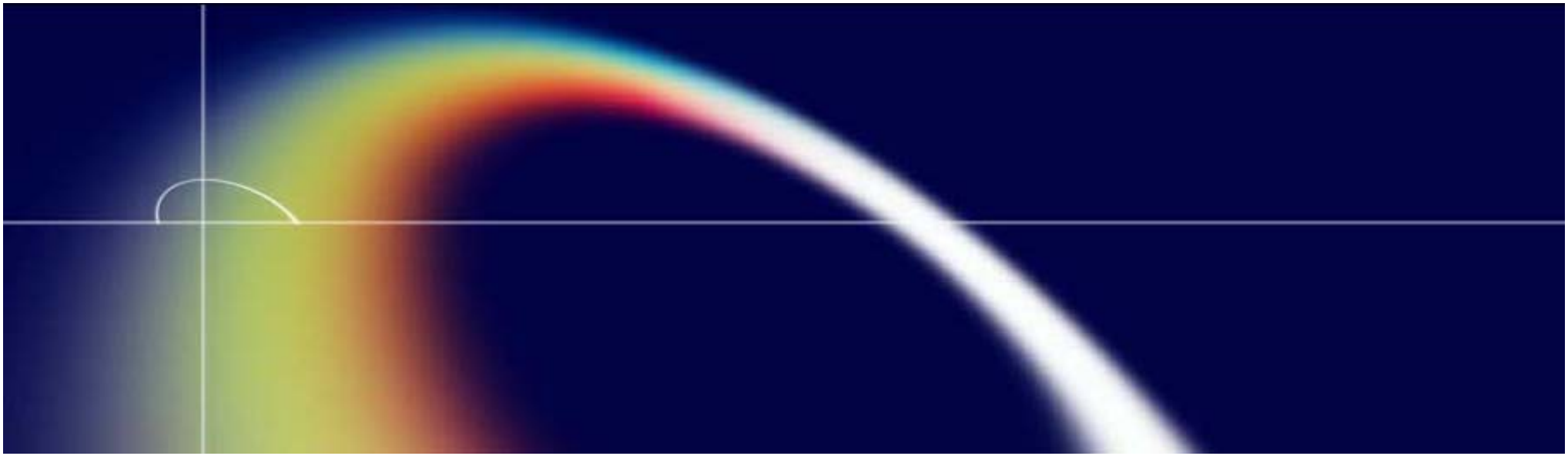

Cross-border Transfer of Climate Change Mitigation Technologies:
The Case of Wind Energy from Denmark and Germany to India

March 5th, 2009

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CAMBRIDGE
Judge Business School

The future of energy

Presentation Outline

- Introducing Cambridge Centre for Energy Studies
- Research Motivation and Focus
- Main Research Questions
- Research Methodology
- Analytical Results
- Research Conclusions
- Issues in Post 2012
- Future Research Agenda

Cambridge Centre for Energy Studies (CCES)

- A part of **University of Cambridge**
- Established in **October 2007**
- First of its kind - Energy Research Centre initiated by one of the World Top **Business School**s **(Judge Business School)**
- Four Major Focus
  - The **changing geography of the energy sector supply** and its implications on international relationships
  - Changing patterns of **ownership of resources** and its impacts on energy markets
  - The role of **public policy on technology transition**
  - The role of **international institutions on management** of climate change

http://www.jbs.cam.ac.uk/research/centres/cces.html

Research Motivation & Research Focus

- Conceptual Disparity of Technology Climate Change Mitigation Transfer – COP and Technology Transfer
  - Annex I – Technology belongs to Private Sector
  - Non-Annex I – Technology should be in the Public Domain because it mitigates Public Problem (Climate Change)
- Research Motivation
  - Lack of Active Private Sector Participation in Climate Change Mitigation Technology Transfer
  - Limited Scholarship on Long-term Process and Conflict involved in Climate Change Mitigation Technology Transfer and Sustainable Development
- Research Focus
  - The Role and Effects of:
    - **Government Policy & Institutions**
    - **Co-evolution Mechanism of Policy, Market, Industry and Technology**
    - **Industrial Competitiveness Management**

Main Research Questions

- Why is it so difficult to transfer more advanced climate change mitigation technologies from developed countries to developing countries?
- How can we stimulate the private sector involvement further in cross-border transfer of such technologies, in order to advance not only the global climate change mitigation efforts but also the long-term sustainable development?

Research Methodology

- In-depth **Case Study** Approach
  - Effective to investigate 'how' and 'why' and when the researcher has no control over events
  - Indeterminacy of Causal Mechanisms – Shortcoming
- Overcome the Shortcoming
  - A number of Observations are included in Analysis of **15-year Chronological Change**
  - Focus on:
    - Technology in **one field**
    - Technology **Transfer from One** Geographical Region (Denmark and Germany) **to Another** (India)
  - **Process Tracking** Procedure

Analytical Results – Innovator/Frontier

- Successful Wind Energy Technology Development and Diffusion
  - **High Technology Depreciation Rate**
    - New model introduction every two to three year by each manufacturer
    - Turbine Up-scaling - From 250kW Capacity in 1990 to 5MW Capacity in 2005
  - **Strong Path-dependency/Incremental** Technological Change
    - Gradual Path Shift toward Variable–speed, Pitch-regulated Turbines
  - **Science-based Pacing Technologies**
    - Computer/Materials Science and Engineering
  - Increased Technological **Complexity**
    - In Both Components and Value Activities
  - Increased **Specialization of Components**
  - Increased **System Integration Needs**
  - Evolved from Assemble of Med-tech Components into **High-technology since the mid 1990s**

Analytical Results – Innovator/Frontier

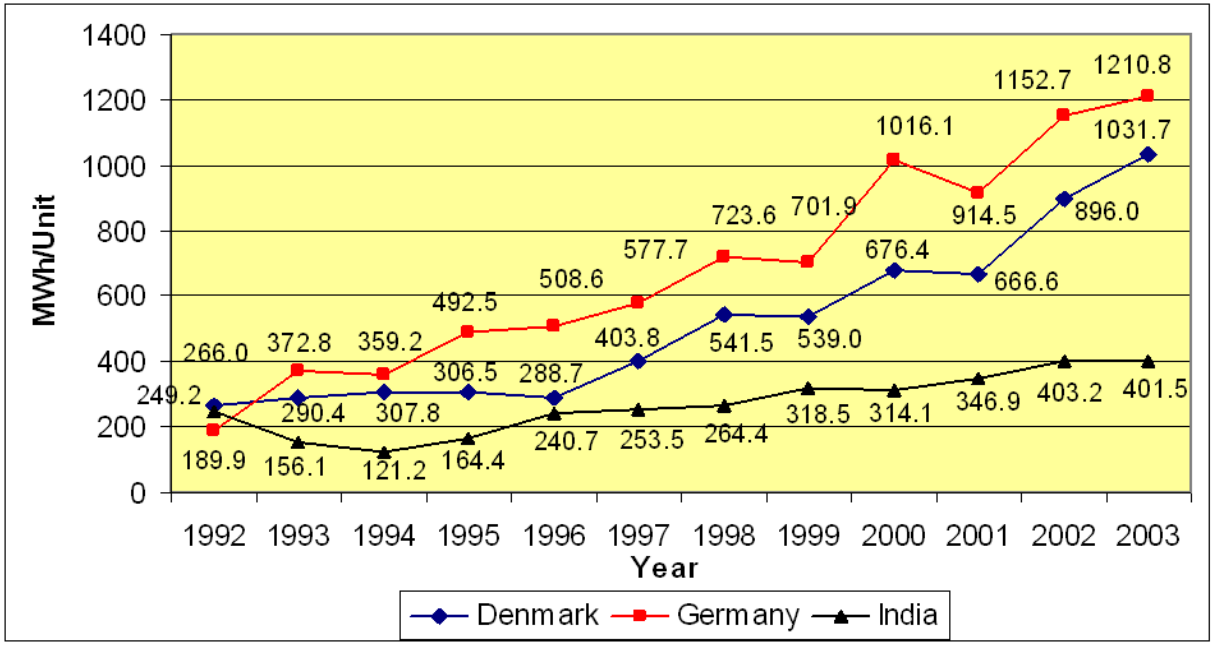
- Market-induced Evolutionary Technological Change
  - Importance of Both Market **Size** and Market **Demand Characteristics in Wind Success – Connection to Market Trials**
    - Regional Market – Strong Role of Germany
    - **Strong Performance/Efficiency Improvement Demand**
      - Competition with Other Investments, Land-Use Pressure (Market and Zoning/Noise Regulations), Continuous Feed-in Tariff Laws, Offshore Development Pressure
- Role and Effects of Policy and Institutions
  - **Monetary Value** Creation and Rewarding Policy
    - The Strongest Driving Force for Market Size Expansion
    - Continuity and Certainty of Investment Recovery
  - Technology/**Quality** Assurance Policy – Multiple Roles
  - System of Innovations
    - Market & Industry **Experience-based** EU/National Government R&DD
    - **Industrial Networks – All Channels of Learning**
  - **Virtuous Cycle Creation and Adjustment**

Analytical Results – Innovator/Frontier

- Strong Connection bet Technological Characteristics & Industry Competitiveness Management Strategies
  - Transformed Competitiveness Management
    - At Every Level of Strategy
    - **Increased Simultaneous Technology and Cost Management Demands**
    - Intertwined with Technology Evolution
  - Management Strategy - **Technology-specific**
    - **Basic Science Innovation - Industry-wide Cooperation**
    - Commercialization – **Two Differing Strategy**
      - Increased In-house Sourcing and Vertical Integration
      - Stronger Manufacturer-supplier Connection
    - Innovation and High-Value Production – **Regionalized Supply Chain Management within EU**
  - Cumulative Nature of Technical Entry/Business Barriers
    - **Consolidation of the Industry**

Analytical Results – Follower

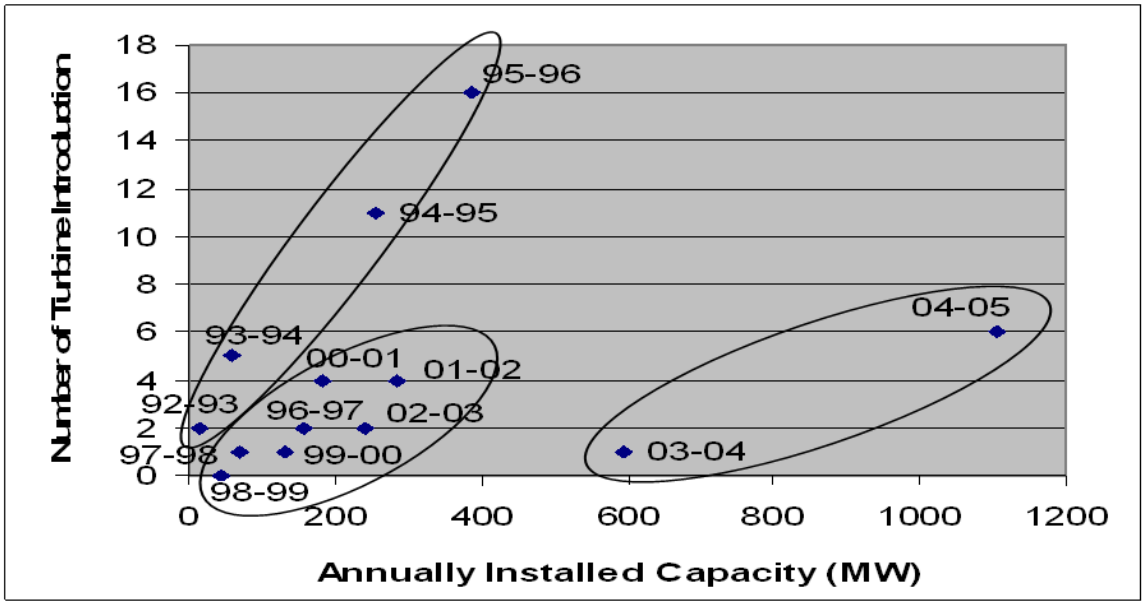
- **Increasing Technology Gaps** with the Frontier
  - Wind Turbine **Productivity**



  - Technological **Capacity & Capability**
    - Innovation – very limited R&D capacity and capability
    - Production –problems in high value technology indigenization and persistent quality issues

Analytical Results – Follower

- Strong Structural Relationship between **Market Development** and **New Technology Introduction**



- 1992-93 year to 2004-05 year (Break at 1996-97 year confirmed)
  Before the structural break: TNUMBER = 1.386 + 0.038*CAPACITY
  After the structural break: TNUMBER = 1.386 + 0.003*CAPACITY
- 1992-93 year to 2002-03 year (Break at 1996-97 year confirmed)
  Before the structural break: TNUMBER = -0.999 + 0.039*CAPACITY
  After the structural break: TNUMBER = -0.999 + 0.007*CAPACITY

Analytical Results – Follower

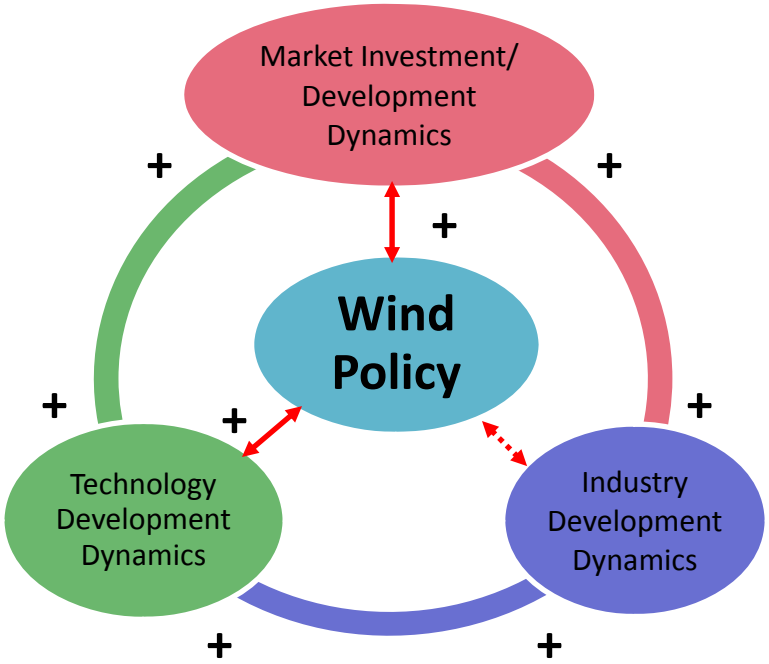
- **Failed** Virtuous Cycle Creation and Replicable Technology Transfer
  - **Weak Internal Policy** and Institutional Settings
    - **Subsidy-driven Investment Mechanism**
      - Lucrative Tax Benefits and Weak Feed-in Tariffs – Abuse of incentives
    - **Lack of Quality Assurance** Policy in Early Years – Abuse of incentives
    - SEB Financial Problems
    - **Weak Demand-pull Technology-Upgrading Forces**
  - Strong Effects of **External Factors**
    - Domination of **Industry Electricity Tariffs** in Economics
    - **Intensified Technology Ownership and Control by Provider**
      - **Restricted Business Practices/Trade Secret - Not Patent**
    - **Weak Supply-push Technology-Upgrading Forces for** Transformed High-Technological Characteristics
  - **Infrastructure Deficiency**
    - **Weak Grid** and **Weak Gird-Interface** Technology Development
    - Logistics Issues – **Weak Transport** Infrastructure for Up-scaled Turbine

Analytical Results – Partnership

- 6 Firm-level Technology Partnership Case Studies
  - 1 License Agreement (Nordex - BHEL)
  - 4 Joint Ventures (Vestas - Vestas RRB, NEG Micon - NEPC, Enercon - Enercon India, Wincon - Pioneer)
  - 1 Independent (Sudwind - Suzon, later Suzlon became independent)
- Case Study Cross-border Technology Transfer Results
  - Determinants of Entry Mode
    - **More Complex than Theories suggest**
  - Entry Mode and Results
    - **Higher Mode and More Advanced Technology Introduction - Importance of Technology Ownership and Control**
    - **Different Results within the Same Mode**
  - Strong Influence of External Factors
    - Technology Provider-side Industry Restructuring
    - Willingness of Transfer/Capacity Building Supports
  - Importance of **Evolutionary Process** of Partnerships on Results
  - In-between of Horizontal and Vertical Transfer

Analytical Results – Virtuous Cycle

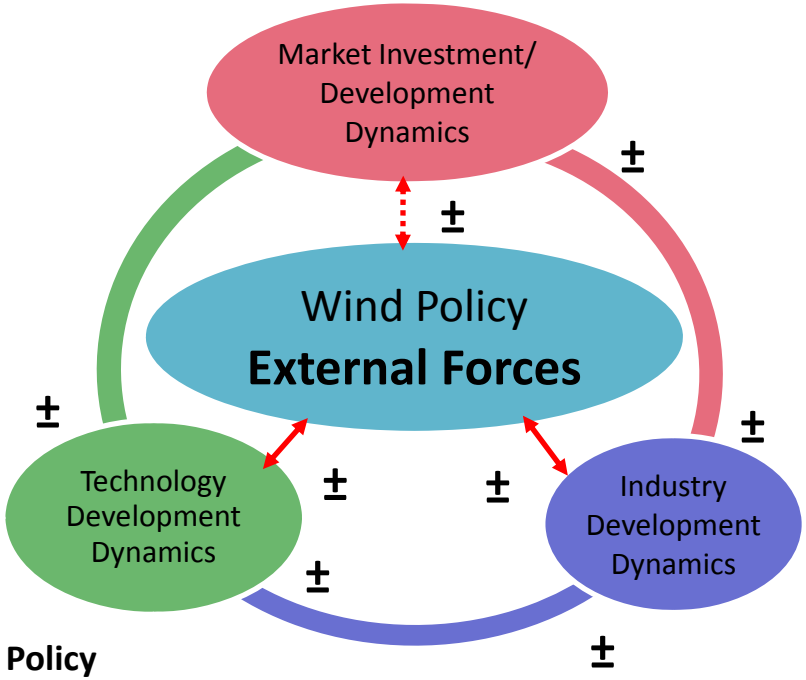
❑ Frontier – Denmark & Germany



Wind Policy

- Investment/Production Incentives
- Land Use/Environmental regulations
- Technology/Quality Assurance Policy
- EU/National R&DD Programs

❑ Follower - India



Wind Policy

- Investment Incentives
- Delayed Technology/Quality Assurance Policy Introduction

External Forces

- High Industry Electricity Tariffs Charge in India
- Frontier Industry/Market Dynamics
- Transformed Wind Technology Characteristics at Frontier
- Technology Provider Characteristics
- Insufficient Infrastructure (Power Grid/Transport)

Research Conclusions

- Importance of **Virtuous Cycle** for both Domestic and International Technology Development and Diffusion of Wind Energy
- **Centrality of Policy** in Creating/Sustaining/Upgrading Virtuous Cycle
  - **Simultaneous Demand-pull and Technology-push Measures**
    - Demand-pull Measures to induce: 1) **Continuous and Sizable** Market; and 2) **Performance-orientated** Market Demands
    - Technology-push Measures **linked with**: 1) **Market Demand and Trials**; 2) **Technology-specific** Learning Mechanisms and Paths; and 3) **Industry Experiences and Networks**
  - **Policy Initiation of Adjustment and Invigoration of the Cycle**
    - **Sequencing** and Combination of Policy

Research Conclusions

- **Technology-specific Competitiveness Management**
  - Strong Connection between Competitiveness Management and Specificity of Technology
    - Science/engineering knowledge base
    - Required technological levels (low-, med-, and high-tech)
    - Technological maturity
    - Factor intensity of components/value activities
    - Technological system complexity
  - **Necessity of Technology-specific Technology-push Measures**
- Necessity of **Replicable** Technology Transfer as a part of Virtuous Cycle and **for Long-term Climate Change and Sustainable Development Success**
  - **Repeated Upgrading of Technology** through Transfer for Technological Capability/Capacity Building
  - Difficulty of Virtuous Cycle Creation in Developing countries due to External Forces

Research Conclusions

- **Process-oriented** Replicable Technology Transfer
  - Both Mode of Transfer (FDI, Joint Ventures, License Agreement, etc) and Evolution of Partnerships determine Transfer Outcomes and Developmental Effects
- Enabling Environments - Necessary Condition for Technology Transfer Initiation
  - 10 Dimensions defined by IPCC Working Group III. 2000 "*Methodological and Technological Issues in Technology Transfer*"
    - National Systems of Innovation; Social Infrastructure and Participatory Approaches; Human and Institutional Capacities; Sustainable Markets; National Legal Institutions; Codes, Standards, and Certifications; Equity Considerations; Rights to Productive Resources; and Research and Technology Development
  - **Missing Dimension** – Physical Infrastructure for Logistics/Distribution
  - Importance of **Building and Re-shaping** to induce **Replicable** technology transfer that remove technology gaps

Issues in Post 2012

- How to Combine the Effectiveness of the Current International **Technology-neutral** Mechanism (ETS, JI and CDM) with **Technology-specific** Policy?
  - Technology Neutrality – the Public sides, i.e. the UN and country governments , do not choose specific technologies)
  - Difficulty – dealing with "additionality" aspect of CDM
- **Large International Policy/Market Block** with **Similar Policy Scheme for Specific Technology?**
    - E.g. F-I-T, Capital Investment supports for RE and their adjustment over time
  - **Certainty for Investment Returns - Large and Strong Market Certainty** to reduce risks and uncertainty
  - **Technology Push Policy - Collaborative R&D in pre-competitive stage** to create industry level competitiveness
  - **Simultaneous Pull and Push Policy** Combination - Bridge over the Valley of Death to reduce Failures and Overall Cost

Issues in Post 2012

- Enabling Environment – What the role of firms and Governments?
  - **Technology-specific** Aspects and **Generic** Aspects in Each Dimension
    - Role of Firm
      - Finding of **Value Creation Opportunities** at Firm/Partnerships and Offering **Mutual Benefits** in a case of Partnership
      - Technology-specific Capability Building Efforts
      - Aggressive Participation to Supply/Value Chain Activities for developing country side
    - Role of Government
      - **Generic Efforts on Capacity Building -**
        - Technological Capability Building
        - Macroeconomic/Market/Legal Dimensions
      - **Simultaneous** Market Value Creation (**Market-Pull**) & Innovation Support/Quality Assurance (**Technology Push and Pull**) Policy
      - Well-considered **Domestic Policy Sequencing and Implementation**
- How will the uncertainty of **New Financial System and Order** affect the future investments?
  - Current Rapid Shift from Market Liberalism to Strong State Intervention/Cheap Oil Price
  - Make Clean Energy as **Great Value Creation Opportunity**!!!

Future Research Agenda

Technology-specific Analysis of Innovation and Diffusion System and Policy for Effective Policy

- Factors
  - **Knowledge Base -** What kind of scientific/engineering discipline that are leading, **pacing** and **enabling** the innovation and diffusion of specific technology
  - **Technological Maturity** – still need to be led by the public R&D, manure enough to be led by the private sector or in-between?
  - **System Complexity & Innovation-Diffusion Time Cycle and Cost** - How long and how much does it take to bring initial R&D to commercialization?
  - **Innovators in Value/Supply Chain** – Who is innovating and who needs the public support?
  - **Other Sectoral Characteristics** – Susceptibility to business cycle/recession, etc
- Determination of the Technology-specific Role of Public and Private Sectors
- IPR – Types of IPR protection is technology specific
  - Macro Knowledge Flow (patent study) between Sectors and between Countries
  - Technology-specific IPR usages (types and importance) and Innovation/knowledge Protection Study

Thank you very much!

This original research was my PhD dissertation

at Massachusetts Institute of Technology

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