Emergence of Universities as Centers of New Knowledge Generation and Cornerstone for Nation’s Competitiveness: A Case Study of The National University of Singapore

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Vice-President, National University of Singapore

3rd International Conference on World Class Universities, WCU3, 2-4 November 2009, Shanghai

Universities Trends

- Education role – Manpower for Industry
- Spread of universities in Europe
- Introduction of Science and Technology
- Aided by print media

1600 - 1900
- Education + Research roles
- Massive expansion of university sector in Europe and USA

Pre-1600
- Few universities
- Theology, Liberal Arts, Law
- To educate nobles, clergy

1900 – 2000
- Education + Research

2000 & Beyond
- Education + Research + Economic role
- Massive expansion of university sector in Asia Pacific
- Global competition for: talents & funds
- Aided by digital media

Reference: Changing Facie of Innovation: Is it Shifting to Asia? - Seeram & Daniel
Changing Landscape of Global R&D

Share of Global R&D Spending

<table>
<thead>
<tr>
<th>Year</th>
<th>Asia</th>
<th>USA</th>
<th>Europe</th>
<th>Rest of the World</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Global R&D Report 2009 – Battelle and R&D Magazine
Reference: Changing Facie of Innovation: Is it Shifting to Asia? - Seeram & Daniel

Changing Landscape of Global R&D

Shift of Innovation from Atlantic to Pacific

USA USD 384 Bi
Europe USD 280 Bi
Asia USD 387 Bi

Global Spending of Innovation Dollars

Reference: Changing Facie of Innovation: Is it Shifting to Asia? - Seeram & Daniel
Economic Development of Singapore

Economic Development of Singapore

Mission
• To advise Singapore Cabinet on national research and innovation policies and strategies to drive the transformation of Singapore into knowledge-based economy, with strong capabilities in research and development (R&D)
• To lead the national drive to promote research, innovation and enterprise by encouraging new initiatives in knowledge creation in science and technology, and to catalyze new areas of economic growth

The members comprise:
• Cabinet Ministers
• Distinguished local and foreign members:
  • the business,
  • science and
techology community

Source: Singapore Department of Statistics
Reference: Changing Face of Innovation: Is it Shifting to Asia? - Seeram & Daniel

Lee Hsien Loong
Chairman, RIEC
Prime Minister

1960s Labour Intensive
1970s Skill Intensive
1980s Capital Intensive
1990s Technology Intensive
2000s Knowledge and Innovation Intensive

Research Intensive Universities are becoming driving force of economic growth
Economic Development of Singapore

3 Key Strategic Research Areas

- Biomedical Sciences
- R&D Driver of Economic Growth
- Environmental and Water Technologies
- Interactive & Digital Media

Goal:
- To achieve a national R&D spending of 3% of GDP by 2010
- To achieve two-thirds of R&D spending by Private sector and one-third by Public sector

Role of Universities in Singapore

SINGAPORE R & D FRAMEWORK

Chairman, RIEC – Prime Minister

Source: Ministry of Trade and Industry (Singapore)
RESEARCH
• Fundamental, cutting edge, research that makes an impact

TEACHING
• Education of people

SERVICE
TIMES HIGHER EDUCATION
QS WORLD UNIVERSITY RANKING

<table>
<thead>
<tr>
<th>Discipline</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>33</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Arts and Humanities</td>
<td>21</td>
<td>30</td>
<td>23</td>
</tr>
<tr>
<td>Engineering and IT</td>
<td>10</td>
<td>11</td>
<td>14</td>
</tr>
<tr>
<td>Life Sciences and</td>
<td>12</td>
<td>17</td>
<td>20</td>
</tr>
<tr>
<td>Biomedicine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Natural Sciences</td>
<td>25</td>
<td>31</td>
<td>27</td>
</tr>
<tr>
<td>Social Sciences</td>
<td>20</td>
<td>18</td>
<td>20</td>
</tr>
</tbody>
</table>

How is NUS doing so far?

Top Asia-Pacific institutions in material science
27 August 2009

<table>
<thead>
<tr>
<th>Rank</th>
<th>World Rank</th>
<th>Institution</th>
<th>Papers</th>
<th>Citations</th>
<th>Citations per paper</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>19</td>
<td>Japan Science &amp; Technology Agency</td>
<td>1,351</td>
<td>14,941</td>
<td>11.06</td>
</tr>
<tr>
<td>2</td>
<td>28</td>
<td>City University of Hong Kong</td>
<td>1,269</td>
<td>11,973</td>
<td>9.43</td>
</tr>
<tr>
<td>3</td>
<td>33</td>
<td>U of Science and Technology of China</td>
<td>1,598</td>
<td>13,016</td>
<td>8.15</td>
</tr>
<tr>
<td>4</td>
<td>34</td>
<td>Seoul National University</td>
<td>2,438</td>
<td>19,778</td>
<td>8.11</td>
</tr>
<tr>
<td>5</td>
<td>35</td>
<td>Nat Inst for Materials Science, Japan</td>
<td>3,722</td>
<td>27,607</td>
<td>7.42</td>
</tr>
<tr>
<td>6</td>
<td>36</td>
<td>Kyoto University</td>
<td>2,630</td>
<td>19,269</td>
<td>7.33</td>
</tr>
<tr>
<td>7</td>
<td>38</td>
<td>Nat Inst of Advanced Industrial Science and Technology, Japan</td>
<td>4,345</td>
<td>31,324</td>
<td>7.21</td>
</tr>
<tr>
<td>8</td>
<td>39</td>
<td>Korea Adv Inst of Science and Tech</td>
<td>2,062</td>
<td>14,636</td>
<td>7.10</td>
</tr>
<tr>
<td>9</td>
<td>40</td>
<td>Kyushu University</td>
<td>1,666</td>
<td>11,717</td>
<td>7.03</td>
</tr>
<tr>
<td>10</td>
<td>42</td>
<td>National Tsing Hua University, Taiwan</td>
<td>1,591</td>
<td>10,890</td>
<td>6.84</td>
</tr>
<tr>
<td>11</td>
<td>43</td>
<td>Tokyo Institute of Technology</td>
<td>2,685</td>
<td>18,217</td>
<td>6.78</td>
</tr>
<tr>
<td>12</td>
<td>44</td>
<td>Tohoku University</td>
<td>5,603</td>
<td>37,888</td>
<td>6.76</td>
</tr>
<tr>
<td>13</td>
<td>45</td>
<td>University of Tokyo</td>
<td>3,071</td>
<td>20,742</td>
<td>6.75</td>
</tr>
<tr>
<td>14</td>
<td>47</td>
<td>Osaka University</td>
<td>3,668</td>
<td>23,985</td>
<td>6.54</td>
</tr>
<tr>
<td>15</td>
<td>48</td>
<td>Nanyang Tech University, Singapore</td>
<td>2,416</td>
<td>15,339</td>
<td>6.35</td>
</tr>
<tr>
<td>16</td>
<td>49</td>
<td>Yonsei University, South Korea</td>
<td>1,638</td>
<td>10,127</td>
<td>6.18</td>
</tr>
<tr>
<td>17</td>
<td>50</td>
<td>Jilin University, China</td>
<td>1,754</td>
<td>10,613</td>
<td>6.05</td>
</tr>
<tr>
<td>18</td>
<td>51</td>
<td>Chinese Academy of Sciences</td>
<td>13,039</td>
<td>72,690</td>
<td>5.57</td>
</tr>
<tr>
<td>19</td>
<td>52</td>
<td>Tsing Hua University, China</td>
<td>4,352</td>
<td>23,496</td>
<td>5.40</td>
</tr>
<tr>
<td>20</td>
<td>53</td>
<td>Nat. Cheng Kung University, Taiwan</td>
<td>2,082</td>
<td>10,583</td>
<td>5.06</td>
</tr>
<tr>
<td>21</td>
<td>54</td>
<td>Zhejiang University, China</td>
<td>2,398</td>
<td>10,818</td>
<td>4.51</td>
</tr>
<tr>
<td>22</td>
<td>55</td>
<td>Shanghai Jiao Tong University</td>
<td>3,044</td>
<td>10,580</td>
<td>3.48</td>
</tr>
</tbody>
</table>

Data provided by Thomson Reuters from its Essential Science Indicators, 1 January 1999-30 April 2009
How is NUS doing so far?

R&D expenditures (US$mi) & innovation outputs per 100 academic staff - NUS vs global universities, 2005

<table>
<thead>
<tr>
<th></th>
<th>MIT</th>
<th>Stanford</th>
<th>UPenn</th>
<th>USC</th>
<th>Georgia Tech</th>
<th>Oxford</th>
<th>Cambridge</th>
<th>Imperial</th>
<th>NUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>R&amp;D expenditure</td>
<td>67.8</td>
<td>45.96</td>
<td>13.95</td>
<td>9.5</td>
<td>46.66</td>
<td>12.93</td>
<td>83.45</td>
<td>12.56</td>
<td>3.78</td>
</tr>
<tr>
<td>Spin-offs</td>
<td>1.2</td>
<td>0.6</td>
<td>0.2</td>
<td>0.2</td>
<td>1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.2</td>
<td>0.1</td>
</tr>
<tr>
<td>Licenses</td>
<td>5.6</td>
<td>6.2</td>
<td>1.7</td>
<td>1.4</td>
<td>4.1</td>
<td>1.5</td>
<td>1.5</td>
<td>0.8</td>
<td>0.7</td>
</tr>
<tr>
<td>Patents</td>
<td>8</td>
<td>5.6</td>
<td>0.8</td>
<td>0.8</td>
<td>4.8</td>
<td>1.1</td>
<td>Na</td>
<td>1.3</td>
<td></td>
</tr>
<tr>
<td>Innovation disclosures</td>
<td>30.8</td>
<td>28.5</td>
<td>7.7</td>
<td>2.7</td>
<td>33.4</td>
<td>3.8</td>
<td>3.8</td>
<td>6.1</td>
<td>3.7</td>
</tr>
</tbody>
</table>

Reference: Wong, P.K., Ho, Y.P.& Singh A., Towards a “Global Knowledge Enterprise”: The Entrepreneurial University model of NUS

Source: NUS Enterprise

How is NUS doing so far?

Contribution of Human Capital by NUS

NUS – Major National Resource Human Capital
- Scientists, Engineers and Medical Professionals -

<table>
<thead>
<tr>
<th>Year</th>
<th>Total RSEs in Singapore</th>
<th>Higher Education RSEs (a)</th>
<th>NUS Research Staff (b)</th>
<th>NUS research staff share of total higher education b/a</th>
<th>NUS faculty in science, engineering and Medicine(SEM) (c)</th>
<th>NUS research staff + SEM faculty share of total higher education RSEs (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>5218</td>
<td>1851</td>
<td>274</td>
<td>14.8%</td>
<td>670</td>
<td>51.0%</td>
</tr>
<tr>
<td>1996</td>
<td>10153</td>
<td>3106</td>
<td>1002</td>
<td>32.3%</td>
<td>735</td>
<td>55.9%</td>
</tr>
<tr>
<td>2001</td>
<td>15366</td>
<td>3518</td>
<td>842</td>
<td>23.9%</td>
<td>793</td>
<td>46.5%</td>
</tr>
<tr>
<td>2006</td>
<td>22675</td>
<td>4451</td>
<td>1218</td>
<td>27.4%</td>
<td>1000</td>
<td>49.0%</td>
</tr>
</tbody>
</table>
How is NUS doing so far?

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Singapore Publications</th>
<th>NUS Publications</th>
<th>% of NUS Contribution to Singapore’s Publication</th>
<th>Number of times NUS Publications were cited</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>2491</td>
<td>1619</td>
<td>65%</td>
<td>21,167</td>
</tr>
<tr>
<td>2002</td>
<td>4717</td>
<td>2519</td>
<td>53%</td>
<td>34,451</td>
</tr>
<tr>
<td>2005</td>
<td>6939</td>
<td>3500</td>
<td>50%</td>
<td>33,332</td>
</tr>
<tr>
<td>2006</td>
<td>7392</td>
<td>3764</td>
<td>51%</td>
<td>24,932</td>
</tr>
<tr>
<td>2007</td>
<td>6356</td>
<td>3746</td>
<td>59%</td>
<td>15,660</td>
</tr>
</tbody>
</table>

Publications in Science, Engineering and Medical Sciences (SCI Extended Version)
Source: Krishna (2009)
Internationalization of NUS Faculty and Researchers

<table>
<thead>
<tr>
<th>Year</th>
<th>Faculty – International Staff</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>10%</td>
</tr>
<tr>
<td>1997</td>
<td>39%</td>
</tr>
<tr>
<td>2008</td>
<td>Over 50%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Researchers – International Staff</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>75%</td>
</tr>
</tbody>
</table>
### Global Partnership

- **Education**
- **Research**

| Duke-NUS Graduate Medical School Singapore | Duke |
| Singapore-MIT Alliance (SMA) | MIT |
| The Logistics Institute-Asia Pacific | Georgia Tech |
| Masters in Public Policy | Stanford |
| Executive Development Programme | Stanford |
| Design Technology Institute | T/u Eindhoven |
| German Institute of Science & Technology | T U Munich |
| French-NUS Double Degree Programmes | 6 Grandes Ecoles |
| International MBA Programme | Peking |
| NYU@NUS Programme | New York |
| JDP in Actuarial Studies & Economics | Australian National |
| Master of Science in Advanced Engineering Materials | Indian Institute of Technology Bombay |

### Faculties and Schools

| Faculty of Arts and social sciences |
| Business School |
| School of Computing |
| School of Dentistry |
| School of Design and Environment |
| School of Engineering |
| Law School |
| School of Medicine |
| Conservatory of Music |
| Faculty of Science |

| Graduate Schools |
| Lee Kuan Yew School of Public Policy |
| NUS Graduate School for Integrative Sciences and Engineering |
| Duke-NUS Graduate Medical School Singapore |

| Research Institutes and Overseas Colleges |
| 6 Overseas colleges |
| 3 Research Centres of Excellence |
| 21 University level research institutes |
| 16 National level affiliated research institutes |
• University Town (Phase One ready by 2011)
  - 5 residential colleges and 2 graduate residences to accommodate 6,000 local and overseas students
  - Academic and learning facilities as well as sports and leisure amenities
  - Enriching campus learning and living experience in a global setting

• Campus for Research Excellence and Technological Enterprise (CREATE)
  - An initiative by National Research Foundation
  - An integrated research community crossing disciplines and institutions
SMART Centre – Singapore-MIT Alliance for Research and Technology

1. SMART Infectious Disease IRG
2. Center for Environmental Sensing and Modeling (CENSAM) IRG
3. BioSystems and Micromechanics (BioSyM) IRG
4. Future Urban Mobility IRG

C.R.E.A.T.E.
Campus for Research Excellence And Technological Enterprise

650,000 sq ft scientific research center located at the National University of Singapore’s new 7 acre University Town campus.

NRF-Israel Universities
• NRF-Technion:
  Regenerative Medicine Initiative in Cardiac Restoration Therapy.
• NRF – Weizmann – NUS – Temasek Life Sciences Lab:
  Joint Research Program on Molecular Mechanisms of Morphogenesis

C.R.E.A.T.E.
Campus for Research Excellence And Technological Enterprise

650,000 sq ft scientific research center located at the National University of Singapore’s new 7 acre University Town campus.
SINGAPORE ETH CENTRE(SEC)-
• Future Cities Laboratory Programme (FCL)

C.R.E.A.T.E.
Campus for Research Excellence And Technological Enterprise

650,000 sq ft scientific research center located at the National University of Singapore’s new 7 acre University Town campus.

Invest in Research Infrastructure
• Global Partners
• Government
• Private Sector – Industries

Collaborative Public and Private Partnerships
• Policy Makers
• Private Sector - Industries

Strengthening of Nexus of Universities, Research Institutions, Policy Makers and Industries

Basic Research
Applied Research
Technology
Industry Cluster

Universities
Research Institutions
Government Agencies
Sustainable Energy

$25 million Clean Energy PhD Scholarships in overseas universities renowned in Energy Clean such as:

- Massachusetts Institute of Technology
- University of California at Berkeley, USA
- Stanford University, USA
- Georgia Institute of Technology, USA
- National Renewable Energy Laboratory (NREL), USA
- Loughborough University, UK
- Sandia National Labs, USA
- Swiss Federal Institute of Technology, Switzerland
- TU Munich, Germany
- Fraunhofer Institute for Solar Energy Systems, Germany
- University of New South Wales (UNSW), Australia

Source: EDB

Collaborative Public and Private Partnerships
- Policy Makers
- Private Sector - Industries

SOLAR ENERGY RESEARCH INSTITUTE OF SINGAPORE

Prof Joachim Luther
- CEO
- Former Director of Fraunhofer ISE from 1993 to 2006
- On commission of experts on research & innovation that advises Chancellor Merkel

Prof Armin Aberle
- Deputy Director
- Ex- Deputy Director of PV Centre of Excellence in UNSW
- Renowned thin-film solar expert

Crystalline & Thin Film Silicon Solar Technology

Testing and Certification with VDE & Fraunhofer

World Class Solar R&D Centre ($140 mi)

Novel Photovoltaic Devices

Solar & Energy Efficient Buildings
Lead by Prof. Artur Ekert, Professor of Quantum Physics at the Mathematical Institute, Oxford University, and a Lee Kong Chian Centennial Professor at the National University of Singapore. Quantum technologies for coherent control of individual photons and atoms and explore both the theory and the practical possibilities of constructing quantum-mechanical devices for the purpose of cryptography and computation.

Collaborative Public and Private Partnerships
- Policy Makers
- Private Sector - Industries

National Agencies and Government Ministry Funding

Lead by Prof. Daniel G. Tenen, Harvard Medical School & National University Hospital. To firmly position Singapore as one of the major centers for cancer biology and treatment in the Asian community and the world.

Collaborative Public and Private Partnerships
- Policy Makers
- Private Sector - Industries

National Agencies and Government Ministry Funding
Co - Lead by Prof Michael Sheetz, Columbia University, USA
Prof Paul Matsudaira, MIT, USA & Dept of Biological Sciences, NUS

Aims to break new ground in studying diseases through the mechanisms of cell and tissue mechanics

National Agencies and Government Ministry Funding

Collaborative Public and Private Partnerships
- Policy Makers
- Private Sector - Industries

Shift Policies to National and Societal Challenges
- Multi-Disciplinary Approach

Clean Water

Multi-National, Interdisciplinary Research Centre of Excellence for Water Knowledge

Area of Focus:
- hydrodynamics
- hydrology
- morphodynamics
- water quality & ecology
- policy analysis
- hydroinformatics

Multi-Disciplinary Approach
Shift Policies to National and Societal Challenges

Public Utilities Board
Singapore

The Netherlands

The Netherlands
GE-NUS partnership paves the way for Singapore as ‘global hydro hub’

- Fundamental technology development
- Water reclamation and reuse
- Novel systems engineering

S$150 million investment by GE and NUS
2,700 sq metres of new R&D laboratory on NUS Campus

- Multi-Disciplinary Approach

NUS Virtual Institute for Study of Ageing (VISA)

<table>
<thead>
<tr>
<th>SINGAPORE</th>
<th>2009</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>No of people of age 65 and above</td>
<td>300,000</td>
<td>900,000</td>
</tr>
</tbody>
</table>

NUS and the Ministry of Community Development, Youth and Sports supported
- Multi-Disciplinary Group of 300
  - Doctors
  - Engineers
  - Architects
  - Social Scientists

Areas of Research

- The ageing body
- The ageing cell
- The ageing society
- The ageing mind

No of people of age 65 and above

- 2009: 300,000
- 2030: 900,000
Concluding Remarks

Center of New Knowledge
Generation and Cornerstone for Nation’s Competitiveness

Internationalization
Shift from Policies to National & Societal Challenges
Research Intensive Universities
Global Partnership
Collaborative Public and Private Partnerships
Invest in Research Infrastructure

Thank You

謝謝