, but considering characteristics of the Indian economy, this is not surprising. Households in India spend on an average almost a quarter of total household expenditure on food. This means a significant portion of the household income generated through new jobs would go to purchase food. This would cause more demand for agriculture outputs. However, the agricultural sector employs an average of 2 people to produce Rs 1 lakh worth of output per year. This is very high compared to other sectors. For example, electrical machinery sector requires only 0.03 people to produce Rs 1 lakh worth of

¹ Most studies that have attempted to study employment effects of infrastructure have used the Input-Output approach.

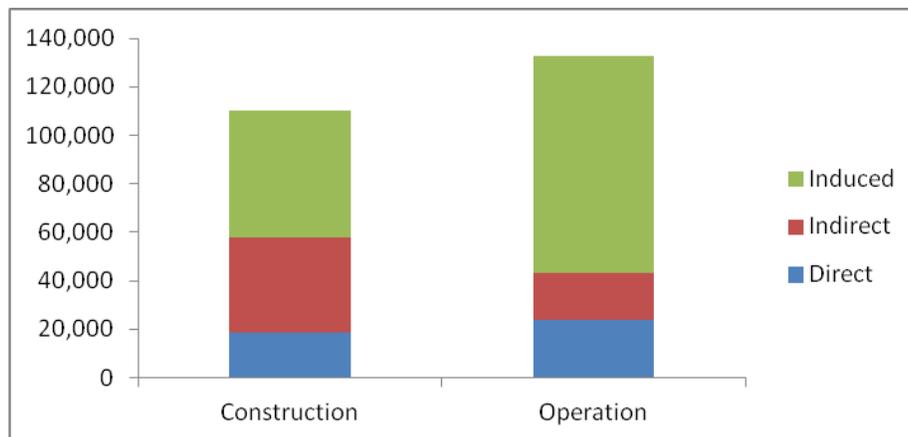
² Person years refer to number employees multiplied by number of years they work for. If an employee works for 10 years, it is counted as 10 person years.

output. Due to the high labour intensity of agriculture sector, more jobs would be created in the agricultural sector.

Employment effects during O&M

Even though one would expect the employment effects of transmission lines to be concentrated during the construction phase, O&M also creates significant employment due to the longer economic life of the infrastructure asset. In comparison the construction phase is short, lasting only 3-4 years in this case as compared with the 25 years of the BOOT of the entire project. The direct jobs are those created by PTL and include the technical and professional staff needed to operate and maintain the transmission lines. We estimate that PTL will create a total of 132,532 person years of employment (or 6,627 jobs)³ through direct, indirect and induced impacts through expenditures on O&M during its BOOT life.

Figure 2. Total employment effects of PTL (Person years)



³ Converting person-years to person or jobs could be misleading because the duration of jobs are different. A job that last for one year cannot be compared to that which lasts for 20 years. Hence person- year is the appropriate unit. But to just convey broad estimates we have converted person -years to number of jobs assuming that all jobs will last for the life of the project (i.e., 20 years).

Combining both construction and O&M phases, the project would create, directly, indirectly and through induced effect about 242,946 person-year employment over the 25 year life period of the project. Translating person-years to a rough job equivalent, this would mean about 9700 additional jobs. The sectors in which these additional jobs would be created are given in Annexure 1. Induced employment effect is the largest contributor to employment. What is interesting is that even though sectors like agriculture and forestry appear not to have a direct relationship with the power sector, in fact are most strongly affected sectors in terms of employment effects through induced channels. This is because the agricultural sector has the highest employment to output ratio and one quarter of the total household expenditure goes to buy primary food produced by the agriculture sector. Thus, the total number of jobs is highest in the agriculture sector, followed by the trade and the transportation sectors.

Employment Multipliers:

Table 1 shows the employment multiplier- i.e. how many additional jobs would be created throughout the economy if PTL creates one job during the construction and O&M.

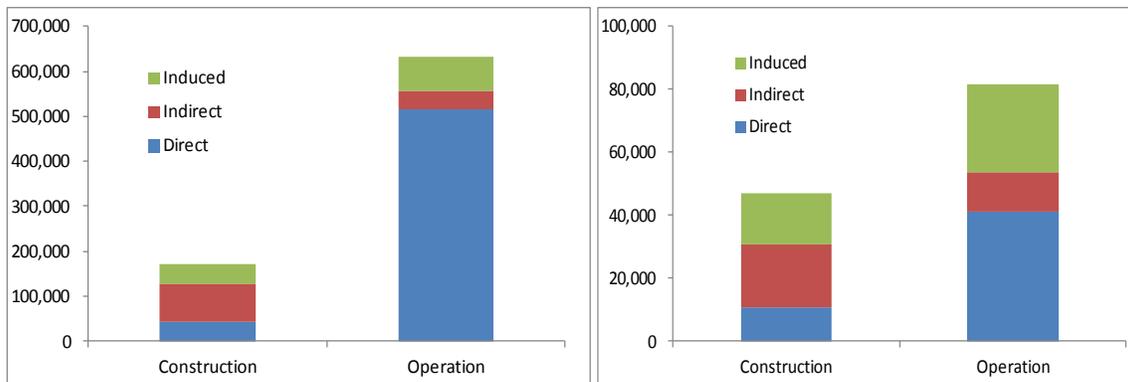
Table 1: Number of person -years created for every one direct person year created by PTL

	Construction	Operation	Total
Indirect	2.1	0.8	1.4
Induced	2.8	3.7	3.4

Table 1 shows that for every 1 person-year employment PTL created during the construction of the transmission system, it created 2.1 person-years employment in the supply chain and additional 2.8 person-years employment through the induced effect. Similarly during the operation, for every 1 person year employment created directly within the PTL, another 0.8 extra person-years employment would be created in the supply chain and another 3.7 person year employment through the induced effect.

Impact on Household Income and GDP

Figure 3 a) shows impact of the construction and operation of PTL transmission lines on GDP and household income. The GDP impact is much higher during the operation phase (2008-2028) because of its longer time span than construction. The project would contribute Rs.632,303 lakh to GDP over the 2008-2028 period (about Rs 33,279 lakh annually) from its operation. The direct GDP impact is high during operation because of the high operating surplus of PTL during its operation. Figure 3 (b) shows the impact of the project on household income. During the construction phase (2003-2007), the PTL would have contributed a total of Rs 47,000 lakh (US \$94 million) to household income. This contribution to household income through construction of the transmission lines would have had significant impact on poverty, especially considering that the construction of the transmission line passed through some of the poorest states in India like Bihar, Jharkhand, Uttar Pradesh, and West Bengal.



(a) GDP

(b) Household Income

Conclusion #1:

The Powerlinks project will create a total of about 243,000 persons-year employment (roughly about 9,700 additional jobs) during its construction and O&M phases through direct, indirect and induced channels over the 25 year life of the project. The project has an employment multiplier of 4.8, which means that for every one direct person year employment the project creates, an additional 4.8 persons- year employment is created through indirect and induced effects.

The employment created during construction added Rs 47,000 lakh (US\$94 million) to household income, which has special implications for poverty reduction as the transmission lines were constructed through some of the poorest states in India.

This section focuses on the second-order employment effects of the project. By increasing transmission capacity within India, Powerlinks helped bring power from India’s neighbor country Bhutan, which is rich in hydropower, to a power scarce India. This helped increase availability of power in the states of Bihar, West Bengal, Orissa, Delhi and Uttar Pradesh. When Powerlinks transmission lines were commissioned the plan was that the power would benefit mainly the northern grid. Subsequently the government allocated most of this power from Tala to the eastern grid. ⁴

The following table shows the allocation of Tala power to the states. This shows that the two largest beneficiary states of Tala power brought in by PTL are West Bengal (39%) and Bihar (26%). So we decided to focus on these two states to study the effects of power supply on employment.

Table2: Allocation of Power from Bhutan Tala Project										
Installed Capacity (MW)	Bihar		Jharkhand		Delhi		Orissa		West Bengal	
	%	MW	%	MW	%	MW	%	MW	%	MW
1020	25.5	260	11.46	117	5.5	57	4.2	43	38.25	390
<i>Source: Central Electricity Authority</i>										

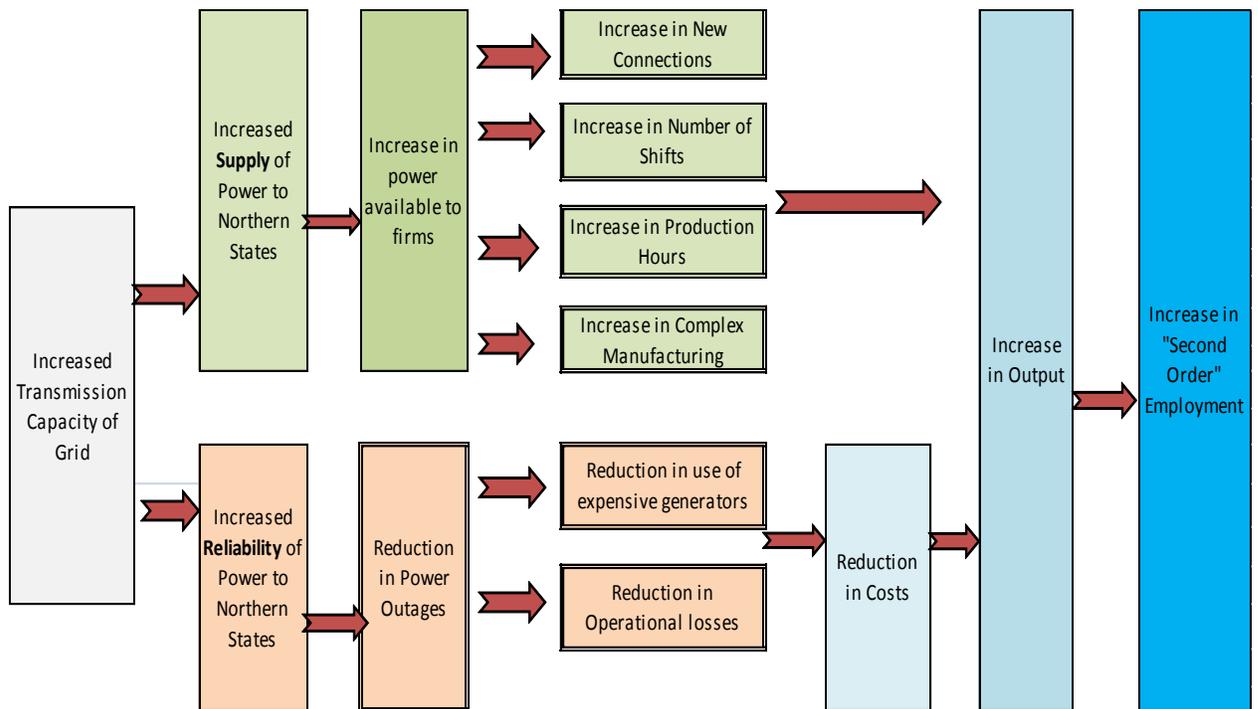
To understand the second order employment effects of Powerlinks, we looked specifically at 2 relationships. *One*, the impact of increased power consumption (as a result of increased power supply) on employment,⁵ and *two* the impact of increased reliability of power supply on employment. While one can assume that an increase in power supply would increase its reliability, we chose to look more deeply at the issue of reliability because our interviews with the private sector in India revealed how critical reliability was for the private sector (more detailed discussion in later section)

⁴ Discussions with CEA, Central Electricity Authority

⁵ The study only looks at formal employment as a long time series of the informal employment is not available. In India the informal sector is surveyed every 5 years.

The causal chain for second order growth effects is outlined below.

Figure 2: Causal Chain for estimating second-order employment effects



CATEGORY 2 A: HOW DOES INCREASE IN SUPPLY OF POWER AFFECT EMPLOYMENT?

An increased supply of electricity in a power deficit country like India implies power availability which induces increased power consumption. This increased power consumption allows firms to operate machinery at capacity (which was otherwise operating below capacity due to lack of power), plan longer production cycles, adopt more electricity-intensive and productive methods, and hence expand their output and employment. In this section we explore the relationship between electricity consumption and employment, especially to determine the direction of causality.

Econometric Model⁶

As all the three endogenous variables are stationary in first differences⁷ we use a Vector Error Correction Model⁸ (VECM) to empirically validate the relationship between increased electricity consumption and higher employment. VECM is a dynamic time series model that allows a dynamic interrelationship between variables. This time series model allows us to measure both the long term relationship between the endogenous variables (electricity consumption, employment and real GDP) and also estimate the short term dynamics of the adjustment to the long term equilibrium relationship.⁹ As the model specifies every endogenous variable as a function of lagged values of all of the endogenous variables in the system, one can estimate the effect of current and past electricity consumption on employment and vice versa. Annual time series data over 1970-71 to 2007-08 for India and over 1980-81 to 2009-10 for Bihar (including Jharkhand) and West Bengal was used to empirically test the model. The annual data on real GDP (in 1999-2000 prices), electricity

⁶ A detailed explanation on the model used for this section is in Annexure 3

⁷ If all the variables were not stationary in first differences, an ARDL model would have been used.

⁸ VECM is a dynamic time series model which allows us to analyze the dynamic impacts of random disturbances on the system of variables. The model specifies every endogenous variable in the system as a function of the lagged values of all of the endogenous variables in the system. It allows us to estimate the long run relationship between endogenous variables and also estimate the short-term dynamics of adjustment.

⁹ References for this section: Chang, T., Fang, W., Wen, L.-F. (2001); "Energy consumption, employment, output and temporal causality: Evidences from Taiwan based on co-integration and error correction modeling techniques", *Applied Economics* 33, 1045-1056. Stern, D.I. (2000); "A multivariate analysis of the role of energy in the US macroeconomy", *Energy Economics* 22, 267-283. Ghosh, S. (2009); "Energy supply, employment, real GDP in India: Evidences from co-integration and Granger-causality tests", *Energy Policy*, vol. 37, pp. 2926-2929.

consumption and employment was obtained from Reserve Bank of India, Ministry of Power and Ministry of Statistics and Program Implementation, Government of India. Data availability controls the choice of the time period of the analysis. Real GDP, electricity consumption and employment are transformed into natural logarithms to reduce heteroscedasticity.

Results:

a) *We find a causal relationship flowing from electricity consumption to employment*

The relationship between electricity consumption, economic growth and employment has been a subject of many empirical studies.¹⁰ A block wise Granger causality¹¹ test is used to determine the direction and strength of the causal relationship between employment and electricity consumption in India, and also for two beneficiary states - West Bengal and Bihar¹² which receive the majority of the power being transmitted via Powerlinks Transmission Ltd. The causality only flows from electricity consumption to employment¹³, i.e. increase in electricity consumption will enable the firms to expand operation and operate at a higher utilization level resulting in an increase in employment. This causality is statistically significant for India, West Bengal and Bihar¹⁴.

¹⁰ Ghosh (2009) establishes growth in electricity consumption is responsible for high level of employment in India. Other similar studies are Chang et. al. (2001); Stern(200) etc.

¹¹ The Granger Causality relationship is a simple approach to assess the direction of this causality. Series X is said to Granger-cause Y if the prediction error of Y declines by using past values of X in addition to past values of Y.

¹² The State of Bihar was divided into Bihar and Jharkhand in 2000. In this study, Jharkhand is included in Bihar as this study looks over a period of 1970-71 to 2007-08.

¹³ This result is not driven by any third variable and hence is an indication of direction of causality.

¹⁴ As the p-values are less than 0.05(0.001) for India (West Bengal and Bihar) the results are statistically significant at 5% (1%) level of significance.

Direction of Granger Causality (p-values)

	India Elect.	India Emp.	West Bengal Elect.	West Bengal Emp.	Bihar Elect.	Bihar Emp.
Electricity does not Granger Cause		0.04*		0.000**		0.000**
Employment does not Granger Cause	0.4907		0.4470		0.7957	

*Note: Probability values are reported. A * indicates rejection at five percent level and ** indicates rejection at one percent level of significance.*

b) Convergence to equilibrium after a shock in electricity consumption takes 6.25 years in India and 3.6 years in West Bengal. The coefficient for Bihar was not statistically significant.

Annexure 3 outlines the VECM model used. Shock to the endogenous variables (such as increase in electricity consumption as a result of increased electricity supply) should result in adjustment dynamics which may ultimately converge to the stable long-run equilibrium relationship. This model allows us to measure both the equilibrium relationship between the endogenous variables (electricity consumption, employment and real GDP) and the dynamics of adjustment. Estimating the equations with employment as the dependent variable (Annexure 3, Equation 1) separately with data for India, West Bengal and Bihar gives the relationship between electricity consumption and employment. Table 2 shows the corresponding speed of convergences to the long-run equilibrium.

Table 3: VECM Model – speed of convergence to long run equilibrium

	India	West Bengal	Bihar
Speed of Convergence (Coefficient on ECT_{t-1})	-0.16	-0.28	-
Convergence duration (yrs) $1/$ Coefficient on ECT_{t-1})	6.25	3.6	-

Note: Statistically significant coefficients reported.

Table 3 shows that the speed of convergences or the coefficient on Error Correction term¹⁵ (ECT_{t-1}) is statistically significant for India and West Bengal, however it is not statistically significant for Bihar. This implies that a long run relationship between electricity consumption and employment holds true for India and West Bengal, whereby any change in electricity consumption will result in a permanent change in employment. Furthermore, as the speed of convergence is of the correct sign it implies that any disturbance in the explanatory variables will result in short term adjustment dynamics in the dependent variable which will eventually converge to the long run equilibrium. For example, in the India model the coefficient is -0.16, which suggests that convergence to equilibrium after a shock in electricity consumption will take 6.25 years. Similarly, the convergence in West Bengal would take 3.6 years.

- c) ***The elasticity of employment with respect to electricity consumption is 0.53 for India and 0.24 for West Bengal. In other words, a one percentage growth in electricity consumption in India will result in a 0.53% growth in employment for India, as additional power consumption will increase output and will result in employment growth.***

The long run equilibrium relationships are¹⁶:

India	$Log emp = 0.53Log elec - 0.24Log GDP$ (5)
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West Bengal	$Log emp = 0.24Log elec - 0.89Log GDP$ (6)
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¹⁵ Error Correction term is the long-run equilibrium relationship, statistical significance of its coefficient provides support to the existence of the long-run relationship and gives the speed of convergence to the long-run relationship. See Annexure 3 for details

¹⁶ While the elasticity of electricity consumption with respect to employment is positive, the elasticity of GDP with respect to employment is negative. Since the 1991 liberalization, total employment (formal and informal sector) and GDP have grown and are positively related. However, the informal sector has grown much more rapidly than the formal sector, with a number of formal firms preferring to be informal in order to avoid the cost of registration and tax liabilities. Hence a negative elasticity of GDP with respect to formal employment is plausible as long as the elasticity of GDP with respect to total employment is positive.

d) The increased supply of power from Tala transmitted through PTL helped increase about 75,000 jobs in India in the period 2006- 2012, of which about 4600 jobs were in West Bengal over 2006-10¹⁷.

Since commissioning in November 2006, Tala hydro power plant which has a capacity of 1020 MW transmits power to India. This accounts for 2363.9 GWh¹⁸ of electricity consumption per annum, or 0.05% of India electricity consumption in 2006-07. Using equation 6, this implies 0.0265% growth in employment which translates to 74,883 new jobs in India¹⁹. Similarly, 390.15 MW of Tala's power capacity has been allocated to West Bengal which translates to 4,591 new jobs in West Bengal.

West Bengal and Bihar have received majority shares of the power allocation from Tala, yet they have responded differently. This difference could be due to two main reasons. One, West Bengal was able to reduce its transmission and distribution losses by 41%²⁰ as compared to a 9% reduction in Bihar. The incremental power supply brought in by PTL therefore was negated to some extent in Bihar due to its high distribution losses. Secondly, the total power deficit in Bihar has increased over the years from 8% to 21% because of demand growth, and so the incremental power supply brought in by PTL was not enough to have a beneficial impact on Bihar's formal employment. In West Bengal, the remaining power deficit was marginal and hence the formal private sector was able to expand and create more employment. We arrived at similar results when we analyzed the effect on reliability of power supply (next section).

Also, the estimates of employment effects are conservative as they overlook the effects in the informal economy. In 2004-05 about 95% of Bihar's²¹ employment was informal which has not been covered in this study while 80% of West Bengal employment was informal. It is expected that the informal employment in Bihar and West Bengal would have also grown as a result of incremental power supply from Tala, as informal firms are more likely to engage in power thefts to reduce cost of procuring power. These firms are usually more labor intensive and hence a small increment in power supply is likely to result in larger effects on employment. However the effects on the informal sector are not captured by our analysis.

¹⁷ The speed of convergence in West Bengal is 3.6 years as compared to 6.25 years for India.

¹⁸ After discounting Tala's generation (4323.4 GWh) for internal consumption (~ 25%) and for T&D losses in India (~ 27%, average T&D loss over 2006-07 – 2008-09) See Appendix 4

¹⁹ See Appendix 4 for calculations.

²⁰ Indiastat.com

²¹ NSSO 53rd Round, Indiastat.com

Conclusion #2

An increase in power supply from Bhutan's Tala hydropower plant transmitted through PTL's transmission lines created about 75,000 new formal jobs in India over the period 2006- 2012 , of which about 4,600 new formal jobs were created in West Bengal. The effect on informal jobs (not captured by our analysis) is expected to be much larger.

This shows that PTL has significant second order employment effects as power supply is a significant constraint for firms in India.

CATEGORY 2B: HOW DOES RELIABILITY OF POWER SUPPLY AFFECT JOB CREATION?

Importance of reliability of power supply

One constant issue we heard during our discussions with the private sector was the importance of reliability. Many industrialists said reliability was even more important than the total supply of power. Knowing exactly when power would be available and when the government would schedule a power cut helps industry plan their production schedules and minimize unexpected disruptions to their production processes. Most industry owners complained also of the large amount of costs they incur in having to install back up power generators, saying they had no option but incur these costs to keep functioning and minimize their losses. These interviews confirmed how important reliability is for the private sector to maximize their productivity.

Estimating relationship between reliability of power supply and employment

Two commonly accepted indicators of reliability of power are the number of power outages and the average duration of each outage.²² To understand the relationship between reliability of power and employment we developed a step-by-step estimation model using data from the World Bank Group Enterprise Survey for India 2005. This survey was conducted in several cities throughout India and for several manufacturing sectors, with a total of 2,286 observations. The survey asked firms detailed questions on reliability of power supply like percentage sales that a firm estimates to have lost due to power outages, the cost of accessing power from the grid, the cost of running a generator etc. Using this data we tried to estimate how many additional jobs could have been created if firms in India did not experience power outages in 2005. We established estimates of potential jobs that could have been created per firm per one less hour of power outage. Using this estimated ratio, we then apply it to the power outages experienced by firms in 2011 in order to estimate how many additional jobs that would have been created due to reduction in power outages in the states that benefitted from Powerlinks power.

²² SAIFI and SAIDI are two most commonly used industry indicators for reliability. A note on the two indicators is in the Annexure.

Estimation Model

Power outages impose two types of costs on firms ²³

A) Value of production loss .(Figure A in green below).attributable to disrupted power supply –this is the amount of output that firms lose due to lost production time, time needed to reset machines, losses and damages due to interruption of production processes

B) The additional cost firms bear to use back up power generation. (Figure B in blue below). (We ignore the capital cost of installing power generators as that cost is sunk). Instead we focus only on the additional incremental cost of running or using the generator as compared to using power from the grid.

A. Estimating potential jobs that could be created by reducing output loss due to power outages

Variable:	Definition	Comments
S	% sales lost due to power outages	The Enterprise Survey asked firms to provide estimates of percentage of sales lost due to power outages.
		
S_F	Average sales lost due to power outages per firm (Rs)	Converting percentages to volume of sales in Rs
		
S_W	Sales per worker	Labor productivity numbers from ES includes both permanent and temporary workers.
		
J_A = S_F/S_W	Additional jobs needed to produce the sales that were lost due to power outages i.e S _F	This number represents additional sales per firm that may have been realized if the firms faced no power outages.
		
J_{PO} = J_A/total hours of outages	Potential Jobs that could be created per firm per one less hour of power outage	

²³ The two factors were clearly outlined by firms that we interviewed. The estimation model is developed for industrial consumers only. However one can assume that agricultural producers would also face similar losses due to unreliable power supply.

B. Estimating potential jobs that could be created by saving the additional cost incurred in running generators as compared to using power from grid

Variable	Definition	Comments
$C_{GEN} - C_{GRID}$	Additional Cost of using generator vs. using power from grid (per kwh)	ES data on cost of running a generator per kwh and also cost of buying power per kwh
		
O_H	# of outages * duration of each outage (per firm)	Total number of hours firms were without power in a year
		
$C_S = (C_{GEN} - C_{GRID}) * O_H$	Potential Cost Savings per firm if there were no power outages	Running a generator is more expensive than buying power from grid. We assume generators run at full capacity
		
$I = R$	I= Additional Investment per firm when savings from reduced use of power generators are reinvested .	Proportion of savings that a firm would reinvest is assumed to be same as previous year's retained earnings-about 50% as per ES.
		
$A/W = \text{asset per worker}$	Ratio of total assets to worker per firm	
		
$J_G = I * A/W$	Additional jobs that would have been created with this additional investment	The cost savings are reinvested to increase assets of the firms.
		
$J_{GEN} = J_G / \# \text{ of hours of power outages}$	Potential Jobs that could be created per firm for every one less hour of power outage	Potential cost savings that firms would enjoy due to decreased use of generators is used for more productive purposes

Therefore: We estimate total jobs that could potentially be created by reducing one hour of outage is $A + B$ or $J_{PO} + J_{GEN}$

Results

Using the above estimation model with data from the 2005 Enterprise Survey for India, especially for the states of Bihar and West Bengal, we estimate that the total amount of jobs that could be created per formal firm in India by having one less hour of power outage is 0.056. This means that for every one less hour of power outage that a firm experiences in India, it can create on an average 0.056 additional jobs. There is a large variation in this estimate across states that are receiving power from PTL. (Table 4 below).

Table 4. Estimation of jobs per hour of outage

	Jobs per hour of outage per firm	Hour of outages per firm (2005)	Number of firms (2004-2005)	Potential job creation in 2005 if no power outages
Bihar	0.057	847.83	1,674	80,378
West Bengal	0.006	440.09	6,105	15,694
Jharkhand	0.066	1,262	1,607	133,019
Orissa	0.101	347.90	1,749	61,343
Uttar Pradesh	0.049	654.25	9,582	308,902
Delhi	0.009	363.07	3,156	10,862
Total	0.056	678.00	136,353	5,193,480

As a thought experiment, we then asked the question - how many jobs could have been created in 2005 if firms in India faced no power outages? Table 3 performs an illustrative calculation at national level and for some selected states. According to the Enterprise Survey in 2005, a firm suffered on average 678 hours of power outages in one year. We estimate that avoiding one hour power outage allows a firm to add 0.056 new jobs. Combining this information with data from the Annual Survey of Industries (ASI)²⁴ for total number of firms in India in 2005, we find that if there had been no outages at all in 2005, the country could have created 5.2 million additional formal jobs in the manufacturing sector in India. This amounts to about 1.2% of the total labor force in India.²⁵ Although the additional informal jobs could not be estimated due to data inadequacies, it is expected that the effect would be higher than that in formal sector.

²⁴ This survey only covers the manufacturing sector.

²⁵ India had a labor force of 455,000,000 in 2004.

Did PTL help improve reliability of power supply in beneficiary states?

Interviews with the government revealed that reliability is a function of two main factors. The first important determinant of the level of power reliability of power outages in a state is the overall power deficit or surplus. The power deficit in a state is a function of the difference between total supply and total demand in a state. So an increase in power supply would definitely impact the reliability of power, but if demand increases at a faster pace, this effect on reliability may not be so large. The second important determinant of power outages or reliability is the efficiency of the distribution network. Our initial hypothesis was that states that received additional power from PTL would have experienced less power outages after the transmission line was commissioned in 2006. Having established a relationship between power outages and jobs for 2005, our objective was to track down the current level of power outages in the beneficiary states, and using the jobs per outages ratio established for 2005, to estimate the jobs that would have been created by making power supply more reliable, attributing a proportion of that increase to Powerlinks.

Reliability of power in West Bengal:

Receiving power from Tala has helped West Bengal manage its power system more effectively because power from Tala is abundant in summer when hydropower is at its maximum potential and demand for power also is high during summers. So Tala power helps West Bengal manage its peak demand.²⁶ The power reliability situation has greatly improved in past few years. While Tala power has been a large reason for this improvement, it is not the only reason. West Bengal government has also recently undertaken a large number of distribution reforms like unbundling the state power utility, creating mobile units to attend to power outage complaints (which have further reduced the number of hours for an average outage). The government-owned WBSEDCL (power distribution company) also instituted a number of reforms to reduce illegal power connections, installing better quality meters etc.

The data received from WBSEDCL (which was corroborated by the private sector) shows a clear reduction in power outages. Our interviews with Confederation of Indian Industries (CII) confirmed that there has been a reduction in power outages in West Bengal. We had already established a jobs per hour outage ratio of .006 using data from Enterprise Survey. Since the

²⁶ Discussions with Mr Rajesh Pande, Chairman and Managing Director West Bengal Distribution Company

number of hours of outages per firm reduced from 2005 to 2010 from 440 hours to 180 hours, we multiply this difference in hours of outages with the jobs per hour outage ratio, *we find that the total additional jobs created by the reduction of power outages in West Bengal is 10,636.*²⁷

The reduction of power outages in West Bengal cannot be entirely attributed to Powerlinks. Assuming that improved reliability can be attributed to increase in power supply and distribution reforms in a ratio of 70:30, 7445 additional jobs were created as a result of improved reliability due to improved supply.²⁸ As 21%²⁹ of the incremental power available to West Bengal over 2005-06- 2008-09 is from Tala via PTL's transmission line, we can attribute creation of 1589 additional formal jobs to reduction in power outages due to the incremental power supply from Tala. This is a conservative result as it does not include the additional informal jobs created.

Reliability of power in Bihar:

Since Bihar is the second largest recipient of power from Tala we decided to also study the change in the power sector in Bihar over the last few years. Based on interviews with the government and also a diverse set of industrialists we concluded that power reliability had not improved in the past years. While government officials said that while Tala power had helped Bihar manage its peak load in summer there was still a large power deficit in the state, and in general industries had assured power for only 8-10 hours in a day.³⁰ The feedback from the private sector was even more dismal. All industrialists we spoke to complained of the severe constraint that power placed on them. In fact the industry complained more about reliability than about total supply. One of the largest industrialists³¹ in the state explained the heavy cost that power outages impose on his output. He said he faced about 80-90 trippings every year. Every single tripping costs him about 2 hours of production. Since his total output is about 150 tons per hour, he loses about 2100 tons of his output every single day due to outages. Besides, he suffers a high level of costs due to damages. He said the an outage for even a second leads to

²⁷ According to Annual survey of Industries West Bengal had 6818 industries in 2010.

²⁸ The Managing Director of WBSEDCL estimated that the major reason why his state has been able to reduce outages is because power supply increased. He said power from Tala brought through PTL was especially valuable. Based on our discussions with him, we use a rough estimate of 70:30 as the reasons for reduction in power outages due to increased power supply and due to distribution reforms.

²⁹ Calculated using data from indiastat; incremental power available = 5522Gwh (30331-24509) and 1240.1 Gwh of Tala power is allocated to WB (Annexure 4)

³⁰ Interviews with Mr Lallan Prasad, Member (Generation), Bihar Electricity Board, Mr Y. P. Thakur, Chief Engineer, Bihar Electricity Board

³¹ Name of the industry is kept confidential on his request.

losses and damages as he has to reset his production process and throw away the material that was in process. He said that if he was given assured power supply he could immediately increase his output by 15% and create more jobs. Other industrialists we interviewed in the food processing industry and cattle feed industry had very similar complaints.³² They elaborated on the high cost they incur in setting up generator sets and running them on diesel. Therefore we concluded that Bihar had not seen the beneficial impact of increased power supply mainly because power shortage in Bihar is huge and the state has very significant regulatory and distribution inefficiencies that it would perhaps need a much larger increase in power supply coupled with reforms in other area to actually show impact. The informal sector of Bihar is labor intensive and employs 94% of the labor force. Hence even a small increase in power reliability, is expected to increase the productivity and employment of these informal firms. However, the magnitude of this effect cannot be estimated due to the lack of data

Conclusion #3

Reliability of power supply is a very important issue for firms in India. If there had been no power outages at all in 2005, the country could have created 5.2 million additional jobs in the manufacturing sector in India. This amounts to about 1.2% of the total labor force in India.

By reducing power outages, West Bengal created an additional about 10,637 jobs from 2005 to 2010, of which about 1600 jobs can be attributed to the incremental power supply from Tala brought by PTL lines. The job effects of increased reliability is a subset of the job effects discussed in the earlier section (of increase in power supply and consumption)

Conclusion #4

Category 2 employment effects (second order) are much larger than Category 1 (direct, indirect and induced) employment effects. An increase in power availability to firms creates additional formal jobs in West Bengal due to simultaneous regulatory reforms, but does not have any significant effect on steady state formal employment in Bihar which has a large power deficit and a weak regulatory system.

³² List of industrialists interviewed is in the Annexure.

DEVELOPMENT IMPACT IN BHUTAN:

The Tala Hydroelectric project in Bhutan is an example of the largest successful cross border electricity exchange project in South Asia. The 1020 MW project generates approximately 4323.5 GWh of power per annum and exports approximately 75% to India. This cross border sale of power to India makes up approximately 30% of Bhutan's export earnings. The Tala project like most other hydropower plants in Bhutan was financed entirely by the Government of India by way of grants (60%) and loans (40%) under a bilateral agreement. The agreement envisaged that India would fund and build the project, and later import the hydropower from Bhutan. Under the agreement, India was to simultaneously construct a transmission network that would enable the evacuation of this power from Bhutan and connect it to the Indian grid. Power Grid (PGCIL), a 100% government owned entity that constructs, operates and maintains the transmission network of India was responsible for constructing the transmission lines that would enable the evacuation of power from Bhutan. Powerlinks, a joint venture between PGCIL and Tata Power Company Limited, one of the largest private utilities in India was funded by IFC and is the first PPP projects in power transmission in India.³³

According to Bhutanese officials the Indian government brought most inputs from India during the construction of the project. The funding, raw materials and labor were all mostly Indian. The significant impact on the Bhutanese economy however comes from the effect of export earnings from the sale of this power to India. (details discussed in next section).

Obviously, the entire development impact of Tala cannot be attributed to PTL. What PTL did do however was enable the evacuation of power and bring in export proceeds into Bhutan, which have a very significant impact on the government's revenue and the country's GDP. Here we asked ourselves the counterfactual question. What if PTL had not constructed the transmission lines? In all likelihood, if PTL had not constructed the transmission lines, PGCIL would have had to do so on its own using its own resources. Nevertheless, PTL played an important role and indirectly contributed to the Bhutanese economy. Therefore the following discussion on

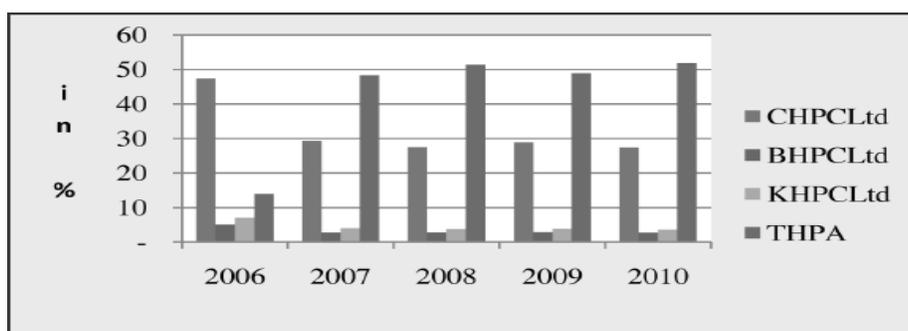
³³ Other sources of funding for PTL were Asian Development Bank (ADB), Infrastructure Development Finance Company (IDFC), and State Bank of India (SBI).

the development impact of the Tala project on Bhutan is not to attribute its effects to PTL but present it as an additional indirect beneficial contribution that PTL had on Bhutan.

Contribution of Tala Hydro in Bhutan's Economic Development

The power sector is the largest contributor to Bhutan's economic output (GDP). In 2010, the power sector contributed 17.6% of GDP.³⁴ Of the 4 main hydropower plants in the country Tala (THPA) is the single largest, contributing a value add of almost 52%, followed by Chukka Hydro plant, which is about 27%. How important the plant is to the Bhutanese economy can be judged by Table 5.

Contribution of Electricity Generation Plants



Source: National Accounts Statistics, 2010, National Statistics Bureau, Bhutan

Table 5. Contribution of Tala Hydropower to Bhutan's GDP

	Contribution of electricity sector to GDP (%)	Share of Tala in total electricity sector (%)	Contribution of Tala to GDP (%)
2006	13.1	13.0	1.7
2007	20.4	49.0	10.0
2008	21.1	51.0	10.7
2009	19.3	49.0	9.5
2010	17.6	52.0	9.2

Source: Statistical Yearbook of Bhutan 2011; National Account Statistics 2010

³⁴ Bhutan's excessive dependence on hydropower is also a matter of concern for the government, especially with the increased vulnerability to impact of climate change. (Discussions with Director-General, National Statistics Bureau, Government of Bhutan.)

The total revenue generated from Tala hydropower project (from both internal sales and export) was more than 55% of the total government revenue in 2007 and 2008; about 50% in 2009 and 42% in 2010.³⁵

Tala's contribution to employment in Bhutan:

Category 1- direct and indirect jobs

The construction of the Tala hydropower plant created a large number of jobs but most employment effects were for India, not Bhutan. This is because most of the construction work was carried out by Indian contractors, who brought almost the entire labor force from India. The indirect employment effects (jobs created in the supply chain) were also minimal within Bhutan during the construction phase as most goods were imported from India.³⁶ Therefore the direct and indirect employment effects of the construction of this plant in Bhutan were more in India than within Bhutan itself.

The employment benefits for Bhutan however came during the operations and maintenance (O&M) phase, after the plant was constructed and commissioned in 2006. In 2011, Tala employed 688 people and 70 contract workers to run and maintain the plant, most of whom are Bhutanese.³⁷ This represents 13.5% of total employment provided by the electricity and water sector, and is Tala's *direct* effect on Bhutanese employment.³⁸

³⁵ All revenues from electricity sales generated by Tala hydro is not counted as government revenue, it is accounted in the value of export. What actually government receives from the power plant is corporate tax and dividends. The government also gets 15% of the total electricity generation as a royalty. The sales revenue goes to Druk Green Power Corporation, which is a government owned corporation to manage generation of electricity in Bhutan

³⁶ Discussions with Bhutan Power Corporation Limited (BPCL)

³⁷ Discussions with Mr. Kencho Dorji, Chief Engineer, Tala Hydropower Plant.

³⁸ Total employment in Bhutan as of 2011 is 323,700. Labor Force Survey Report 2011, Ministry of Labor and Human Resources, Thimphu, Bhutan.

The indirect and induced effects of the project could not be calculated as Bhutan does not have an Input/output table.³⁹ In any case, we did not expect the indirect and induced effects to be significant within Bhutan.

Category 2: Second order employment effects of Tala in Bhutan

We expected second-order growth effects (of increased availability of power supply) from Tala to also be minimal for Bhutan since this project was mainly constructed with the help of Indian government with the objective of exporting most of the power to India. Only a small percentage (about 22-25%) of Bhutan's hydropower is consumed internally. One significant impact of the Tala hydropower project on Bhutanese employment is that with increased power generation from Tala, Bhutan was able to allot additional industrial licenses, especially to those industries like steel that are more power intensive.⁴⁰ The government was able to expand the *Pasakha Industrial Estate* that is situated very close to the Tala power plant, and grant 18 additional industrial licenses for 11 KV industries and 11 more licenses for 66kv industries. These additional 29 industrial units added approximately 480 jobs.⁴¹ These jobs are directly attributable to the Tala project. Government officials confirmed that these additional industrial units have come up only because of the additional capacity of the Tala power plant, since the government would not have granted them licenses without this additional power from Tala. The government restricts the number of industrial licenses, especially those that are power intensive in an effort to manage its power supply. Even though Bhutan is a power surplus country, most of the power comes from hydropower through run of the river projects, which shrink to almost 20% of their capacity in winter. Because of this fluctuation in winter months the government is careful about managing industrial demand. On the other hand, the issue is also the capacity of the industrial sector to consume power. The government has about 305 MW connected load for the industrial sector but only 60% of it is consumed.⁴² The government (with the assistance of the Indian government) plans to install 10,000 MW by

³⁹ According to the National Statistics Bureau, the government is in the process of constructing Input-Output tables for the country with the help of the IMF.

⁴⁰ Discussions with Bhutan Power Corporation and Department of Hydropower and Power Systems, Government of Bhutan.

⁴¹ Establishment Census 2010 recorded exact employment figures for 4 of the 29 industrial units that were especially extracted for us by the Ministry of Labor. Extrapolating from those number, we roughly calculated a total number of jobs of about 480.

⁴² Discussions with Department of Hydropower and Power Systems, Government of Bhutan.

2020 under which 10 additional hydropower plants will be set up. Simultaneously the government plans to set up industrial estates in western Bhutan, with the additional power anticipated. Power is thus not just a very important stimulant for overall Bhutanese GDP growth, but also every additional hydropower plant has stimulated the industrial sector and employment.⁴³

Tala's contribution to the welfare of Bhutanese people

Most hydropower produced in Bhutan is exported. Hydropower is therefore a primary source of revenue for the government. This additional revenue enhances the government's capacity to invest in social programs. This section tries to estimate the welfare effects of this increased government revenue brought in by Tala on the people of Bhutan.

The nation which brought gross national happiness to the world promotes health and education for all; education in government schools and institutes and medical treatment is free for all citizens. In 2010, the government spent about 10 % of GDP on health and education. This section tries to explore the link between GDP benefits from incremental hydropower production to education and health care, which indirectly improves the quality of jobs⁴⁴.

A simple National Accounting model allows us to estimate how the increase in GDP caused by Tala affects the welfare of the Bhutanese people especially in terms of education and healthcare. Equating GDP by production approach and GDP by expenditure approach we can estimate expenditure on education and healthcare as a result of electricity production in Tala and thereby estimate the number of students and number of patient days that could have benefitted from Tala's GDP contribution.⁴⁵

⁴³ Department of Hydropower and Power Systems, Government of Bhutan.

⁴⁴ Better healthcare allows a person to get better jobs and also perform better at work. Education enables skill formation and thereby allows people to get better jobs.

⁴⁵ GDP figures are in constant 2000 prices

$$Exp_H = \frac{\text{Government Expenditure on health}}{\text{Total GDP (expenditure)}}$$

$$Exp_E = \frac{\text{Government Expenditure on education}}{\text{Total GDP (expenditure)}}$$

$$GDP_{TALA} = \% \text{ share of Tala to GDP (production)}$$

S = total # of students currently enrolled

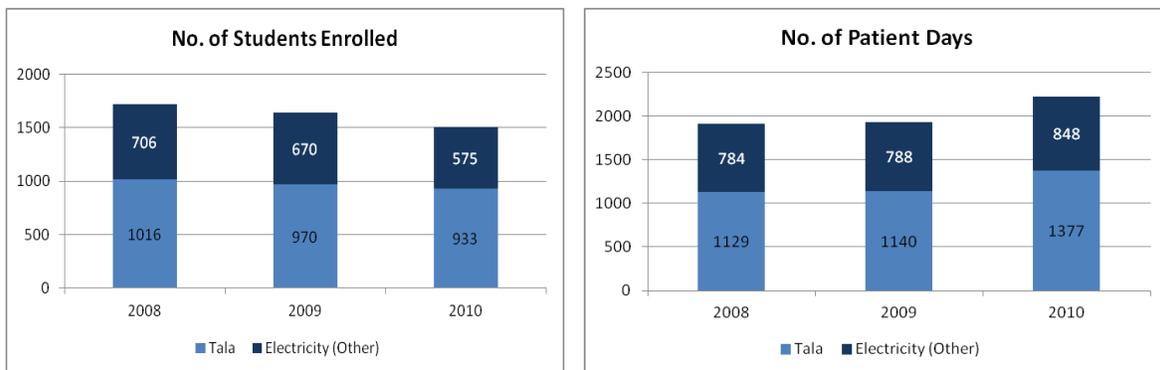
P = # of patient days currently benefitted

Given that $GDP \text{ (production)} = GDP \text{ (expenditure)}$

We estimate the total number of students that would be enrolled through the additional contribution of Tala to the GDP by: $S * GDP_{TALA} * Exp_E$

We estimate the total number of patient days benefitted through the additional contribution of Tala to the GDP by: $P * GDP_{TALA} * Exp_H$

Figure 4: Tala's contribution to student enrollment and patient days



Source: Bhutan National Account Statistics (2010) & Bhutan Statistical Yearbook 2011

Figure 4, shows that as a result of Tala's contribution to GDP over 2007- 2010 on an average, per annum 973 students are enrolled and 1215 patient days are supported, which is more than half what the electricity sector reaches as a whole. For example in 2010, 933 students were reached by the government with the increased revenue from Tala and 575 students were

reached as a result of increased revenue from the rest of the power sector. Hence, the sale of power generated from Tala has more than doubled the number of students and patients reached. With education, employment opportunities are better and income levels increase. Similarly healthy people are expected to get and keep jobs more than unhealthy ones.

Therefore, Tala hydroelectric power plant is not only has an important contributor to Bhutan's GDP and growth, but also supports employment indirectly by increasing government's ability to spend on the crucial health and education sector, that further affects employment.

CONCLUSIONS

Through this study we tried to assess the employment effects of investing in power transmission in India. Contrary to popular perception that transmission projects have marginal employment effects, we find that the Powerlinks Transmission project has had large employment effects. Using a diverse array of techniques – Input output models, econometric time series models and step-by-step estimation we find that increasing supply of power and increasing its reliability, has substantial development impact in a power deficit country like India.. Additionally, this vital transmission link enables cross border trade of Tala's hydropower, which results in boosting Bhutanese economy via GDP growth, increasing government revenues, which further enables the government to spend more on social sectors like health and education- which in turn improves the quality of life and also the employability of the people of Bhutan.

The second order employment effects are much more significant –these are jobs that are created because increasing power supply helps relieve a binding constraint on the output of firms, and helps them generate more employment. Induced jobs are many times larger than the direct jobs that are created by PTL. In other words, while measuring development impact of a crucial infrastructure asset like power, it is very important to go beyond the direct number of jobs that are created. What is most important is the spill over and growth effect that takes place throughout the economy as a result of an investment in the power sector

ANNEXURE 1

Table 1. Sectors in which employment is created by PTL (person-years)

Sectors	Construction (2003-2007)			Operation (2008-2027)			Total (2003-2027)		
	Direct	Indirect	Induced	Direct	Indirect	Induced	Direct	Indirect	Induced
Agriculture & Forestry	0	5,086	35,620	0	1,778	60,568	0	6,865	96,188
Coal & lignite	0	420	32	0	112	54	0	532	86
Natural Gas	0	184	32	0	51	54	0	235	86
Crude oil	0	1,036	485	0	408	824	0	1,444	1,309
Mining -non energy	0	1,978	122	0	440	208	0	2,418	330
Food & beverage industry	0	61	1,251	0	27	2,127	0	89	3,378
Textile and apparel	0	415	1,565	0	150	2,661	0	565	4,226
Wood & furniture	0	1,708	281	0	444	477	0	2,152	758
Paper & printing	0	354	146	0	205	248	0	559	394
Plastic, Rubber & leather	0	744	204	0	295	347	0	1,039	552
Petroleum and coal products	0	444	209	0	175	356	0	619	566
Chemicals & Fertilizers	0	601	256	0	218	435	0	819	691
Non metallic minerals	0	1,681	120	0	321	204	0	2,002	325
Basic metals	0	1,439	45	0	352	76	0	1,791	121
Fabricated metals	4,874	2,354	183	0	610	311	4,874	2,963	494
Electrical machinery	1,706	743	50	0	1,093	85	1,706	1,836	136
Transport equipment	0	84	72	0	63	122	0	148	194
Other manufacturing	0	1,518	345	0	904	586	0	2,422	931
Construction	5,821	1,991	518	0	929	881	5,821	2,919	1,399
Electric utility	0	358	79	23,917	134	134	23,917	491	213
Other utilities (water, communication)	0	231	38	0	115	64	0	347	102
Transportation	0	3,476	2,163	0	2,348	3,678	0	5,824	5,840
Trade	0	7,379	4,637	0	2,197	7,885	0	9,576	12,523
Hotels & restaurants	0	300	833	0	158	1,416	0	458	2,249
Finance, insurance & real estate	1,434	1,663	941	0	682	1,601	1,434	2,345	2,542
Health and education	0	113	1,777	0	163	3,022	0	277	4,800
Other services	4,822	2,782	627	0	4,753	1,066	4,822	7,534	1,692
Total	18,657	39,144	52,630	23,917	19,125	89,491	42,574	58,269	142,122

ANNEXURE 2

Technical Note on INPUT-OUTPUT approach

Background

An input-output model (hereafter I-O model) is based on the I-O analytical framework pioneered by Professor Wassily Leontief in 1936. For this work, Professor Leontief was awarded Nobel Prize in Economics in 1973. It has been extensively used in both developed and developing worlds for assessing impacts of project activities.

An I-O model has four matrices:

- (i) Inter-industry transactions matrix;
- (ii) Direct-input coefficient matrix;
- (iii) Direct and indirect (or Total) coefficient matrix and
- (iv) Direct, indirect, and induced coefficient matrix.

Inter-Industry Transaction Matrix: An economy is divided into a number of production sectors such as mining, construction, manufacturing, trade and services. The transaction matrix accounts for the flows of goods and services between these sectors. A column of the transaction matrix shows the requirements of outputs produced by various sectors as well as by itself in order to produce its output. This table is also referred to as “Use Table” as it indicates how much of goods and services are used to produce its output. A row of the transaction matrix represents the distribution (or delivery) of its output throughout the economy (i.e., to various production sectors as well as final demand sectors). This table is referred to as “Make Table” as it shows supply of goods and services to various industries and final demand sectors. It can also be interpreted that columns of the transaction matrix represent purchase by industries and rows represent sales by industries.

Direct-input Coefficients Matrix ([A] Matrix): The direct coefficients matrix shows how much worth of goods and services produced by each industry is required to produce an average 1 dollar’s worth of output from a particular industry. These coefficients (or input ratios) are derived by dividing input data in each sector column of the transaction matrix by the corresponding output value for that sector.

Direct and Indirect (or Total) Coefficients Matrix $[(I-A)^{-1}$ Matrix): The direct and indirect coefficients matrix shows required changes in outputs from each of the production sectors to meet a dollar worth change in final demand of a good and service.

Direct, Indirect and Induced Coefficients Matrix: Household sector in one hand provides factors (e.g., labor) to the production sectors and on the other hand consumes goods and services produced from the production sectors. An industry requires not only outputs produced by itself and other industries but also factors (i.e., labor and capital) to produce an output. An increase in its output would mean an increased in factor demand. Increase in factor demand would mean increase in payments to households (i.e., increase in household income), this further implies an increase in household consumption. In order to account for these interactive effects, household sector can be added in the rows of the transaction matrix. This process of treating household as an endogenous sector is termed as closing the model with

respect to households⁴⁶. The coefficients calculated including households are known as “direct, indirect and induced” coefficients, as these coefficients capture the interactions between the households and the production sectors.

Use of the I-O Modeling Framework in the Study

Building a power plant or a transmission system creates employment during construction and also the O&M of the lines. The total construction expenditure is allocated to purchase of various goods and services, and for payment to labor. Similarly, the total revenue is allocated to purchase goods/services needed to operate and maintain the transmission lines (e.g., labor, repair equipment/machinery), taxes and royalties and operating surplus. Thus, demands for goods/services or outputs from various sectors required during the construction and operation of the transmission system, are derived. To meet the new demands for goods/services, industries producing these goods/services also need additional inputs (goods/services, labour). This cycle goes on.

The direct and indirect impacts are calculated as follows. First, impacts on gross outputs from a sector I are calculated:

$$\Delta GO_i = [I - A]^{-1} \times \Delta F_i \quad (1)$$

Where:

ΔGO_i = Change (or increase) in gross output in sector I due to construction and operation of the transmission system

A = The input coefficient matrix. An element of this matrix is derived dividing use of a commodity in a sector by the total output of that sector. The element represents requirements of a commodity in a sector to produce one unit of output from that sector.

ΔF_i = Change (or increase) in final demand of commodity I (or commodity I directly purchased) for the construction of the electricity transmission and its operation and maintenance.

The impacts of GDP, household income and employment are calculated as follows:

$$\begin{aligned} \Delta GDP_i &= f_{GDP_i} \times \Delta GO_i \\ \Delta HI_i &= f_{HI_i} \times \Delta GO_i \\ \Delta EMP_i &= f_{EMP_i} \times \Delta GO_i \end{aligned} \quad (2)$$

Where ΔGDP , ΔHI and ΔEMP are change in GDP, household income and employment; f_{GDP} , f_{HI} , and f_{EMP} are the ratios of GDP, HI and employment with GDP, respectively.

⁴⁶ More detail discussions on this are available at Miller, R.E. and P.D. Blair (1985), Input-Output Analysis: Foundations and Extensions, Prentice-Hall, Inc., New Jersey.

The direct, indirect and induced impacts are also calculated in the similar manner as in Equations 1 and 2, but Equation (1) is replaced with Equation (3) as shown below:

$$\Delta GO_i = [I - AH]^{-1} \times \Delta F_i \quad (3)$$

Where:

AH = the input coefficient matrix when household is also included.

Limitations of I-O Approach

Although I-O approach is a popular approach and has been widely used around the world for economic impact assessment, there are certain limitations in this approach. Some of the well-known limitations of I-O approach are discussed below:

Static relationship: The I-O coefficients are based on value relationships between one sector's output to others. The relationship could change over time due to several factors including, changes in technology, relative price of commodities, productivity and so on, but these factors are not captured in the I-O approach. Therefore, I-O model could be reasonable for a short time horizon where relative prices and productivity are expected to remain relatively constant. Hence, for a long run assessment of impacts I-O models could not be the best tools. General equilibrium models or macroeconomic models accounting for the factors mentioned above could be more appropriate although general equilibrium models too are not capable for incorporating technical changes.

Assumption of unlimited resources or supplies: The I-O approach simplistically assumes that there are no supply or resources constraints. In reality, in order to increase the output of a sector, factors of production (i.e., labour and capital) currently allocated to other sectors need to be diverted to the given sector, as the total supply of goods and services in an economy in a given year could be fixed. However, in the context of India where there exists huge unemployment despite availability of skilled manpower, elastic labour supply would not be an unreasonable assumption.

Annexure 3

Technical Note on Vector Error Correction Model

Background

Econometric analysis of long-run relationships has been the subject of numerous empirical studies. The general practice to model the relationship between stationary variables is an autoregressive distributed lag (ARDL) model. However, when the concerned variables are non stationary the analysis becomes complicated. The recent literature and the current model is concerned with the analysis of the long run relationship between non stationary variables. Pioneering works of Engle and Granger (1987), Johansen (1991), Phillips (1991), Phillips and Hansen (1990) and Phillips and Loretan (1991) have tried to estimate alternative testing procedures for such modeling using Vector Error Correction or ARDL models.

Methodology

The Augmented Dickey Fuller (1981, henceforth ADF) and Phillip and Perron (1988, henceforth PP) tests are employed to determine whether the series are stationary. When the null hypothesis of non stationarity is not rejected it implies that the series is non stationary. The series is then differenced and tested again for stationarity. This process is repeated until a stationary series is obtained.

Next, the lag length n of the vector error correction model with the stationary series is determined based on the standard log likelihood (LR) tests using the Schwarz-Bayesian (SBC) information criteria. The Johansen and Juselius (1990) co-integration test is employed to assess the existence of a long run equilibrium relationship and determine the co-integrating relationship⁴⁷ between the series. It uses the Maximum Eigen value test and the trace test

The study explores the relationship between increased electricity consumption and employment via a Vector Error Correction Model (VECM)⁴⁸. In cases where the endogenous series are integrated of the same order the VECM and ARDL model give similar results. The VECM model specification restricts the long run equilibrium behavior of the endogenous variables to converge to the co-integrating relationship while allowing for short-run adjustment dynamics. Engle and Granger (1987) showed that if two variables X and Y are co-integrated, then changes in the dependent variable would be a function of the imbalance in the co-integrating relationship (represented by the error correction terms, ECT) and by other explanatory variables. Additionally through the error correction term, VECM allows the discovery of Granger causality relationship (Granger 1968 and Sims 1972).

⁴⁷ When two or more individually non-stationary (stationary in first difference) series has a linear combination which is stationary, this linear combination is the co-integrating relationship

⁴⁸ VECM is a dynamic time series model which allows us to analyze the dynamic impacts of random disturbances on the system of variables. The model specifies every endogenous variable in the system as a function of the lagged values of all of the endogenous variables in the system. It allows us to estimate the long run relationship between endogenous variables and also estimate the short-term dynamics of adjustment.

Model Specification

In the current context the model is specified as three equations VECM⁴⁹ where employment, electricity consumption and real GDP are endogenous variables dependent on lagged values of all dependent variables.

Let $LEmp$, $LGDP$ and $LEle$ refer to the logarithms of employment, Gross Domestic Product(at constant prices) and electricity consumed , refers to the error correction term, n is number of lags to be included for and ε is the uncorrelated error terms. The variables are defined in logarithms to abstract from heteroscedasticity. The stationarity tests show that the three series are stationary in first differences the model is specified in first difference. Next the Johansen and Juselius co-integration test show that one co-integrating relationship exists between these three endogenous variables. This co-integrating relationship is defined as the error correction term e in the model below. The lag length n is determined using the optimal length log likelihood test. This brings out the up to $t-n$ lags of the endogenous variables which can explain the dependent variable at time t .

$$\Delta LEmp_t = a_{emp} + \delta_{1emp} e_{t-1} + \sum_{i=1}^n \theta_{i1emp} \Delta LEle_{t-i} + \sum_{i=1}^n \theta_{i2emp} \Delta LEmp_{t-i} + \sum_{i=1}^n \theta_{i3emp} \Delta LGDP_{t-i} + \varepsilon_{1t} \quad (1)$$

$$\Delta LEle_t = a_{els} + \delta_{1elsc} e_{t-1} + \sum_{i=1}^n \theta_{i1elsc} \Delta LEle_{t-i} + \sum_{i=1}^n \theta_{i2elsc} \Delta LEmp_{t-i} + \sum_{i=1}^n \theta_{i3elsc} \Delta LGDP_{t-i} + \varepsilon_{2t} \quad (2)$$

$$\Delta LGDP_t = a_{GDP} + \delta_{1GDP} e_{t-1} + \sum_{i=1}^n \theta_{i1GDP} \Delta LEle_{t-i} + \sum_{i=1}^n \theta_{i2GDP} \Delta LEmp_{t-i} + \sum_{i=1}^n \theta_{i3GDP} \Delta LGDP_{t-i} + \varepsilon_{3t} \quad (3)$$

where $LEmp$, $LGDP$ and $LEle$ refer to the logarithms of employment, real Gross Domestic Product (at constant prices) and electricity consumed, e refers to the error correction term or the long run equilibrium relationship, δ refers to the speed of convergence to the long run equilibrium, n is number of lags to be included and ε is the uncorrelated error terms. We employ block wise Granger causality⁵⁰ to assess the existence of a causal relationship between electricity consumption and employment. It is a simple procedure to test the direction of

⁴⁹ VECM model is used as employment, electricity consumption and GDP are integrated of order 1 and hence VECM and ARDL would give similar results.

⁵⁰ Engle and Granger show that if two series X and Y are individually $I(1)$ and co integrated then a causal relationship at least in one direction would exist.

causality, i.e. whether electricity consumption granger causes⁵¹ employment in the long term or vice versa. If the probability value is less than 0.001 then the causality is significant at 1 % level of significance. Thus any change in electricity consumption will result in a statistically significant change in employment.

From equation (1) we can find that *LEmp* granger causes *LEle* in the short run if the estimated coefficient θ_{i1emp} is statistically significant using the joint F test. Additionally, the existence of a long run causal relationship from *LElec* to *LEmp* can be assessed by the statistical significance of the coefficients of the error correction term. This coefficient is an adaptive parameter, which measures the short term dispersal from the long term equilibrium. Statistical significance of this parameter provides evidence of an error correction mechanism that drives the variables back to their long-run equilibrium after being disturbed. $1/\delta_{1emp}$ gives the duration of the error correction mechanism or the time it takes for the error correction mechanism to drive the variables to the long run equilibrium.

From equation (1) , the e_{t-1} term gives us the long run equilibrium relationship between the endogenous variables, as shown in equation (4) where c and d are the elasticity of electricity consumption and real GDP with respect to employment. Thus a one percent change in logarithm of electricity consumption would result in a c percent change in the logarithm of employment. This relationship would hold true after the error correction mechanism convergences to the equilibrium level (equation 4) in $1/\delta_{1emp}$ years.

$$LEmp_t = b + cLEle_t + dLGDP_t \quad (4)$$

⁵¹ Series X is said to Granger-cause Y if the prediction error of Y decline by using past values of X in addition to past values of Y.

ANNEXURE 4

Calculation of # of new jobs as a result of power coming from Tala (using 2006-07 data)

	India	West Bengal
a. Power Generated p.a (GWh)*	4323.5	-
b. Power Exported to India p.a (@ 75% ,GWh)	3242.6	-
c. Power Allocated to West Bengal (@38.2% of b, in GWh)	-	1240.1
d. India T&D Losses p.a (@ 27.1% of b, in GWh)	878.7	-
e. West Bengal T&D Losses p.a. (@23.76% of c, in GWh)	-	294.7
f. Power Consumed p.a (GWh) (b-d for India and c-e for WB)	2363.9	945.5
g. Power Consumption in 2006-07 (GWh)**	455748	25240
h. % share of Power consumption from Tala to Total (f/g)	0.5%	3.7%
i. elasticity of employment with respect to electricity consumption (from VECM model)	0.53	0.24
j. % change in Employment (i*h)	0.3%	0.9%
k. Employment in 2006-07 (#)***	27240000	510701
l. New Jobs(k*j)	74,883	4,591

Note: * from Bhutan Statistical Year Book 2011,** CEA Publication *** Labor statistics of India 2006-07

ANNEXURE 5

List of People Interviewed

Bihar

1. Mr. S. P. Sinha, CII Chairman, Bihar
2. Mr. S. Poddar, CII Director, Bihar
3. Mr. Sharan, Desi Power Station, Bihar
4. Mr. Prabhat, owner of food processing unit
5. Mr. Amit, owner of animal feed in Muzaffarpur
6. Mr. Kesri, ex CII Chairman and owner of food processing unit
7. Mr. Y. P. Thakur, Chief Engineer-Transmission, Bihar State Electricity Board
8. Mr. L. Prasad, Member, Generations, Bihar State Electricity Board

West Bengal

1. Mr. Tuhin Chatterjee, CII Director, Eastern Region
2. Mr. Rajesh Pandey, Chairman, WBSEDCL

Delhi

1. Mr. S Dasmohapatra, CII Director, Energy
2. Mr. C Neogi, Professor, ISI Kolkata
3. Mr. P. Singh, Consultant, AF- Mercandos Consulting
4. Mr. A. Singh, CEO, Powerlinks Transmission Ltd.
5. Mr. A. Bagri, CFO, Powerlinks Transmission Ltd.
6. Mr. B. Banmali, GE Energy, Ex Powerlinks Transmission Ltd
7. Mr. A. S. Bakshi, Chairman, CEA
8. Mr. R.K Pahwa, Director- Statistics, CEA
9. Ms. N. Mathur, Chief Engineer, CEA
10. Director, Transmission, CEA

Bhutan

1. Mr. K.Tshering, Director General, National Statistics Bureau
2. Mr. T. Gyeltshen, General Manager, Transmission, Bhutan Power Corporation Ltd.
3. Mr. K. Tshewang, Chief Engineer, Department of Hydropower & Power Systems
4. Mr. T. Dorji, Department of Employment, Ministry of Labor
5. Mr. U. Namgyal, Director- Finance, DGPC Ltd
6. Mr. Dorji, Chief Engineer, Tala hydroelectric plant
7. Mr. K. Choki, Assistant Engineer, Tala hydroelectric plant
8. Mr. C. Dorji, Executive Engineer, Tala hydroelectric plant

ANNEXURE 6

According to the IEEE Standard the two most commonly accepted indicators for reliability of power are SAIFI and SAIDI. The **System Average Interruption Duration Index (SAIDI)** is the average outage duration for each customer served, and is calculated as:

$$\text{SAIDI} = \frac{\sum U_i N_i}{\sum N_i}$$

where N_i is the number of customers and U_i is the annual outage time for location i . In other words,

$$\text{SAIDI} = \frac{\text{sum of all customer interruption durations}}{\text{total number of customers served}}$$

SAIDI is measured in units of time, often minutes or hours and is usually measured over the course of a year, and according to IEEE Standard 1366-1998 the median value for North American utilities is approximately 1.50 hours.

The **System Average Interruption Frequency Index (SAIFI)** is the average number of interruptions that a customer would experience, and is calculated as

$$\text{SAIFI} = \frac{\sum \lambda_i N_i}{\sum N_i}$$

where λ_i is the failure rate and N_i is the number of customers for location i . In other words,

$$\text{SAIFI} = \frac{\text{total number of customer interruptions}}{\text{total number of customers served}}$$

SAIFI is measured in units of interruptions per customer. It is usually measured over the course of a year, and according to IEEE Standard 1366-1998 the median value for North American utilities is approximately 1.10 interruptions per customer.

ANNEXURE 7

News Story published in NDTV

NDTV News: Reported by Uma Sudhir, August 24, 2012

In Andhra Pradesh, industry is trying to figure out how to manage with just four days of power a week. A three-day a week power holiday for industrial units began this week to cope with the huge gap in demand and supply that has been exacerbated over the last several weeks. Dayanand Shah a supervisor at a bulb-making factory in the Jeedimetla industrial belt said that some workers were sent back home because of erratic power supply and the output of the factory had reduced by 40% since the electricity problems began. That means not just daily wage earners are in danger of losing their jobs, even those who have been around for long, may lose job and salary.

Some 18 industrial estates in and around Hyderabad, many of them small-scale units, have said they are worried about going out of business if the power crisis continues. "Overall we have about 2 lakh workers employed in small-scale units in the state and the total money invested is about 1,50,000 crores. That includes some Rs.23000 crore from industry and the rest are loans from banks. It's all going waste and without power, we will all become non-performing assets, NPAs, within three months," says Vijay Kumar, who owns the bulb-making unit and was the president of the Federation of Andhra Pradesh Small Industries Association. Devendra Surana, President of the Federation of Andhra Pradesh Chambers of Commerce and Industry (FAPCCI), says the 12 days in a month power holiday will force all the manufacturing concerns to shut their factories. The estimated daily revenue loss of Rs. 300 crore is being incurred. That would lead to closure of industries and job-loss.

