Did the Rise of Service Off-shoring and IT-Boom Change India’s Economic Landscape?

Devaki Ghose
University of Virginia and Dartmouth College, Visiting
Presented at CEP-IMF-WB-WTO Conference, Geneva

April 2018
Motivation

- Rising high-skill service exports from developing countries
- Specific types of service exports, examples:
  - China 3rd largest exporter of services, India 8th but 2nd largest exporter of ICT services
Motivation

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- Specific types of service exports, examples:
  - China 3rd largest exporter of services, India 8th but 2nd largest exporter of ICT services
Types of Skills

Different sectors require different types of skills: Hotel management in tourism, CS graduates in IT.
Types of Skills

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“With the downfall in IT sector, is engineering the right career choice to opt for”? (India today, 2017)
Types of Skills

“With the downfall in IT sector, is engineering the right career choice to opt for”? (India today, 2017)
Research Question

1. How does a sector-specific trade shock affect the supply of different types of skilled labor across regions?
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- Ignoring this margin can lead to over-prediction of wage response, no prediction about the economy’s skill composition.
Research Question

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Not in today’s presentation:

2. What are the effects for the distribution of worker welfare across regions and types of skill?

- Skill-intensity of the sector
- Sector specific comparative advantage of different regions
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   - Skill-intensity of the sector
   - Sector specific comparative advantage of different regions

Context: IT industry in India
Contribution of IT to India’s GDP

![Graph showing the percentage contribution of IT to Indian GDP from 1997 to 2013. The graph indicates a steady increase in the IT/GDP ratio over time.](image)

Export’s Share of Total Output
Growth of IT Firms and Engineering Colleges in India
Growth of IT Firms and Engineering Colleges in India

![Graph showing the growth of IT firms and engineering colleges in India from 1985 to 2015. The graph plots the number of IT firms and engineering colleges over the years. The number of IT firms and engineering colleges have both increased significantly over time.]
Survey Evidence: About 2/3rd of all job offers to CS graduates came from software companies.

Share of Workers in IT-CS Occupations with an Engineering Degree
Spatial Distribution of no. of IT Firms and Technical Colleges

Computer Science Colleges Per 1 Million

Number of IT firms per 1 million population
This Paper

- New instrument to identify how colleges respond to IT employment
  - Ideal Experiment: Exogenously increase IT employment in a location and see how many colleges enter

- Challenge: Unobservables such as location fundamentals, changing infrastructure could be driving both

- New Instrument: Use an off-shoring shock from abroad combined with pre-existing regional differences to identify effect of firm location on colleges

Key Finding: Supply response: If a district’s IT sector employs 1,070 more workers, then this results in the creation of 4 new colleges, 1 of which specializes in providing an engineering education
This Paper

- New instrument to identify how colleges respond to IT employment
  - **Ideal Experiment:** Exogenously increase IT employment in a location and see how many colleges enter
  - **Challenge:** Unobservables such as location fundamentals, changing infrastructure could be driving both
  - **New Instrument:** Use an off-shoring shock from abroad combined with pre-existing regional differences to identify effect of firm location on colleges

- **Key Finding:**
  - Supply response: If a district’s IT sector employs 1,070 more workers, then this results in the creation of 4 new colleges, 1 of which specializes in providing an engineering education
Contribution

- Trade Liberalization and Educational attainment: Non-tertiary enrollment in developing countries

**Contribution:** Response of tertiary education to an export demand shock in a developing country
Contribution

- **Trade Liberalization and Educational attainment: Non-tertiary enrollment in developing countries**

  **Contribution:** Response of tertiary education to an export demand shock in a developing country

- **Quantitative Economic Geography Models:** (see Redding and Rossi-Hansberg 2016 for a review)

  **Contribution:** Worker field of education and location choice, taking into account long-term occupation choice
Roadmap

1. Background
2. Empirical Strategy and Results
3. Mechanism
4. Conclusion
The Growth of Exports

![Indian Software Exports as a share of Software Sales](image)

- Devaki Ghose UVA
- Off-shoring and Changing Education
- April 2018
The Y2K Problem

- Wide-spread panic that computer systems will fail
The Y2K Problem

- Wide-spread panic that computer systems will fail
- Total world-wide y2k expenditure $300-$500 billion
The Y2K Shock and India

Rusi Brij, vice-president, Satyam Computer: “Y2K has been a godsend”

Thomas Friedman, “World is Flat”: August 15 commemorates freedom at midnight, Y2k made possible employment at midnight...Y2k should be called Indian Interdependence Day” (Interdependence with Western companies)
The Y2K Shock and India

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- NASSCOM (2000) estimated India’s software exports at $2.65 billion in 1998 - 1999, with Y2K-related projects accounting for 20% of Total Revenue, (about $560 million)
Cross-sectional variation in IT demand shock

- Huge Variation in number of firms that receive y2k projects: 52% of districts did not receive a y2k project.
- 10 firms on average received y2k projects in the remaining 48%, with a standard deviation of 29 firms.
Cross-sectional variation in IT demand shock

- Huge Variation in number of firms that receive y2k projects: 52% of districts did not receive a y2k project
- 10 firms on average received y2k projects in the remaining 48%, with a standard deviation of 29 firms

What generates this cross-sectional variation?
Cross-sectional variation in IT demand shock

- Huge Variation in number of firms that receive y2k projects: 52% of districts did not receive a y2k project
- 10 firms on average received y2k projects in the remaining 48%, with a standard deviation of 29 firms

What generates this cross-sectional variation?
- Proportion of historical software exports from that district
- Linguistic distance of that district
Linguistic Distance

- 1652 different languages spoked in India (1991 Census)
- Vehicular mode of communication: Hindi and English
- Example of linguistic distance: distance between languages calculated on the basis of similarity between grammar and cognates
Linguistic Distance

- 1652 different languages spoked in India (1991 Census)
- Vehicular mode of communication: Hindi and English
- Example of linguistic distance: distance between languages calculated on the basis of similarity between grammar and cognates
- Shastry (2012): IT firms locate more in districts that are linguistically closer to English
Data Sources

- Linguistic Distance: Census of India
- Data on district-wise number of colleges, year of establishment of each college, state-wise intake: Official Government of India data on education (AICTE and AISHE)
- Data on IT industry: (NASSCOM)
Stylized Fact 1

IT employment increases more in relatively linguistically closer to English district following the Y2K shock

![Graph showing employment in IT sector and the Y2K Shock](chart.png)

Legend:
- Linguistically close English
- Linguistically far
Stylized Fact 2

Number of engineering colleges increases more in relatively linguistically closer to English district following the Y2K shock

Not-normalized graph
Roadmap

1. Background
2. Empirical Strategy and Results
3. Mechanism
4. Conclusion
Effect of Demand Shock

- Long difference:
  \[ \Delta y_{dt} = \alpha + \beta \text{frac of y2k projects} + \epsilon_{dt} \]

- \( y_{dt} \): IT employment, number of firms, number of colleges


- Instrument frac of y2k projects
  \[
  \text{frac of y2k projects} = \gamma + \delta \text{frac of software exports from d at t-k} + \epsilon'_{dt}
  \]
Effect on IT Employment: OLS Estimation

Table: OLS: Change in IT Employment following IT Demand Shock

<table>
<thead>
<tr>
<th></th>
<th>(1) Employment</th>
<th>(2) Employment</th>
<th>(3) No. of firms</th>
<th>(4) No. of firms</th>
</tr>
</thead>
<tbody>
<tr>
<td>fracy2k</td>
<td>0.459**</td>
<td>0.432**</td>
<td>0.270***</td>
<td>0.231**</td>
</tr>
<tr>
<td></td>
<td>(2.08)</td>
<td>(1.99)</td>
<td>(3.33)</td>
<td>(2.53)</td>
</tr>
<tr>
<td>District-specific trends</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>N</td>
<td>343</td>
<td>343</td>
<td>343</td>
<td>343</td>
</tr>
</tbody>
</table>

Finding: A 1% ↑ in number of firms receiving y2k projects in a district leads to a .46 standard deviation (around 3485) ↑ in IT employment and a .27 standard deviation. (around 17) ↑ in new firms
Effect on IT Employment: IV Estimation

Results using historical software exports as an instrument

<table>
<thead>
<tr>
<th></th>
<th>(1) Employment</th>
<th>(2) Employment</th>
<th>(3) No. of firms</th>
<th>(4) No. of firms</th>
</tr>
</thead>
<tbody>
<tr>
<td>fracy2k</td>
<td>0.523***</td>
<td>0.523***</td>
<td>0.590***</td>
<td>0.590***</td>
</tr>
<tr>
<td></td>
<td>(6.96)</td>
<td>(7.45)</td>
<td>(14.65)</td>
<td>(15.42)</td>
</tr>
<tr>
<td>District-specific trends</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>N</td>
<td>340</td>
<td>340</td>
<td>340</td>
<td>340</td>
</tr>
</tbody>
</table>

Finding: A 1% ↑ in number of firms receiving y2k projects in a district leads to a .52 standard deviation (around 3500) ↑ in IT employment and a .59 standard deviation. (around 36) ↑ in new firms
### First Stage Results

**Table:** First stage results using historical software exports as an instrument

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>frac of y2k</td>
<td></td>
</tr>
<tr>
<td>Historical Software Exports</td>
<td>0.90***</td>
</tr>
<tr>
<td></td>
<td>(5.39)</td>
</tr>
<tr>
<td>SW Chi-sq/F/Kp Wald F</td>
<td>29.25</td>
</tr>
<tr>
<td></td>
<td>(0.0000)</td>
</tr>
<tr>
<td>sheapr2</td>
<td>.77</td>
</tr>
</tbody>
</table>

Robust Standard errors are used. t statistics reported in parenthesis

A 1% ↑ in historical software exports is associated with a .9% ↑ in number of firms receiving y2k projects. The instrument is statistically significant—the F-statistic is 29.25.
Effect on Engineering Colleges: IV Estimation

**Table:** Change in Number of CS Colleges following IT Demand Shock

<table>
<thead>
<tr>
<th></th>
<th>(1) CS Colleges</th>
<th>(2) CS Colleges</th>
<th>(3) State CS Colleges</th>
<th>(4) State CS Colleges</th>
</tr>
</thead>
<tbody>
<tr>
<td>fracy2k</td>
<td>0.583**</td>
<td>0.566**</td>
<td>0.309***</td>
<td>0.262***</td>
</tr>
<tr>
<td></td>
<td>(2.07)</td>
<td>(2.22)</td>
<td>(3.37)</td>
<td>(2.94)</td>
</tr>
<tr>
<td>District-specific trends</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>N</td>
<td>340</td>
<td>340</td>
<td>340</td>
<td>340</td>
</tr>
</tbody>
</table>

**Finding:** For every 1% ↑ in number of firms receiving y2k projects in a district, the total number of colleges offering CS, IT and engineering courses increases by .58 standard deviation (around 2 in numbers) and 90% of this is driven by private colleges!
Effect on Total Colleges: IV Estimation

Table: Change in Number of Colleges following IT Demand Shock

<table>
<thead>
<tr>
<th>Fracy2k</th>
<th>(1) Total Colleges</th>
<th>(2) Total Colleges</th>
<th>(3) Agricultural Colleges</th>
<th>(4) Agricultural Colleges</th>
<th>(5) State Colleges</th>
<th>(6) State Colleges</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.478*</td>
<td>0.468**</td>
<td>0.057</td>
<td>0.043</td>
<td>0.257***</td>
<td>0.169***</td>
</tr>
<tr>
<td></td>
<td>(1.87)</td>
<td>(2.08)</td>
<td>(0.57)</td>
<td>(0.44)</td>
<td>(3.45)</td>
<td>(4.07)</td>
</tr>
</tbody>
</table>

District-specific trends  | No | Yes | No | Yes | No | Yes |

Finding: A 1% ↑ in number of firms receiving y2k projects creates 8 new colleges in a district. Thus, 1/4 th of the increase in colleges that are driven by the IT demand shock came from growth in engineering colleges!
Roadmap

1. Background
2. Empirical Strategy and Results
3. Mechanism
4. Conclusion
Conceptual Framework

For now: A framework to understand a possible mechanism
Conceptual Framework

For now: A framework to understand a possible mechanism

Future goals of the model:

- Qualitatively match stylized facts: predictions for the spatial distribution of IT firms and colleges
- Quantify the general equilibrium effects of a sector-specific trade shock (IT sector): changes in spatial distribution of enrollment, employment and wages in all sectors

New Approach: Endogenize supply of labor to each sector by incorporating worker field of education choice in a workhorse quantitative economic geography model
An Off-shoring Shock and the Domestic Economy
An Off-shoring Shock and the Domestic Economy

Let’s Outsource to India!
An Off-shoring Shock and the Domestic Economy

Let’s Outsource to India!

Firms (IT, Others)
An Off-shoring Shock and the Domestic Economy

Let's Outsource to India!

Firms (IT, Others)

Skilled Workers

Wages

Travel to Work

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Off-shoring and Changing Education
April 2018

25 / 29
An Off-shoring Shock and the Domestic Economy

Let’s Outsource to India!

Firms (IT, Others) → Wages → Skilled Workers → Travel to Work → Colleges (Engineering, Others)
An Off-shoring Shock and the Domestic Economy

Let’s Outsource to India!

Wages

Firms (IT, Others) ➔ Skilled Workers

Travel to Work

Pay tuition and travel to study

Students ➔ Colleges (Engineering, Others)

Training
Let's Outsource to India!

Firms (IT, Others) → Skilled Workers

Wages

Travel to Work

Skilled Workers → Colleges (Engineering, Others)

Pay tuition and travel to study

Training

Colleges (Engineering, Others) → Students

Students → Firms (IT, Others)
Empirical Evidence: Effect of IT Employment on No. of Colleges

\[ \Delta Y_{dt} = \alpha' + \beta' \Delta \text{IT Employment}_{dt} + \epsilon'_{dt} \]

\( \Delta Y_{dt} \): change in the number of CS colleges/total colleges

Instrument \( \Delta \text{IT Employment}_{dt} \) with historical software exports (and historical linguistic variation in the other specification).

First Stage:

\[ \Delta \text{IT Employment}_{dt} = a + b \text{Historical software exports}_{dt-k} + \epsilon_{dt} \quad (1) \]
Result: Effect of IT Employment in No. of Colleges

Table: Change in Number of CS Colleges following IT Demand Shock

<table>
<thead>
<tr>
<th>IT Employment</th>
<th>CS Colleges</th>
<th>CS Colleges</th>
<th>State CS Colleges</th>
<th>State CS Colleges</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>IT Employment</td>
<td>1.255***</td>
<td>1.223***</td>
<td>0.665***</td>
<td>0.567***</td>
</tr>
<tr>
<td></td>
<td>(3.93)</td>
<td>(4.21)</td>
<td>(3.34)</td>
<td>(3.18)</td>
</tr>
<tr>
<td>District-specific trends</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>N</td>
<td>340</td>
<td>340</td>
<td>340</td>
<td>340</td>
</tr>
</tbody>
</table>

For every one standard deviation increase in IT employment (about 3747 employees), number of engineering colleges increases by 1.25 standard deviation (about 5 colleges)
Mechanism

- 26% of increase in total number of colleges driven by increasing IT employment opportunities came from engineering colleges.
- No long-run effect on any other sectors of the economy: eg, Health, finance, manufacturing, agriculture
- Evidence that growth in IT sector sustained by increasing supply of skilled labor, rather than drawing labor away from other sectors

First direct evidence of how a sector-specific trade shock affects the education sector, and hence, skill formation in a country by studying how different types of colleges respond
Roadmap

1 Background
2 Empirical Strategy and Results
3 Mechanism
4 Conclusion
Conclusion

Policy Implications

- Investment in IT software parks: Effect on employment and educational attainment
- How does an external demand shock from abroad, for example, a ban on IT off-shoring, affect the Indian economy?

Future Work

- Model Estimation. Counter-factual questions: What are the implications for employment, college enrollment, wage inequality and worker welfare if labor markets across states are more integrated?
- Effect on wages: Short-run spike, in long-run supply response attenuates wage response
Thank You
Roadmap

Appendix
- Appendix: Background
- Appendix: Model Derivations
Growth in Undergraduate Number of Institutions

**Figure:** Growth in Undergraduate Number of Institutions
Growth in Number of Diploma-Granting Institutions

Figure: Growth in Number of Institutions granting Diploma
Growth in Intake of Diploma-Granting Institutions

Figure: Growth in Intake of Diploma Granting Institutions

- Added in Year
- TOTAL
- PHARMACY
- HOTEL MANAGEMENT AND CATERING
- ENGINEERING AND TECHNOLOGY
- ARCHITECTURE
Growth in Institutions Offering Graduate Degrees

Figure: Growth in Graduate Number of Institutions
Growth in Intake of Institutions Offering Graduate Degrees

![Bar chart showing growth in intake of institutions offering graduate degrees over years.]

**Figure:** Growth in Intake in Graduate Number of Institutions
Spatial Distribution in the no. of Colleges Offering Non-CS Degree Programs
Aggregate Statistics: India’s Software Exports
Aggregate Statistics: Export’s Share of Total Output

![Graph showing Indian IT: Export’s Share of Total Output (1991-2015)]
Aggregate Statistics: Export Domestic Growth
Aggregate Statistics: India’s Software Exports
Aggregate Statistics: IT output Level Growth
## The Y2K and India

**Parent Company**
- Tufts Health Plan
- Florida Power and Light
- Bank of America
- GE
- Aetna Health Insurance
- Orion Auto
- US Cold Storage Inc.
- Martin & Co.

**Offshoring Company**
- Wipro
- Mastech Corp
- HCL and Hexaware
- India’s Mascot System
- A no. of companies in Bangalore
- Cognizant Technology Solutions
- Cognizant
- HCL
Figure 3. Global Distribution of Offshore IT Services and ITES Markets

Define IT and IT-Enabled Services

In my study I consider both IT and IT-Enabled services from India. These are the definitions as per -
Industry-wise Share of India’s BPO/ITES Services

## Table 2: Industry-wise Share of ITES/BPO Services Exports

<table>
<thead>
<tr>
<th>Activity</th>
<th>2012-13 (1)</th>
<th>2013-14 (2)</th>
<th>2014-15 (3)</th>
<th>2015-16 (4)</th>
<th>2016-17 (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BPO Services</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Customer interaction services</td>
<td>82.5</td>
<td>81.9</td>
<td>77.6</td>
<td>80.6</td>
<td>76.8</td>
</tr>
<tr>
<td>Finance and Accounting, auditing, book keeping and tax consulting services</td>
<td>10.9</td>
<td>8.4</td>
<td>4.6</td>
<td>3.5</td>
<td>5.0</td>
</tr>
<tr>
<td>HR Administration</td>
<td>0.9</td>
<td>0.7</td>
<td>0.9</td>
<td>1.2</td>
<td>0.6</td>
</tr>
<tr>
<td>Procurements and logistics</td>
<td>0.4</td>
<td>0.3</td>
<td>0.5</td>
<td>0.5</td>
<td>0.4</td>
</tr>
<tr>
<td>Medical transcription</td>
<td>0.7</td>
<td>1.3</td>
<td>1.0</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>Document Management</td>
<td>0.5</td>
<td>0.9</td>
<td>0.7</td>
<td>0.4</td>
<td>0.3</td>
</tr>
<tr>
<td>Content development and management and publishing</td>
<td>1.4</td>
<td>0.9</td>
<td>0.9</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>Other BPO services *</td>
<td>58.0</td>
<td>58.2</td>
<td>56.8</td>
<td>62.2</td>
<td>58.6</td>
</tr>
<tr>
<td>Engineering Services</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Embedded Solutions</td>
<td>17.5</td>
<td>18.1</td>
<td>22.4</td>
<td>19.4</td>
<td>25.2</td>
</tr>
<tr>
<td>Product Design Engineering (mechanical, electronics excluding software)</td>
<td>4.1</td>
<td>5.5</td>
<td>4.1</td>
<td>4.3</td>
<td>3.7</td>
</tr>
<tr>
<td>Industrial automation and enterprise asset management</td>
<td>5.0</td>
<td>5.5</td>
<td>5.0</td>
<td>5.1</td>
<td>7.7</td>
</tr>
<tr>
<td>Other Engineering services *</td>
<td>2.4</td>
<td>0.2</td>
<td>0.2</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Total ITES/BPO Services</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

*‘Other services’ include a combination of the services indicated above, which are provided by companies where activity-wise revenue segregation is not available. This is applicable for all tables.*

Exports of ITES/BPO services are categorised as per the industrial classification of the Department of Information Technology (DIT-2003), Ministry of Electronics and Information Technology, Government of India.
Types of IT Service Exports

(b) Growth in the Indian IT sector

Value in 2010 Indian Rupees (billions)

- Software Exports
- BPO Services Exports
- Hardware Exports
- Total IT Exports
- Total IT output
- Total Software Output

General Education of IT Vis-à-Vis Other Workers

General Education of Workers in CS/IT Sector

- Not literate
- Below primary
- Middle General Education
- Higher secondary
- Graduate

Percent

0
20
40
60
General Education of IT Vis-à-vis Other Workers

General Education of Workers in Financial Activities

- Not literate
- Below primary
- Middle General Education
- Higher secondary
- Graduate

Percent

0
10
20
30
40
General Education of IT Vis-à-vis Other Workers

![Chart showing general education levels of workers in manufacturing.](chart.png)
Average Wage of IT Vis-Vis Other Workers

![Graph showing the average wage of IT workers compared to other workers in various industries.](image)

- Computer
- Finance
- Education
- Health and social work
- Communication
- Extraterritorial organizations
- Manufacturing
- Real Estate, Business
- Wholesale and retail
- Other Community
- Private Household

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Average Wage of IT Vis-à-Vis Other Workers
Engineering Versus Other Technical Disciplines

Figure: Growth in Student Intake in Undergraduate Programs
Field of Training of Workers in CS and Related Occupations

Source: Calculated using NSSO 2009
Model Intuition: A simple 2 Region Example

\[\text{A} \quad \text{B} \]

\[\begin{array}{c}
\text{IT} \\
\text{non-IT} \\
\text{Eng} \\
\text{nonEng}
\end{array} \quad \begin{array}{c}
\text{IT} \\
\text{non-IT} \\
\text{Eng} \\
\text{nonEng}
\end{array}\]
Model Intuition: A simple 2 Region Example
Model Intuition: A simple 2 Region Example

\[ \text{A} \]
\begin{align*}
\text{IT} \\
\text{non-IT} \\
\text{Eng} \\
\text{nonEng}
\end{align*}

\[ \text{B} \]
\begin{align*}
\text{IT} \\
\text{non-IT} \\
\text{Eng} \\
\text{NonEng}
\end{align*}

ROW
Model Intuition: A simple 2 Region Example

- **non-IT**
  - LNT: eg: medical
  - LT: eg: agri, manu

- **nonEng**
  - No College
  - NonEng degree
The Market

Field of Training of Workers in CS and Related Occupations

Source: Calculated using NSSO 2009
Additional Instruments

**Instrument** \( \Delta \sum_{o=1}^{D} N_{ot} \left( \frac{T_{od}^{-\sigma}}{\sum_{d'=1}^{D} T_{od'}^{-\sigma}} \right) \) with

- \( \Delta \sum_{d=1}^{D} \frac{n_{id}}{n_d} \) *(y2k spending by region i)* *(Export of IT-services from India to i)*

where \( n_{id} \): number of serving country i in district d

\( n \): total number of firms in district d

- **Traditional Bartic:** \( \Delta \sum_{d=1}^{D} \frac{x_{dt-k}}{X_{t-k}} \) *(Aggregate exports in year t)*

Problem: many zeros, differential trends in college growth driven by unobservables that are correlated with initial export exposure of that region

- **Instrument relying on variation in exposure according to countries:** \( \Delta \sum_{d=1}^{D} \frac{n_{idt-k}}{n_{dt-k}} \) *(exports from India to i in year t)*
Other Events 1996-1998 Affecting Regional IT Growth

- State IT Policy by Karnataka in 1997: very low tax policy, open training centers for IT firms, encourage private initiative in the education sector, promotion of venture capital.
History of Internet in India

- Early 1990s: Internet for restricted group of users- ERNET, NICNET, STPI through satellite connectivity
- 1993: STPI Bangalore started Internet Services through VSAT satellite link. The network consists of a Hub located at Bangalore where the VSAT communicates to the HUB through Express AM1 Satellite.
- 1995: VSNL provides first public internet-connection between VSNL and MCI in the US starts with "multiple 64kbps" links. Users anywhere can connect through the Department of Telecommunications’ I-NET, an X.25 network accessed through leased lines.
- Till 2002: STPIs were providing high-speed data communication services through satellites. However, VSNL’s control of International Fiber connections in India prevented STPIs from using these till they were liberalized in 2002.

History of Regional Distribution of IT Industry India

- Initial Concentration in Bombay: TCS opened in Bombay. SEEPZ opened in Mumbai in partnership with American hardware companies Burroughs. Of the top 8 exporters 7 in Mumbai with 90% export share.
Satellite vs Fiber Optics

Satellite transmission slow, but much less affected by distance than terrestrial fiber optic connection. Though weather plays a role. Satellite internet was the only one in the beginning
Map of Submarine Cables India
Composition of India’s Software Exports

IT services + software product development = computer services BPO
services + engineering services = ITES/BPO
IT Exports

(b) Growth in the Indian IT sector

Value in 2010 Indian Rupees (billions)

- Software Exports
- BPO Services Exports
- Hardware Exports
- Total IT Exports
- Total IT output
- Total Software Output

Years:
- 1980
- 1982
- 1984
- 1986
- 1990
- 1992
- 1994
- 1996
- 1998
- 2000
- 2002
- 2004
- 2006
- 2008
- 2010
- 2012
- 2014
## AICTE Norms

<table>
<thead>
<tr>
<th>3</th>
<th><strong>Excess admissions</strong></th>
</tr>
</thead>
</table>
| 3.1 | Excess admissions over the sanctioned intake shall not be allowed under any circumstances. In case any excess admission is reported to / noted by the Council, appropriate penal action will be initiated against the Institution. The Institution shall be liable to following punitive action from any one or more of the following by the council.  
1. Excess admission fee amounting five times the total fees collected per student shall be levied against each excess admission.  
2. Suspension of approval for supernumerary seats for one academic year  
3. No admission status in one / more courses for one academic year  
4. Withdrawal of approval for Program / course.  
5. Withdrawal of approval of the Institution. |
Derivation of Worker Indirect Utility

Problem of worker $i$ educated in $k$ in field $s$ who goes to work in $k'$ in sector $S$ is given by: $\text{Max } \Pi_S C_S^\alpha_S$ where $C_S = \left( \sum_d c_{dk'S}^{\sigma_S} \right)^{\frac{\sigma_S}{\sigma_S-1}}$

s.t $\sum_d \sum_{S'} p_{dk'S'} c_{dk'S'} = W_{k'Ss} \eta_{ikk'Ss} \mu_{kk'}$

This yields : $c_{idk'S'} = p_{dk'S'}^{-\sigma_S} P_{k'S}^{\sigma_S-1} (\alpha S W_{k'Ss} \eta_{ikk'Ss} \mu_{kk'})$

Assuming ice-berg transportation cost:

$p_{dk'S'} = \tau_{dk'S'} P_{dS'}$

$c_{idk'S'} = (\tau_{dk'S'} P_{dS'})^{-\sigma_S} P_{k'S}^{\sigma_S-1} (\alpha S W_{k'Ss} \eta_{ikk'Ss} \mu_{kk'})$

Using the above quantities, worker indirect utility is derived as:

$V_{ikskk'} = \frac{W_{k'Sst} \eta_{ikk'Ss} \mu_{kk'}}{\Pi_S P_{k'S}^{\alpha_S}}$

where $P_{k'S} = \sum_d \tau_{dk'S} P_{dS}$
Derivation of Expected Income

Expected income before realizing the Frechet draws: Expected Income \( y_{ikst} = E(V_{ikst}) = E(\max(\frac{W_{k'st}}{P_k't} \mu_{kk'}\eta_{kk'Ss})) \)

Note the similarity with EK:

\( P_n(k) = \min P_{ni}(k), i = 1, \ldots, N = \max \frac{Z_i(k)}{d_{ni}w_i} \)

Exactly same derivation as EK
Identification

\[ \Delta Y_{dt} = \beta_1 \Delta \sum_{o=1}^{D} N_{ot} \left( \frac{\tau_{od}^{\sigma}}{\sum_{d'=1}^{D} \tau_{od'}^{\sigma}} \right) + \alpha_1 T + \alpha_2 X_{dt} + \epsilon_{dt} \]

**Challenge:** Same unobservables drive firm and college location.
Identification

\[
\Delta Y_{dt} = \beta_1 \Delta \sum_{o=1}^{D} N_{ot} \left( \frac{\tau_{od} - \tau_{od'}}{\sum_{d'=1}^{D} \tau_{od'}} \right) + \alpha_1 T + \alpha_2 X_{dt} + \epsilon_{dt}
\]

**Challenge**: Same unobservables drive firm and college location

**Instrument**: 1. Demand Shock: \(y_{2k}\)
   - Identifying Assumption: Affects colleges only through firms

2. Cross-Sectional Variation: Linguistic Distance
   - Identifying Assumption: Absent \(y_{2k}\), the rate of growth of engineering colleges is not correlated with historical linguistic differences.
Identification

\[ \Delta Y_{dt} = \beta_1 \Delta \sum_{o=1}^{D} N_{ot} \left( \frac{\tau_{od}^{\sigma}}{\sum_{d'=1}^{D} \tau_{od'}^{\sigma}} \right) + \alpha_1 T + \alpha_2 X_{dt} + \epsilon_{dt} \]

**Challenge**: Same unobservables drive firm and college location

**Instrument**: 1. Demand Shock: y2k

- Identifying Assumption: Affects colleges only through firms

2. Cross-Sectional Variation: Linguistic Distance

- Identifying Assumption: Absent y2k, the rate of growth of engineering colleges is not correlated with historical linguistic differences.

**Threat to Identification**: Differential trends in engineering college growths across districts driven by un-observables correlated with historical linguistic differences.
Robustness & Additional Results

Robustness

- Differential time trends of observables
- Falsification: Colleges do not respond to non-technical employment, other types of colleges do not respond to opening of IT firms
- Additional Instrument: Details

Additional Results

- Enrollment
General Equilibrium

Equilibrium Wages, Prices and Tuitions:

Wages of workers trained in field $s$ working in industry $S$ in district $k'$ in period $t$

$$w_{k'St}^e = \frac{\partial Q_{k'St}p_{k'S}}{\partial \tilde{L}_{k'sS}} = p_{k'S}A_{k'sS}Q_{k'S}^{\frac{1}{p_S}}Q_{k'eS}^{\frac{1}{p_{eS}}-\frac{1}{p_S}}\tilde{L}_{k'sS} - \frac{1}{p_{eS}}$$

where $e=$ college education (high-skilled), no college education (low-skilled), $\tilde{L}_{k'sS} = \sum_k \tilde{L}_{kk'sS}$
General Equilibrium

**Equilibrium Wages, Prices and Tuitions:**

- Wages of workers trained in field $s$ working in industry $S$ in district $k'$ in period $t$

$$w_{k'St}^{e} = \frac{\partial Q_{k'St} p_{k'S}}{\partial L_{k'ss}} = p_{k'S} A_{k'ss} Q_{k'ss}^{\frac{1}{\rho_S}} \left[Q_{k'sS}^{\left(\frac{1}{\rho_eS} - \frac{1}{\rho_S}\right)} - \frac{1}{\rho_eS}\right] L_{k'sS}^{-1}$$

where $e =$ college education (high-skilled), no college education (low-skilled), $\tilde{L}_{k'sS} = \sum_k L_{kk'sS}$

- Prices of goods in industry $S$ in district $k'$ in period $t$:

$$p_{k'St}^{1-\rho} = \left[\left(\sum_{s \in h} A_{k'ss}^{\rho_h} w_{k'sS}^{1-\rho_h}\right)^{1-\rho} + \left(\sum_{s \in l} A_{k'ss}^{\rho_l} w_{k'sS}^{1-\rho_l}\right)^{1-\rho}\right]^{1-\rho}$$
General Equilibrium

Equilibrium Wages, Prices and Tuitions:

- Wages of workers trained in field $s$ working in industry $S$ in district $k'$ in period $t$:

$$w^{e}_{k's} = \frac{\partial Q^e_{k'S} p^{e}_{k'S}}{\partial \tilde{L}^{e}_{k's}} = p^e_{k'S} A^{p_{h}}_{k's} Q^e_{k'S} (\frac{1-p_{eS}}{p_{eS}}) \tilde{L}^{e}_{k's}$$

where $e$ = college education (high-skilled), no college education (low-skilled), $\tilde{L}^{e}_{k's} = \sum_k \tilde{L}^{e}_{kk's}$

- Prices of goods in industry $S$ in district $k'$ in period $t$:

$$p^{1-\rho}_{k'S} = \left[ \sum_{s \in h} A^{\rho_{h}}_{k's} w^{1-\rho_{h}}_{k's} \right]^{1-\rho} + \left[ \sum_{s \in l} A^{\rho_{l}}_{k's} w^{1-\rho_{l}}_{k's} \right]^{1-\rho}$$

- Tuition in region $k'$ in field $s$ in period $t$:

$$\rho_{k's} = c_{k's}$$
General Equilibrium

Equilibrium Aggregate Prices and Quantities in Each Location and Industry:

- Market Clearing: total income of sector $S$ in district $k'$ = total sales of sector $S$ from district $k'$

$$\pi'_{k'S} = \pi_{k'S}^y = \sum_{d} x_{k'dS} = \sum_{d} \tau_{k'dS}^{1-\sigma} p_{k'S}^{1-\sigma} p_{dS}^\sigma E_{dS}$$

- Trade Balance: Total expenditure in district $k'$ on sector $S$ goods must equal export flows from all other districts

$$\pi_{k'S} = \sum_{d} x_{dk'S} = \sum_{d} \tau_{dk'S}^{1-\sigma} p_{dS}^{1-\sigma} p_{k'S}^\sigma E_{k'S}$$
General Equilibrium

Equilibrium Employment in each Location and Industry:

Effective number of people working in district $k'$ in sector $S$ with a degree in field $s$:

$$
\tilde{L}_{k'Sst} = \sum_k m_{kk'Sst} L_{kst} \bar{e}_{kk'Sst}
$$
General Equilibrium

Equilibrium Employment in each Location and Industry:

Effective number of people working in district $k'$ in sector $S$ with a degree in field $s$:

$$
\tilde{L}_{k'Sst} = \sum_k m_{kk'Sst} \bar{L}_{kst} \bar{e}_{kk'Sst}
$$

$$
m_{kk'Ss} = \frac{(W_{k'Sst} \mu_{kk'})^{(\theta)}}{P_{k't}} \Phi_{ks}
$$

where

$$
\Phi_{ks} = \sum_{k''S''} \left( \frac{W_{k''S''st} \mu_{kk''}}{P_{k''t}} \right)^{(\theta)}
$$

Back
General Equilibrium

Equilibrium Employment in each Location and Industry:

Effective number of people working in district $k'$ in sector $S$ with a degree in field $s$:

$$\tilde{L}_{k'Sst} = \sum_k m_{kk'Sst} L_{kst} \tilde{\epsilon}_{kk'Sst}$$

Equilibrium Enrollment in each Location and Field of Education:

$$L_{kst} = \sum_o l_{okst-1} L_{ot-1}$$
General Equilibrium

**Equilibrium Employment in each Location and Industry:**

Effective number of people working in district $k'$ in sector $S$ with a degree in field $s$:

$$\tilde{L}_{k'St} = \sum_k m_{kk'St}L_{kst}\bar{e}_{kk'St}$$

**Equilibrium Enrollment in each Location and Field of Education:**

$$L_{kst} = \sum_o l_{okst-1}L_{ot-1}$$

$$l_{okst-1} = \frac{\exp\left(\frac{W_{kst-1}}{P_{kt-1}}\mu_{ok} - \rho_{ks} + \beta T_{ks}\Phi_{ks}^{\frac{1}{2}}\right)}{\sum_{k''s''}(\exp\left(\frac{W_{k''s''t-1}}{P_{k''t-1}}\mu_{ok''} - \rho_{k''s''} + \beta T_{k''s''}\Phi_{k''s''}^{\frac{1}{2}}\right))}$$
General Equilibrium

Equilibrium Employment in each Location and Industry:

Effective number of people working in district $k'$ in sector $S$ with a degree in field $s$:

$$\tilde{L}_{k'SS} = \sum_k m_{kk'SS} L_{kSS} \tilde{e}_{kk'SS}$$

Equilibrium Enrollment in each Location and Field of Education:

$$L_{kS} = \sum_o l_{okS-1} L_{o-1}$$

Equilibrium Number of Colleges in each Field and Location:

$$C_{kS} = \frac{L_{ks}}{e_{ks}}$$

where $e_{ks}$ is average mandated intake per field per district.
Calibrating Consumption Expenditure Shares

Table: Calibrating $\alpha_{sK'}$

<table>
<thead>
<tr>
<th>Country</th>
<th>Sector</th>
<th>Calibration</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>India</td>
<td>IT</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>India</td>
<td>trade-able</td>
<td>Import/GDP</td>
<td>World Bank</td>
</tr>
<tr>
<td>India</td>
<td>non-tradeable</td>
<td>Non-tradeable/GDP</td>
<td>NSS Consumer Exp</td>
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<tr>
<td>India</td>
<td>agri</td>
<td>Agri/GDP</td>
<td>NSS Consumer Exp</td>
</tr>
<tr>
<td>USA</td>
<td>IT</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>USA</td>
<td>trade-able</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>USA</td>
<td>non-tradeable</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>
Stylized Facts

Percentage increase in employment in IT sector following y2k shock is positively correlated with a district’s linguistic distance from Hindi/ negatively correlated with linguistic distance from English.
Stylized Facts
Stylized Facts
Stylized Facts
Below Primary

![Graph showing percentage change in EbelowPrimary against linguistic distance from Hindi.](image-url)
Graduates
Graduates

![Graph showing percentage change in Engineering Colleges against linguistic distance from Hindi with a fitted line.]

- Percentage change in Engineering Colleges
- Fitted line

April 2018
Estimation Step 3: Recovering Trade Elasticities

- Regress $p_{k'St}^{\sigma S-1}$:

$$
\ln(p_{k'St}^{\sigma S-1}) = (\sigma S - 1)\ln(((p_{hS}^{S})^{1-\rho} + x_{k'St}(p_{lS}^{S})^{1-\rho})^{1-\rho}) - (\sigma S - 1)(\frac{\rho_h}{\rho_h - 1})\ln A_{k'St}^{S}
$$

where $p_{k'St}^{S} = (\sum_{s\in e}(A_{k'St,s,e}^{S})\rho_e W_{k'St}^{S} W_{k'St}^{S})^{1-\rho_e} + (W_{k'St}^{S})^{1-\rho_e})^{1-\rho_e}$

and, $Q_{k'St}^{S} = (\sum_{s\in e}(A_{k'St,s,e}^{S})L_{k'St}^{S} L_{k'St}^{S})^{1-\rho_e} + (L_{k'St}^{S})^{1-\rho_e})^{1-\rho_e}$

and, $x_{k'St} = \frac{\hat{p}_{k'St}^{S} Q_{k'St}^{S}}{\hat{p}_{k'St}^{S}}$

and productivity: $\frac{A_{k'St,s,e}}{A_{k'St,s,e}^{S}} = (\frac{W_{k'St}^{S}}{W_{k'St}^{S}})(\frac{L_{k'St}^{S}}{L_{k'St}^{S}})$

$P_{k'S} = A_{k'S}^{\rho_h-1} ((p_{hS}^{S})^{1-\rho} + x_{k'St}(p_{lS}^{S})^{1-\rho})^{1-\rho}$
Determinants of Gravity Equation for IT

What goes into the distance measure?

- Linguistic distance
- Reputation/prior links (Banerjee et. al., 2001)
- Distance to Satellite/fiber optic cables (Actual physical speed of data transmission)
Percentage of direct and indirect IT value added in total services trade

OECD computer service definition: Computer services are defined as computer programming, consultancy and related activities and information service activities (ISIC 62 and 63).
Definition: In the International Standard Industrial Classification (ISIC) Rev. 2 services are defined as all activities in major Divisions 6 through 9 described as follows:
6 Wholesale and retail trade and restaurants and hotels 7 Transport, storage and communication 8 Financial, insurance, real estate and business services 9 Community, social and personal services.
Summary Statistics

pre-period: 87 % of districts 0 IT presence (out of 343), mean and SD of total emp 226 and 1753 resp

post-period: mean and Sd of Total num employees 2132 and 13368 resp. 75 % districts had no IT presence

historical software exports: 92 % of districts did not export in 1995 For those who exported in pre-period: mean 3.69 , sd 4.86 (in million USD)