Pandaigdigang
Araw ng Liwanag
Ika-16 ng Mayo

Measuring the Performance of the Philippine Scientific Enterprise System

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NAST PH

DOST NAST Luzon Regional Scientific Meeting
Royce Hotel & Casino, Clark Freeport Zone
9-10 May 2018

Aim

- **To propose metrics for measuring the capability of the Philippine scientific enterprise system to produce human and intellectual capital relative to the resources given into it.**

- **There is no science without measurement.**

STEM – Science, Technology, Engineering and Mathematics

Outline of Presentation

- **Preliminaries (Data)**

  Yearly national budget and GDP growth

  Publication per capita and GDP of ASEAN economies

  Human capital generation and the HEIs

- **Proposed metrics for R&D performance**

- **Recommendations**

Definitions

- **Philippine scientific enterprise system**

  Agencies directly involved in:

  - **Training of future Filipino scientists and researchers.**
  - **Generation of new scientific knowledge that improves our understanding of natural phenomena.**

- **Funding absorption (output-input relationship)**

  More PhD graduates and peer-reviewed scientific publications (outputs) relative to an increase in financial and logistical support for R&D activities (inputs).

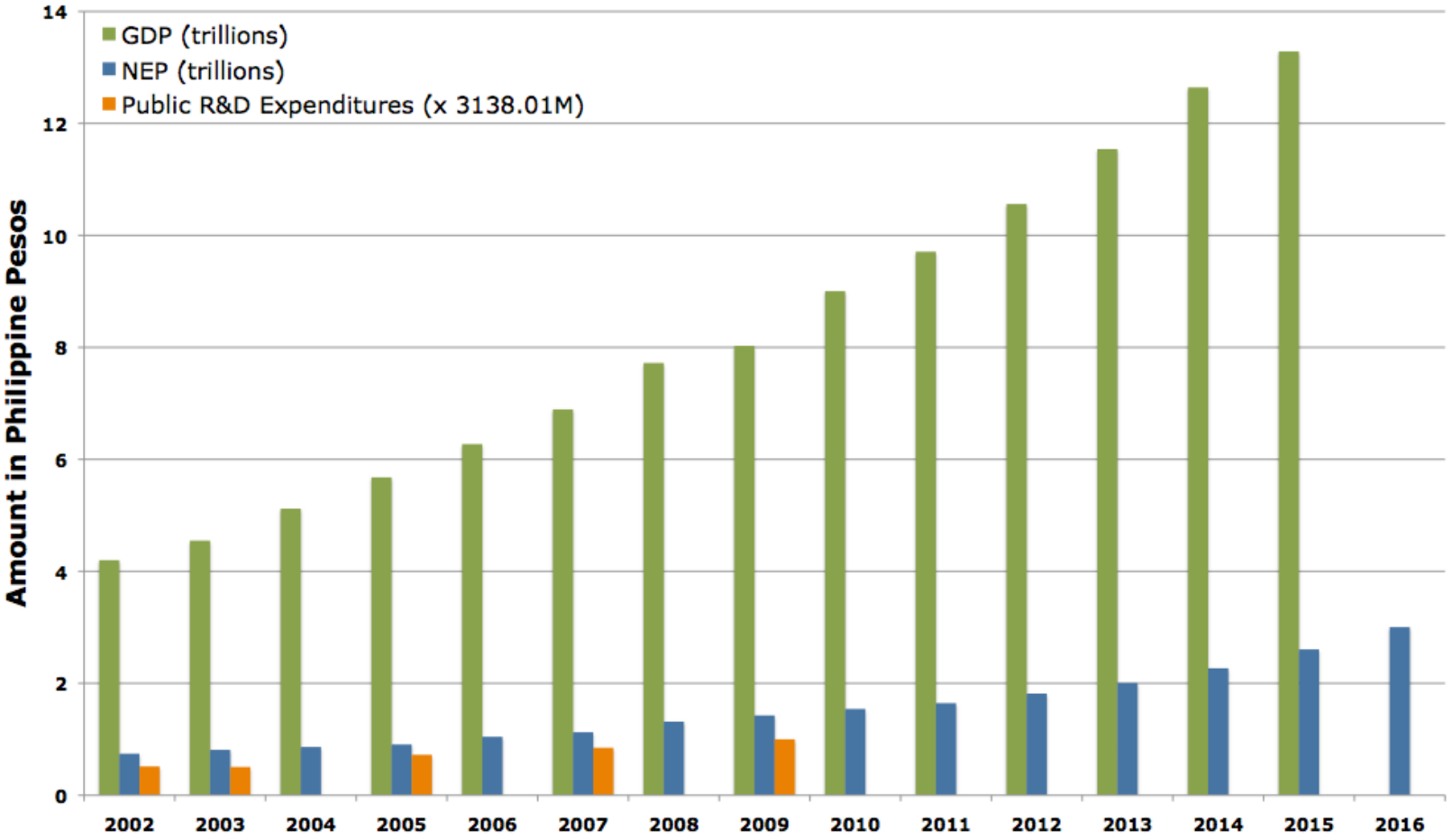
System's Analysis

- **Outputs**
  - **Peer-reviewed publications (research productivity)**
  - **PhD graduates per year (human capital generation)**

- **Inputs**
  - **Budgetary allocation**
  - **Graduate scholarships**
  - **Regular faculty items**
  - **PhD faculty members**
  - **Duration of PhD study**
  - **Research load**

STEM – Science, Technology, Engineering and Mathematics

GDP and National Expenditure Program



Average GDP Growth (2005 – 2015): 8.9±2.54% per year

Yearly NEP (2006 – 2016) = 19.3±1.32% of GDP in previous year

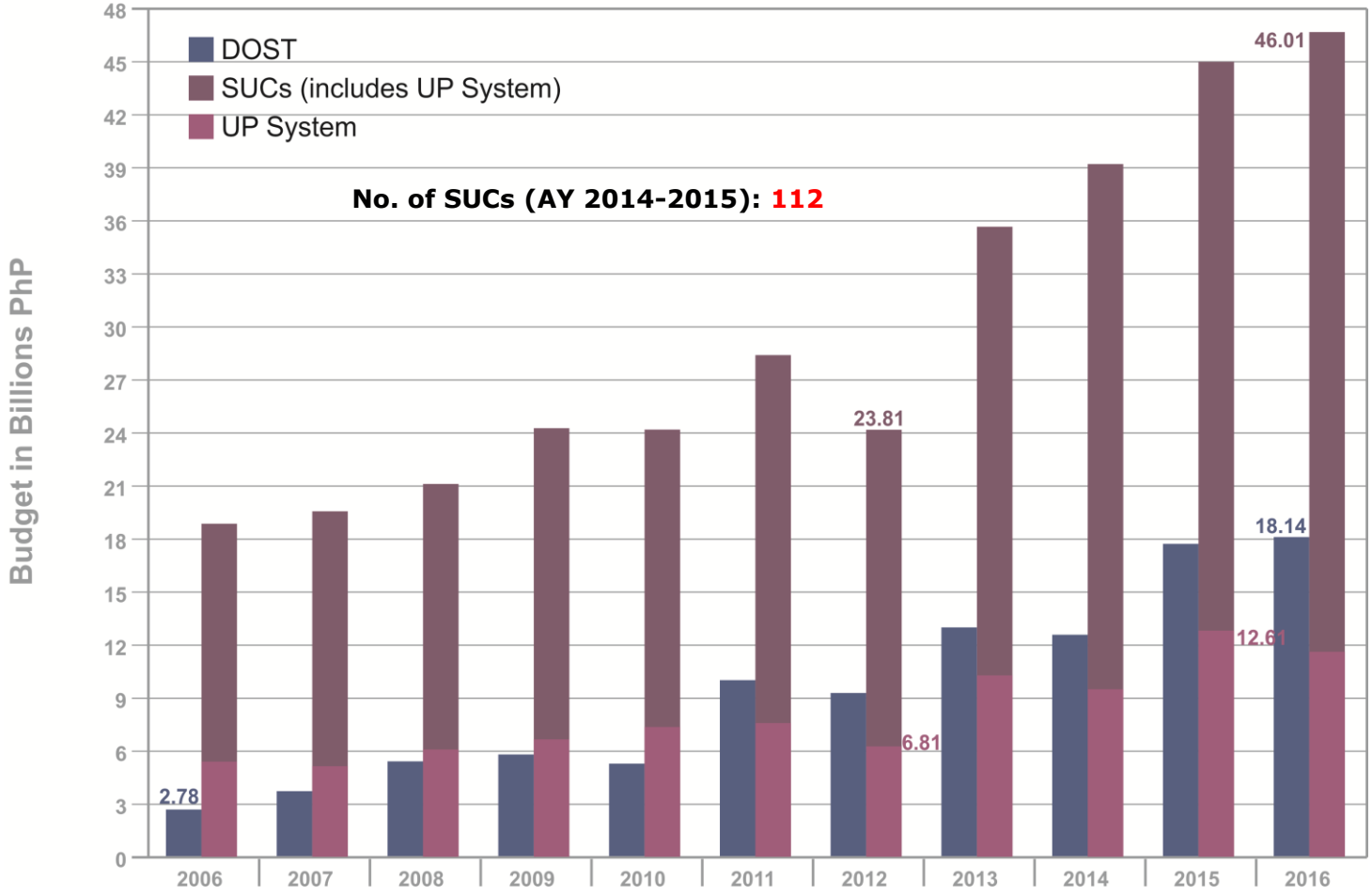
Source (National Expenditure Program, GDP): www.dbm.gov.ph accessed 10 February 2016
Source (R&D Expenditure): Compendium of Science and Technology Statistics, DOST (July 2012) ISSN 2244-3614

Annual Budget

DOST, SUCs and UP System

Budget Increase (from 2006 to 2016)

DOST: 115.11%
SUCs: 61.53%



UP Budget (2006 – 2016): 27.4±1.32% of SUC Budget

Budget Comparison
2006: DOST (PhP 2.781B) = 0.52 UP Budget
2016: DOST (18.137B) = 1.58 UP Budget

ASEAN Member States

Population

Country	2009	2014	2015
Indonesia	238,465,165	254,454,778	257,563,815
Philippines	91,641,881	99,138,690	100,699,395
Vietnam	86,025,000	90,728,900	91,703,800
Thailand	66,548,197	67,725,979	67,959,359
Myanmar	51,369,725	53,437,159	53,897,154.0
Malaysia	27,661,017	29,901,997	30,331,007
Cambodia	14,144,337	15,328,136.0	15,577,899
Lao PDR	6,153,153	6,689,300	6,802,023
Singapore	5,647,194	5,469,724	5,535,002
Brunei	387,080	417,394	423,188

GDP per capita (in current USD)

Country	2009	2014	2015
Singapore	38,577.6	56,007.3	52,888.7
Brunei Darussalam	27,726.5	40,979.6	36,607.9
Malaysia	7,312.0	11,307.1	9,766.2
Thailand	4,231.1	5,969.9	5,816.4
Indonesia	2,262.7	3,499.6	3,346.5
Philippines	1,836.9	2,872.5	2,899.4
Vietnam	1,232.4	2,052.3	2,111.1
Lao PDR	948.0	1,751.4	1,812.3
Myanmar		1,203.8	1,203.5
Cambodia	690	1,094.6	1,158.7

SCOPUS-indexed publications (Citable Documents)

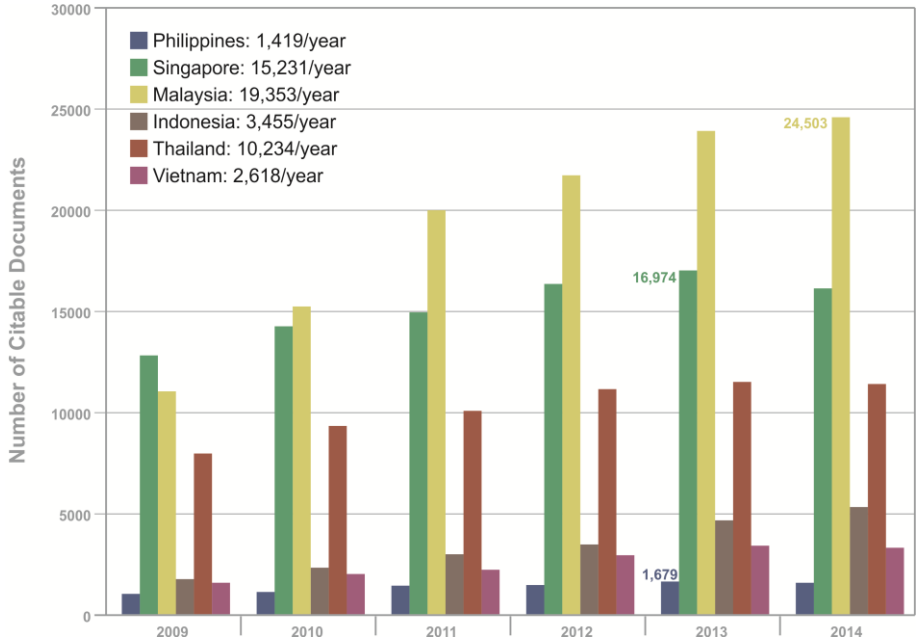
Country	2009	2014	2015
Malaysia	11098	26990	22357
Singapore	12805	17554	16351
Thailand	7992	12497	10886
Indonesia	1809	6027	6040
Vietnam	1629	3758	3855
Philippines	1066	1812	1869
Brunei	89	318	341
Cambodia	167	269	287
Lao PDR	97	190	204
Myanmar	131	128	164

Citable Documents: Articles, reviews, conference papers published by a journal in the three previous years (selected year documents are excluded).

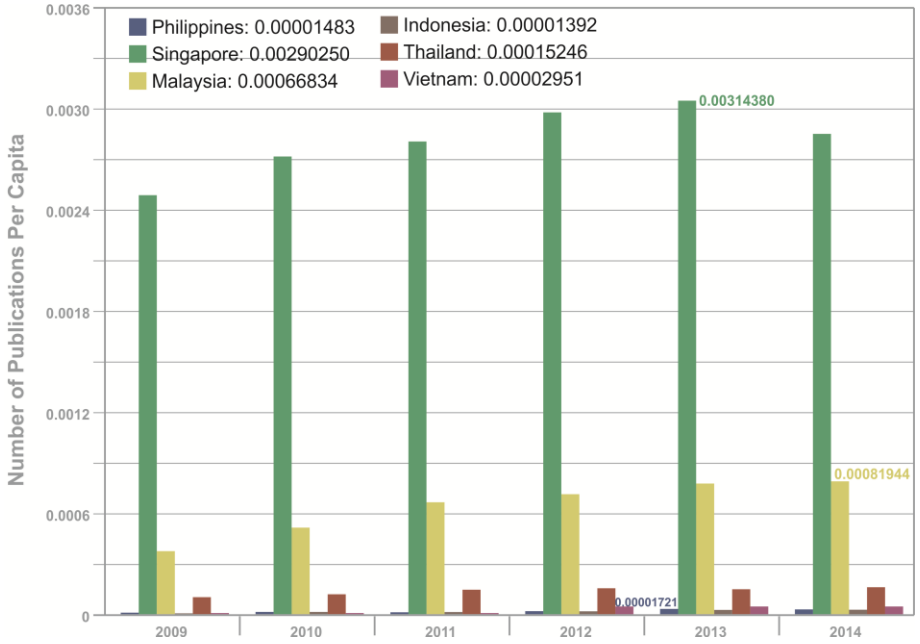
Source (Citable Documents): scimagojr.com accessed 9 July 2016
Source (Population, GDP per capita): databank.worldbank.org/data/ accessed 9 July 2016

Research Productivity of Six Largest ASEAN Economies

SCOPUS Publications (2009 – 2014)

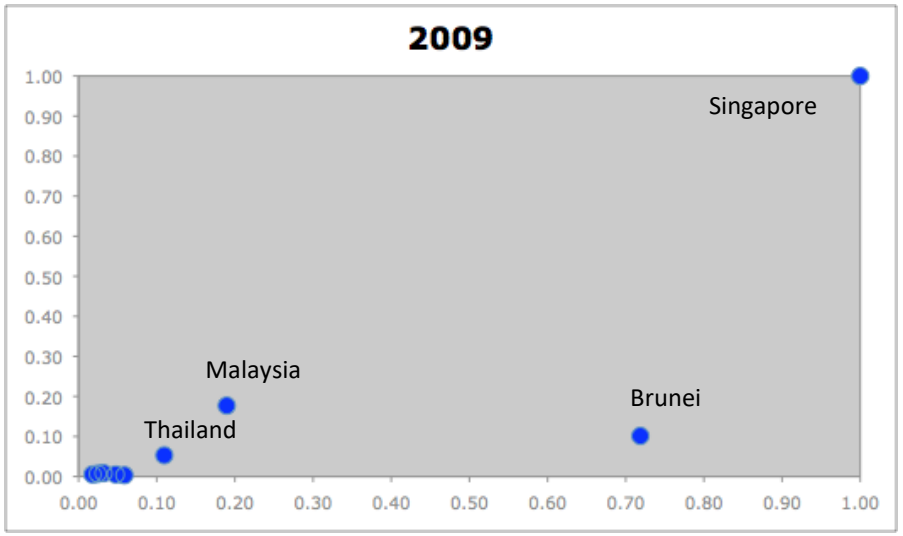


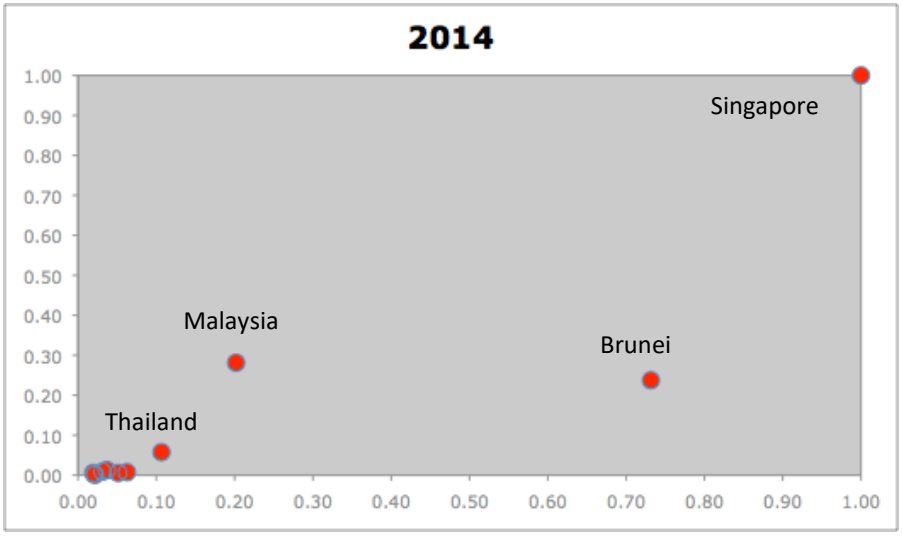
Publications per Capita (2009 – 2014)

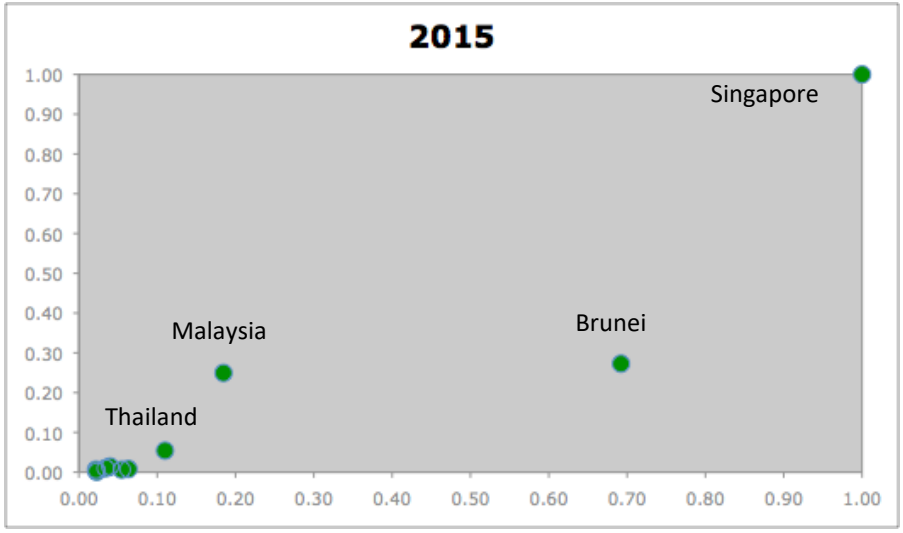


Source: scimagojr.com accessed 10 February 2016

Publications per capita (y-axis) versus GDP per capita (x-axis) of ASEAN states







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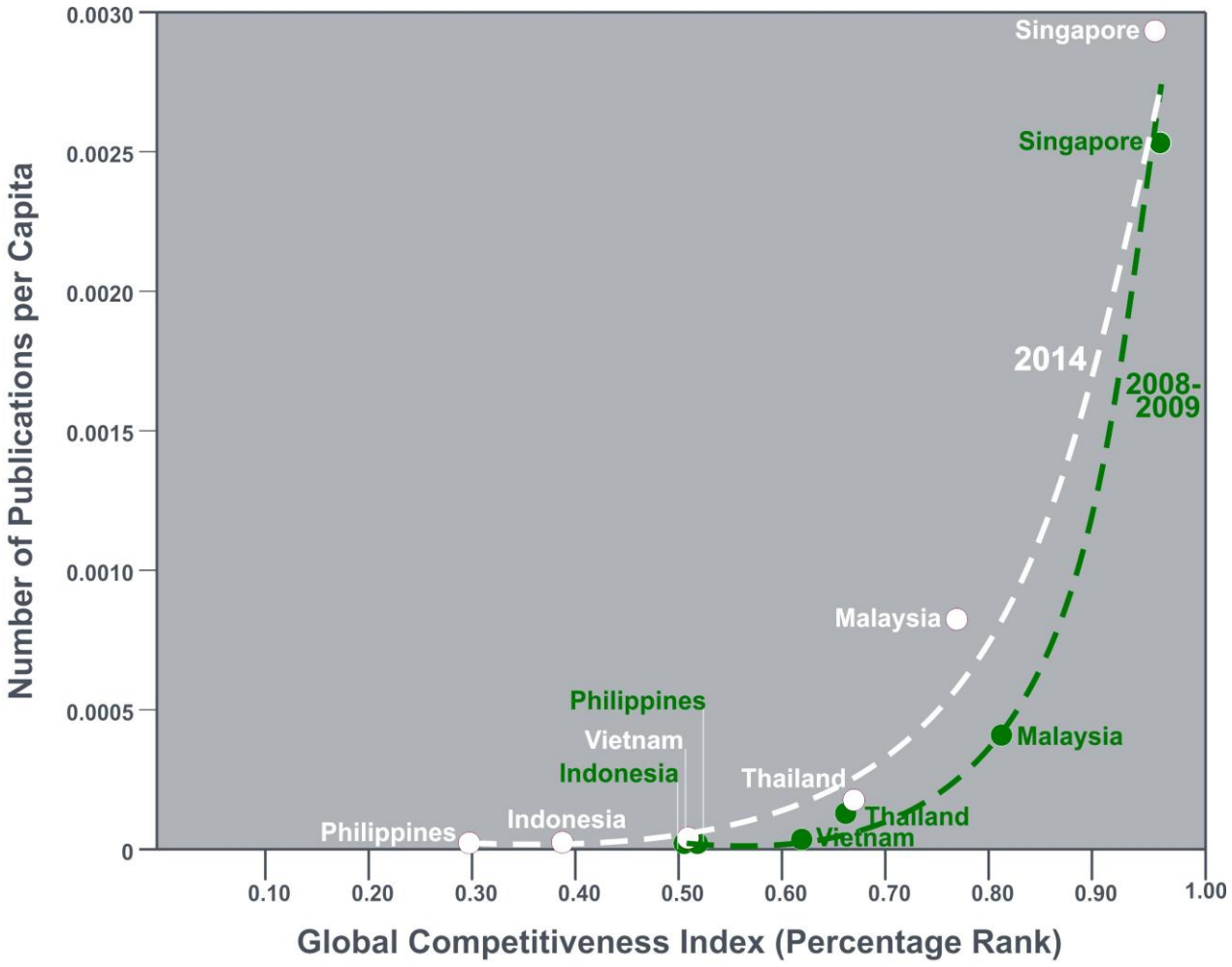
Threshold

Publications per capita and Global Competitive Index (2009 and 2014)



GCI Criteria (12): Institutions, infrastructure, macroeconomic environment, health & primary education, higher education & training, goods market efficiency, labor market efficiency, financial market development, technological readiness, market size, business sophistication, innovation

Source (GCI): http://www.weforum.org accessed 16 March 2016

Human Capital Generation

- **New lawyers per year (2000 – 2017): 1486**
  Passing rate in Philippine Bar Exams: 24.52%
- **New CPA's per year (2000 – 2016): 1776**
  Passing rate in CPA Exams: 35.6%
- **New MD's per year (2014 – 2016): 2875**
  Passing rate in Physician Board Exams: 81%
- **New STEM PhD graduates per year* (1999 – 2014): approximately 100**

***Basic and applied sciences, social sciences, technology & engineering, pure & applied mathematics**

Philippine Higher Education System
AY 2016-2017

Higher Education Institutions: 1943 (88% private)
Public Institutions: 233
State Universities & Colleges: 112
National University: 1 (UP)

Undergraduates: 3,589,484 (public: 45.73%)
Sciences + Mathematics + Engineering: 13.7%

Graduate Students: 681,468 (public: 50.42%)
Sciences + Mathematics + Engineering: 12.9%
Sciences + Mathematics: 1.49%

PhD Faculty (0.3% increase per year): 9.24% (SY 2003-04)
12.54% (2014-15)
13.32% (2016-17)

Source: CHED

More than 99% of HEI's are incapable of offering STEM PhD degree programs due to lack of qualified faculty members.

Philippine Science High School

established in 1964 (RA 3661)
operated by DOST

- **main campus + 16 regional campuses**
- **7,882 students (FY 2017)**
- **Approximately 1,300 students per level (K-12)**

- **Science High Schools in PH: 53**

Source: pshs.edu.ph; wikipedia

Engineering Research & Development for Technology (ERDT)

Established by the DOST in 2007

- University of the Philippines
- Central Luzon State University
- Mindanao State University
- Ateneo de Manila University
- De La Salle University
- Mapúa Institute of Technology
- University of San Carlos

Higher Education Institutions: 1935 (88.3% private)
State Universities & Colleges: 112

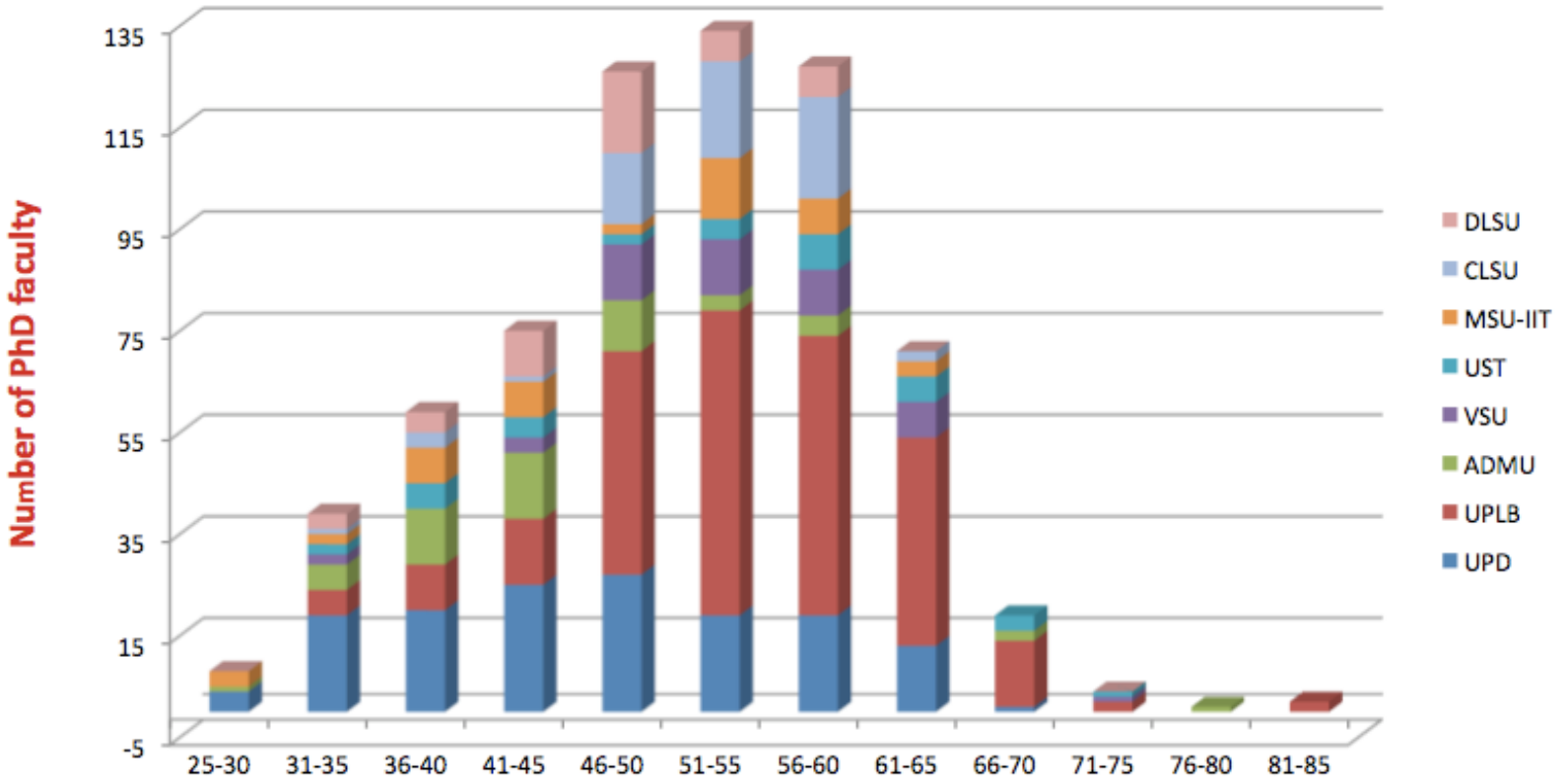
Advanced Science & Technology Human Resource Development Program (ASTHRDP)

Established by the DOST in 2009

- University of the Philippines
- Central Luzon State University
- Mindanao State University
- Visayas State University
- Ateneo de Manila University
- De La Salle University
- University of Santo Tomas
- University of San Carlos

Higher Education Institutions: 1935 (88.3% private)
State Universities & Colleges: 112

National Science Consortium: Demographics
as of 20 October 2010



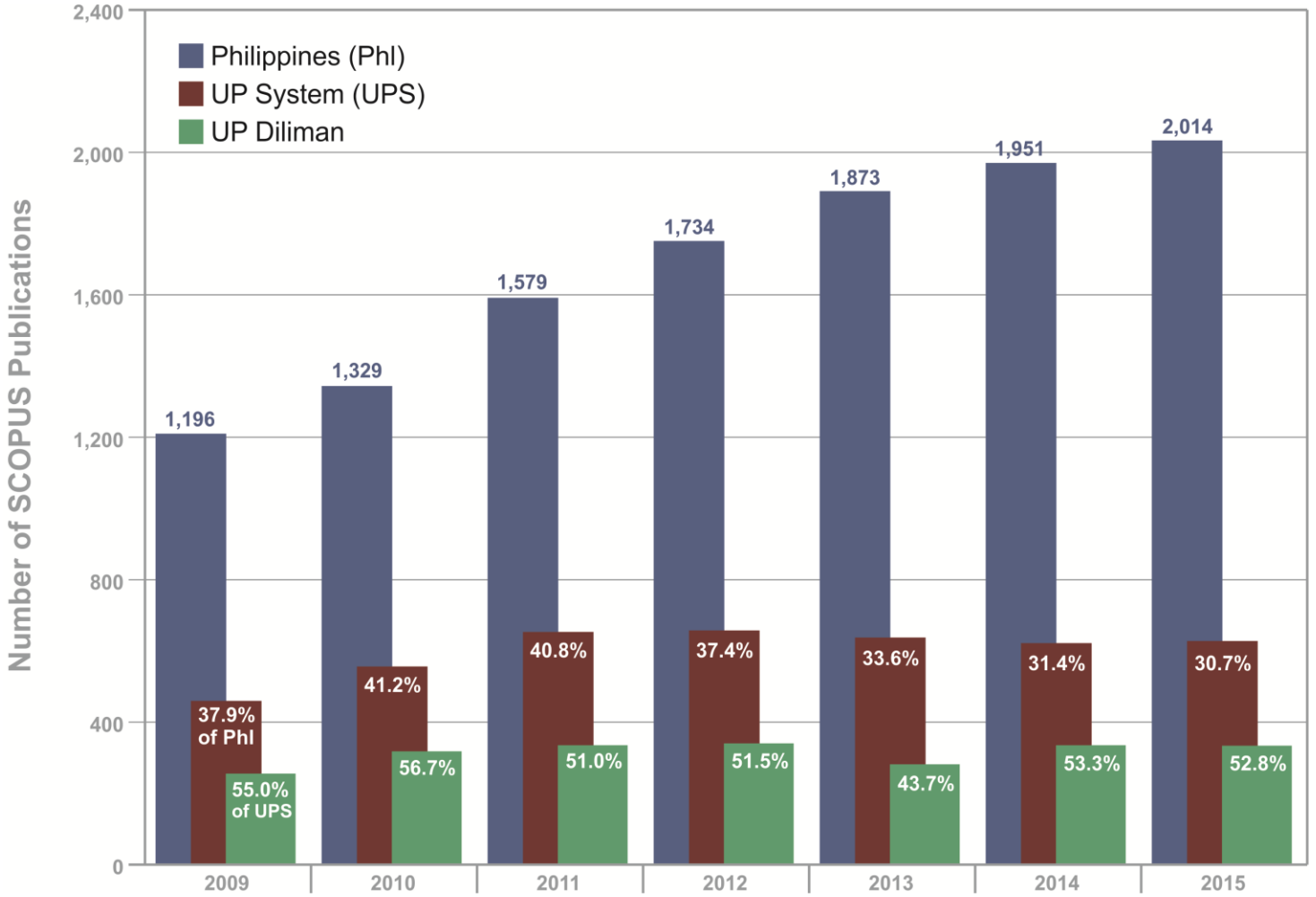
Total Number of PhD Faculty: 764
51 years old and above: 56.7%

Source: 2009 DOST-Science Education Institute Survey for the National Science Consortium (ASTHRDP)

Research Output
Peer-reviewed publications

SCOPUS Publications (2009 – 2015)

Philippines, UP System and UP Diliman



Increase rate (Philippines): 136±66.43 publications/year
Contribution of UP: 35.57%
Contribution of UP Diliman to UP Output: 51.77%

Increase in 2015 publications from 2009: 68.4%
Increase in SUC + DOST Budget: 110%
Increase in UP Budget: 91.7%

Source: College of Science Library (A. Villaflor)

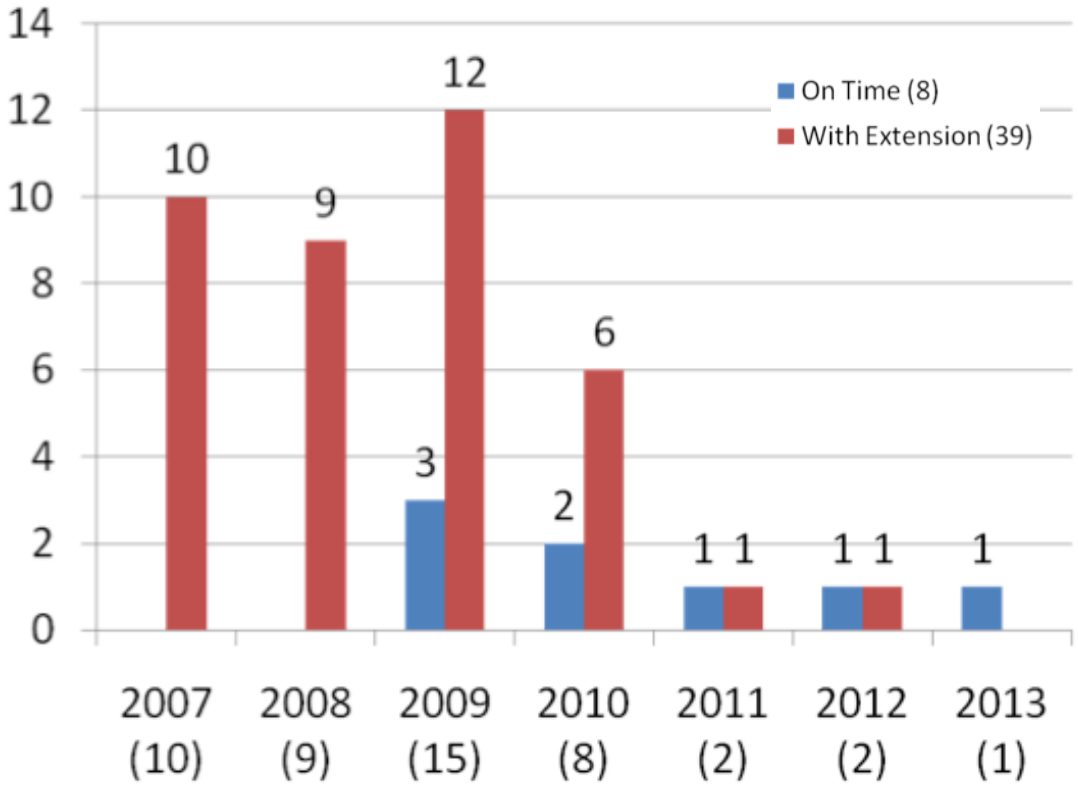
Human Resource Output

PhD Graduates

ERDT Performance
2007-2015

Local PhD Scholarships Awarded: 246 (75.9% of available slots)

No. of PhD Graduates (as of 28 May 2015): 47



Participating Institutions

University of the Philippines
Central Luzon State University
Mindanao State University
Ateneo de Manila University
De La Salle University
Mapúa Institute of Technology
University of San Carlos

UP Diliman
PhD Graduates: 32 (68.1% of total)
PhD Scholars: 111 (45.1%)

MS Graduates: 213 (39.9% of total)
MS Scholars: 587 (40.2%)

Source: Dean Aura Matias, UP Diliman College of Engineering

ASTHRDP Performance
2009-2015

PhD Scholarships Awarded (2010 – 2013): 229

No. of PhD Graduates (as of April 2015): 22

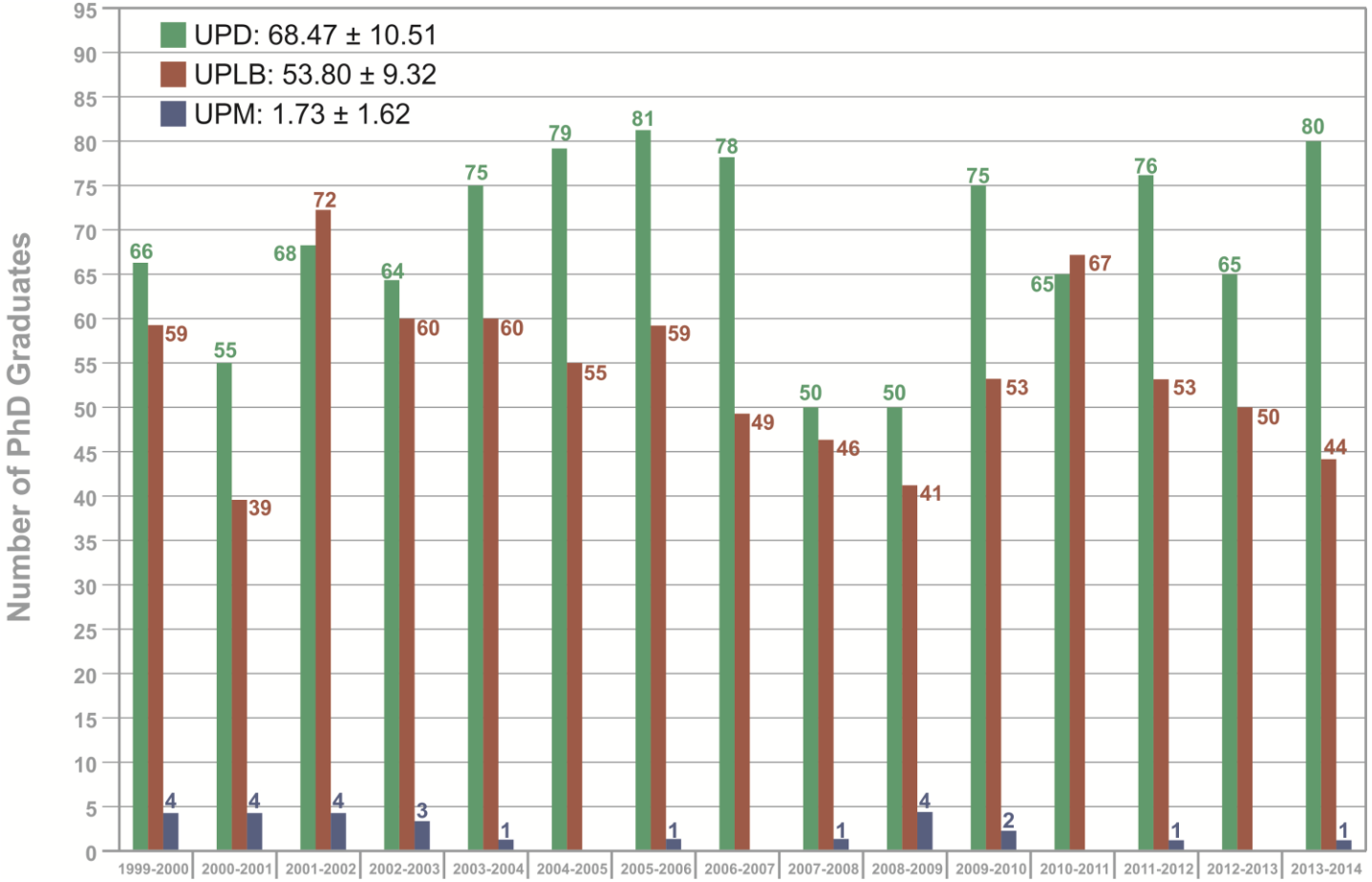
Distribution of PhD Graduates (22 out of 164 scholars)	
UP Los Baños	9 (out of 68 scholars)
Central Luzon State Univ	3 (9)
University of Santo Tomas	3 (15)
MSU Iligan Institute of Tech	3 (9)
De La Salle University	2 (11)
Visayas State University	1 (5)
UP Diliman	1 (23)
Ateneo de Manila University	0 (9)
UP Visayas	0 (5)
UP Manila	0 (2)

PhD Scholarships Awarded (2010 – 2012): 164

Sources: Dean Jose Ma. Balmaceda (UP Diliman College of Science), Dr. Toby Dayrit (Ateneo de Manila University)

PhD Graduation Rates

Selected UP CUs (1999-2014)



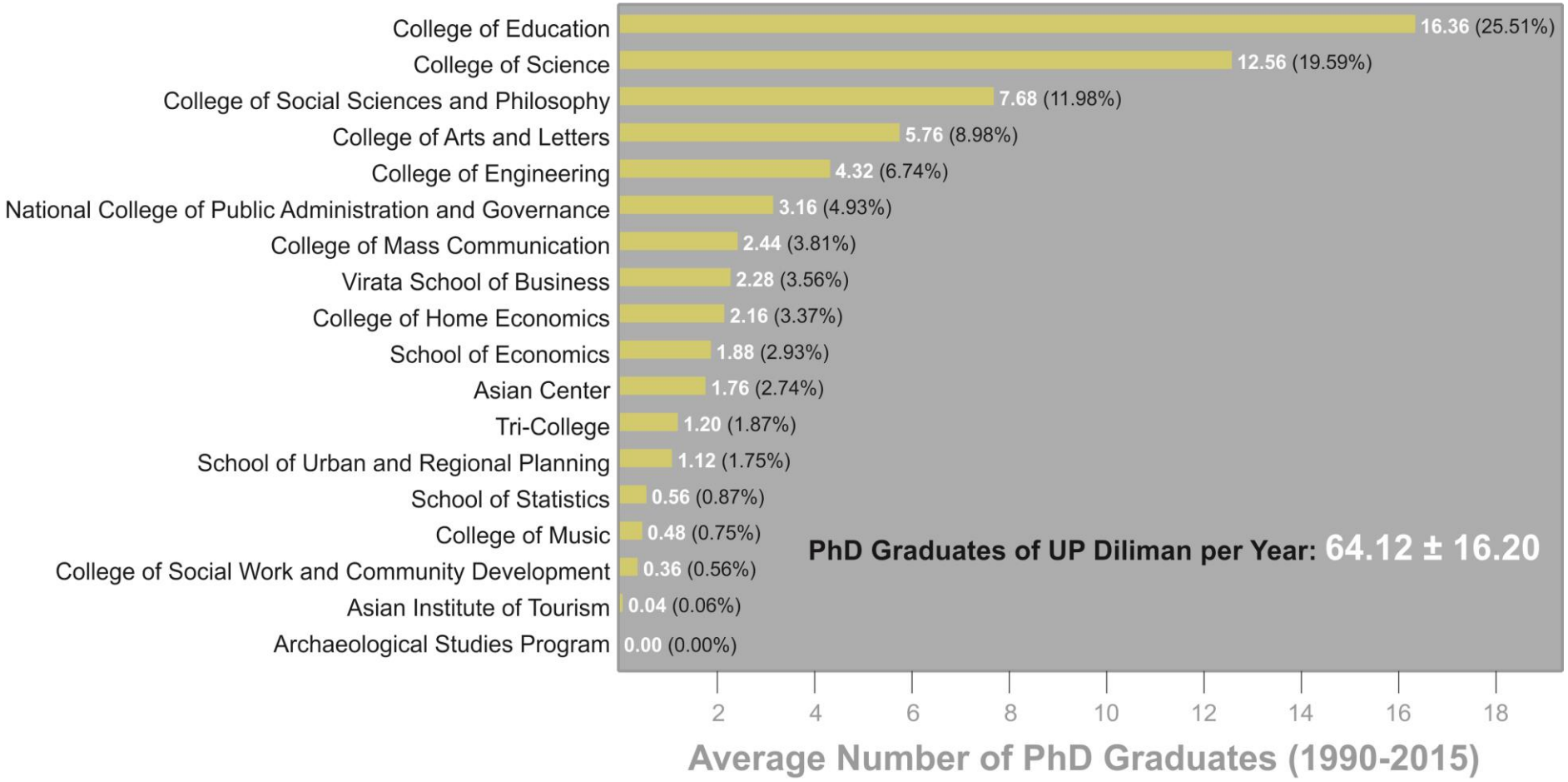
Regular UP Faculty (30 April 2011)

UP Diliman :	**43.6%**
UP Los Baños:	**24%**
UP Manila :	**16.4%**
Other CUs :	**16%**

Sources: UP Diliman OUR, UPLB Commencement Programs, UP Manila Graduate Office

PhD Graduation Rates

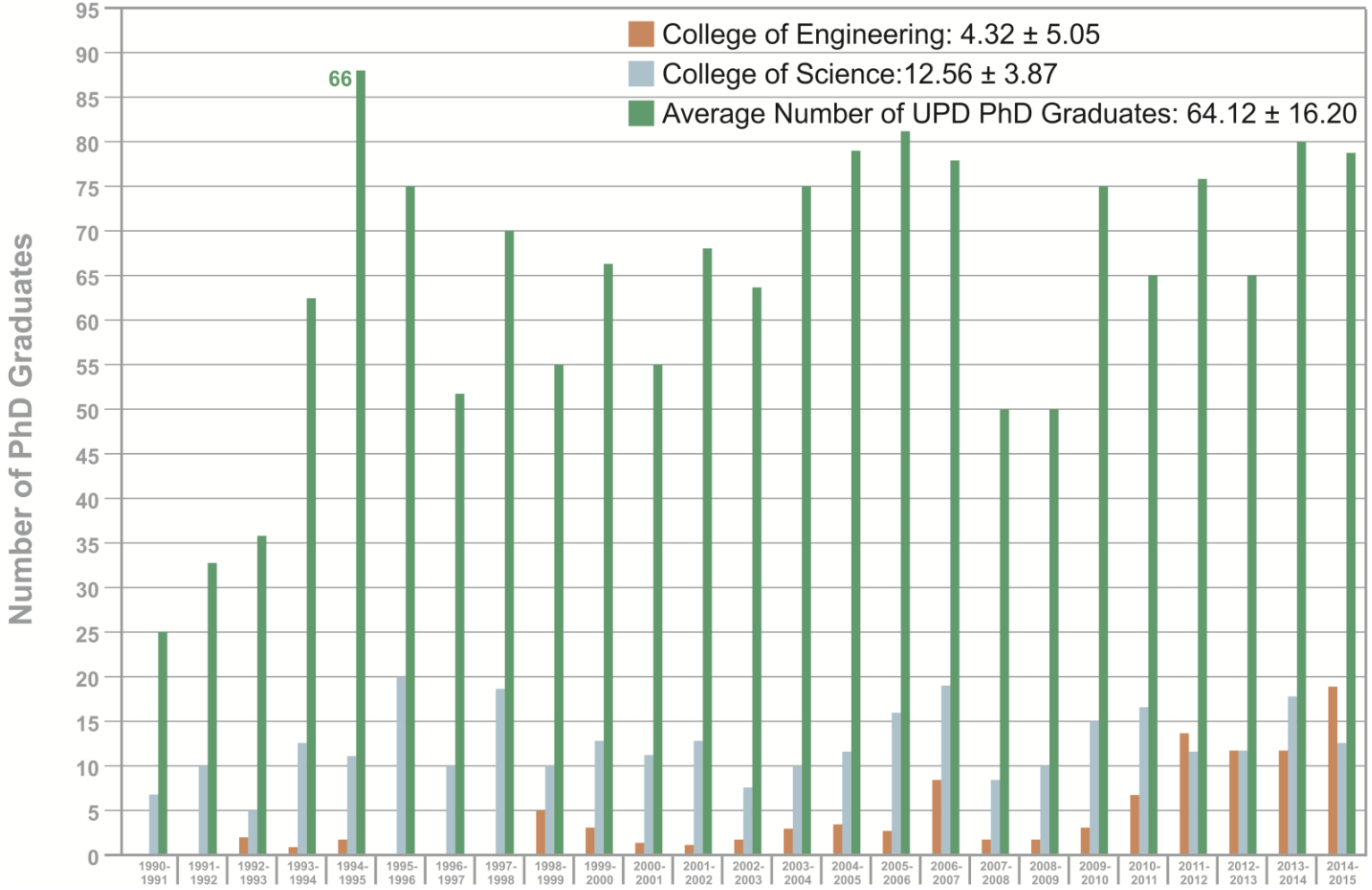
Colleges of UP Diliman (1990-2015)



Source: Office of the University Registrar

PhD Graduation Rates

College of Science and College of Engineering (1990-2015)



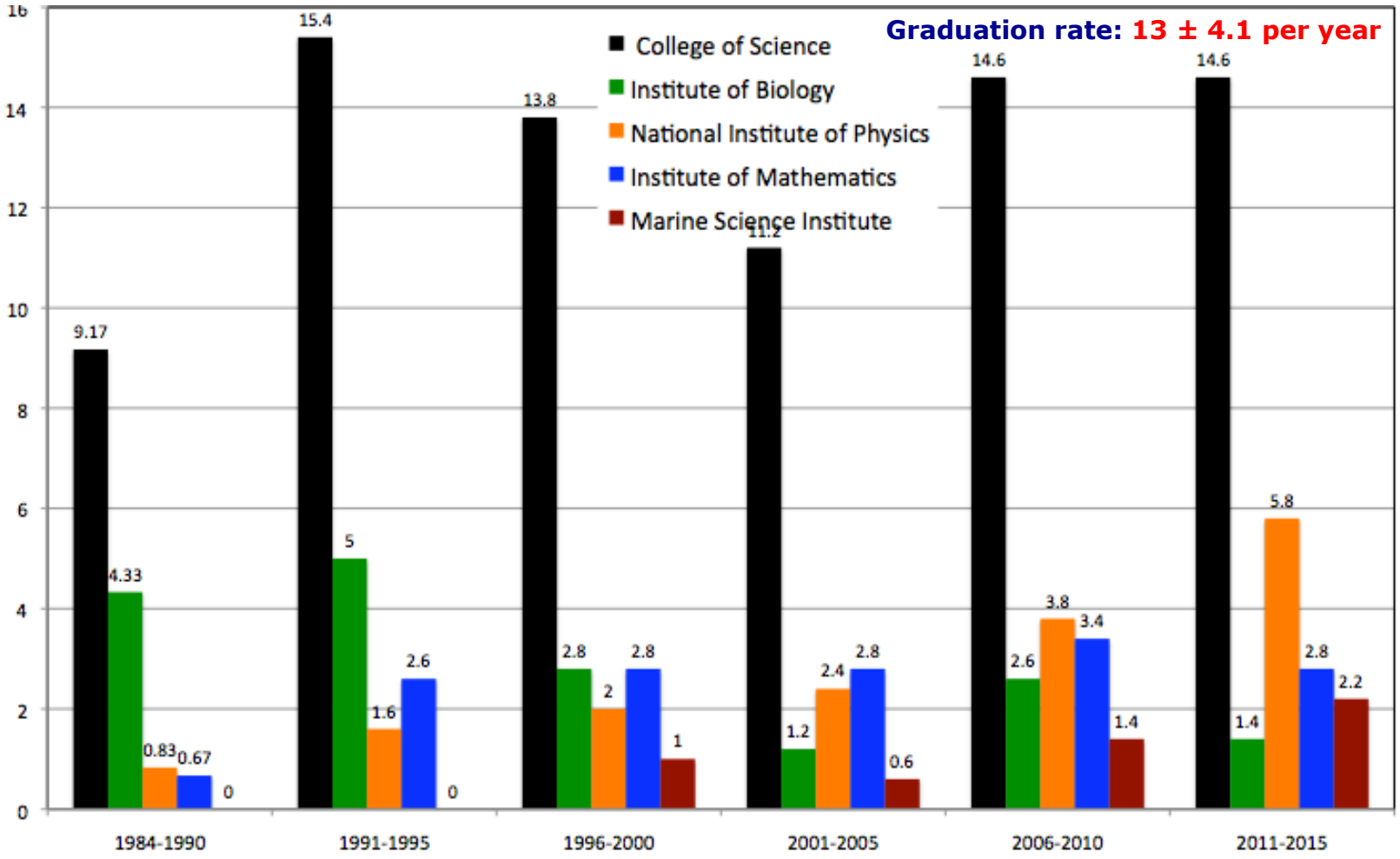
PhD Faculty (9 Dec 2015)

UP Diliman :	**498**
Science :	**154**
Engineering:	**73**

Sources: Office of the University Registrar, Office of the CS Dean, Human Resource Development Office

Average Number of PhD Graduates

Selected College of Science Units



PhD production of NIP and MSI has been growing in the last 15 years (2001 -2015).

Relative Productivity
of UP Constituent Units

$$\text{Productivity Index} = \frac{\text{Output}}{\text{Input}}$$

$$\text{CU Productivity Index (CPI)} = \frac{(N_P \text{ ⓾ } N_G)^{1/2}}{(N_F \text{ ⓾ } B_{CU})^{1/2}}$$

Geometric Mean

N_P = Normalized No. of Scopus Publications = $\dfrac{N_P\,(CU) - \min N_P}{\max N_P - \min N_P}$

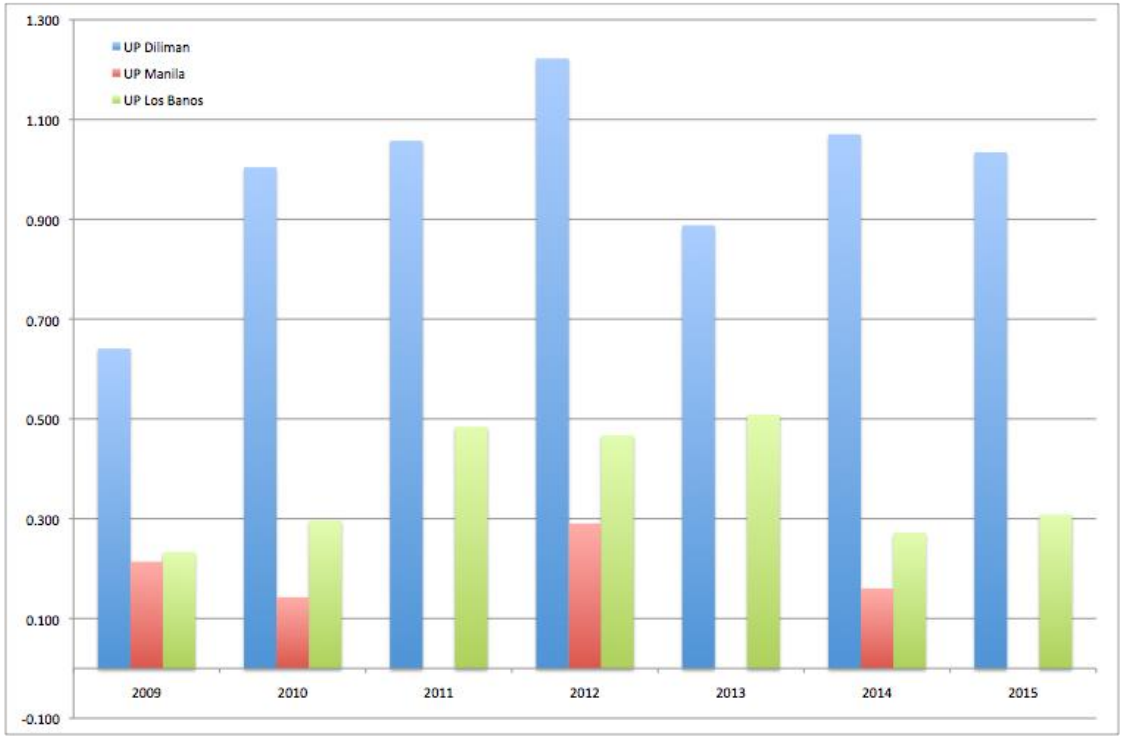
N_G = Normalized No. of PhD Graduates

N_F = Normalized No. of Regular Faculty Members

B_{CU} = Normalized CU Budget Allocation

CU Productivity Index Scores

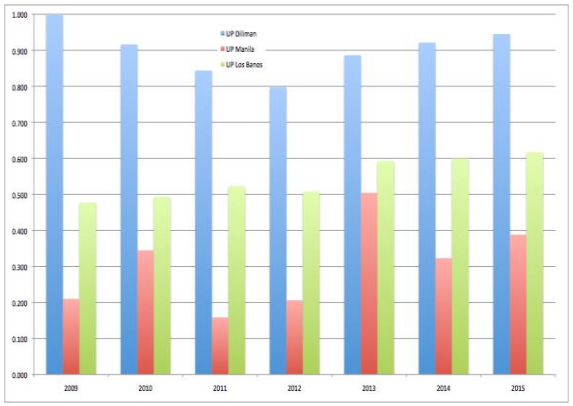
Output / Input



Output (Publications, PhD Graduates)

$(N_P \circledcirc N_G)^{1/2}$

Input (Faculty, Budget)



$(N_F \circledcirc B_{CU})^{1/2}$

Average CPI Scores (2009 – 2015)

UP Diliman : 0.99 ± 0.182
UP Los Baños : 0.37 ± 0.115
UP Manila : 0.12 ± 0.118

Relative Productivity
of College of Science Units

$$\text{Performance Indicator} = \frac{\text{Output}}{\text{Input}}$$

$$\text{CS Productivity Index} = \frac{(N_P \text{ ⓾ } N_G)^{1/2}}{(N_F \text{ ⓾ } R_L)^{1/2}}$$

N_P = Normalized No. of Scopus Publications = $\dfrac{N_P \text{ (unit)} - \min N_P}{\max N_P - \min N_P}$

N_G = Normalized No. of PhD Graduates

N_F = Normalized No. of Regular Faculty Members

R_L = Normalized Research Load

Faculty Profile

College of Science Units

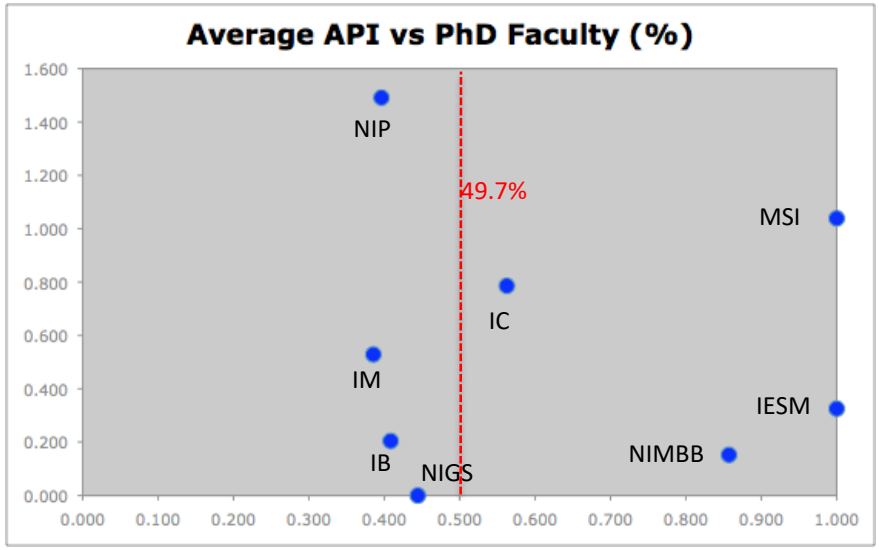
Department	with PHD	Tenured	Untenured	with Item	w/o Items	No. of Faculty
CS-BIO	18	9	23	32		32
CS-CHEM	29	18	53	53	18	71
CS-IESM	9	3	6	9		9
CS-MATH	32	16	67	75	8	83
CS-MSI	21	14	7	21		21
CS-NIGS	12	8	19	24	3	27
CS-NIMBB	12	3	11	12	2	14
CS-NIP	21	14	39	38	15	53
	154	85	225	264	46	310

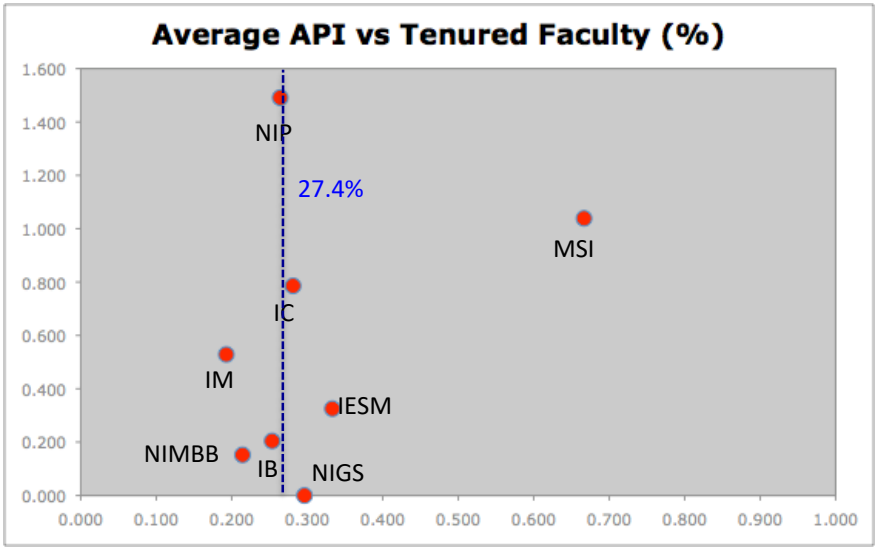
Source: HRDO (as of December 2015)

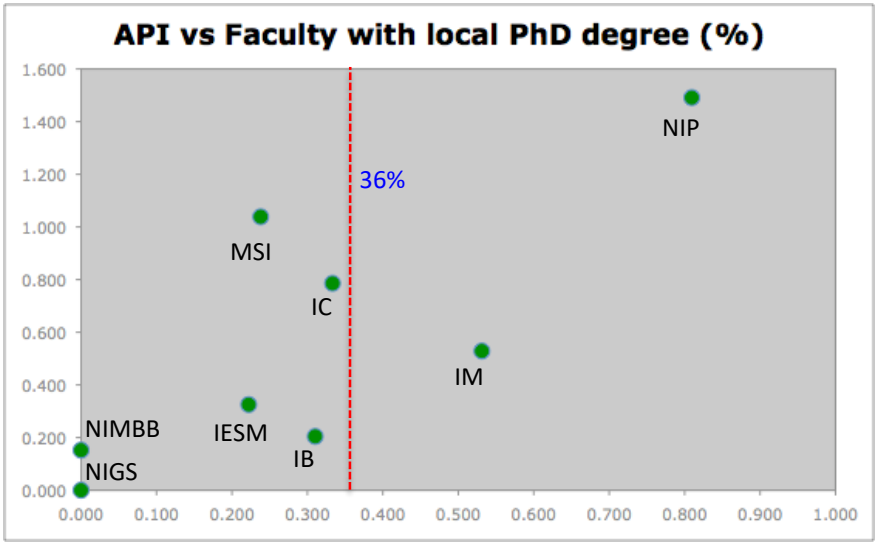
Institutes	PhD Faculty	with local PhD degree		with PhD degree from foreign university	
Biology	18	6	33%	12	67%
Chemistry	29	9	31%	20	69%
Env Sci & Meteo	9	2	22%	7	78%
Mathematics	32	17	53%	15	47%
Marine Science	21	5	24%	16	76%
Geo Sciences	12	0	0%	12	100%
Mol Bio & Biotech	12	0	0%	12	100%
Physics	21	17	81%	4	19%
NSRI	3	0	0%	3	100%
Incl. NSRI	157	56	36%	101	64%
Excl. NSRI	154	56	36%	98	64%

Source: CS Dean Balmaceda (as of 1st sem AY 2015-2016)

CS Productivity Index and Unit Faculty Profile



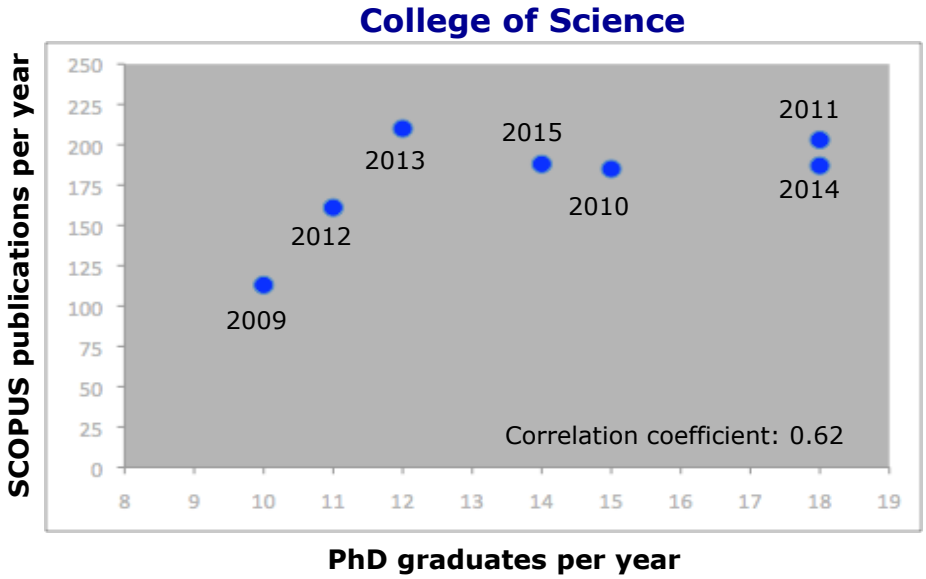


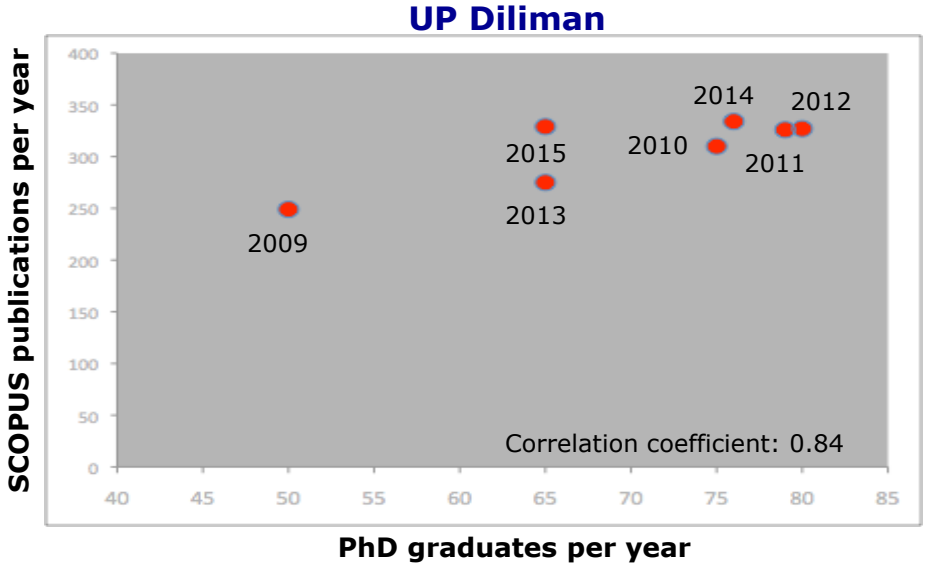


CS Unit (December 2015)	Regular faculty	PhD faculty	With PhD deg from UP	With tenure
Marine Science Institute (MSI)	21	21	5 (24%)	14
National Institute of Physics (NIP)	53	21	17 (81%)	14
Institute of Mathematics (IM)	83	32	17 (53%)	16
National Institute of Geological Sciences (NIGS)	27	12	0	8
Institute of Biology (IB)	32	18	6 (33%)	9
Institute of Chemistry (IC)	71	29	9 (31%)	18
Institute of Environmental Science & Meteorology (IESM)	9	9	2 (22%)	3
National Institute of Mol Bio & Biotechnology (NIMBB)	14	12	0	3
Natural Science Research Institute		(3)	0	
Total	310	154 (49.7%)	56 (36%)	85 (27.4%)

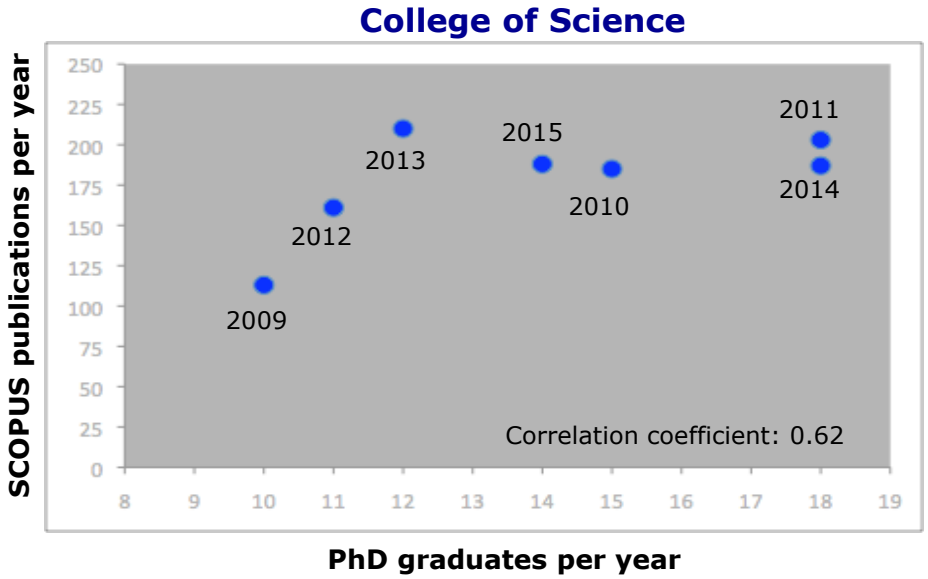
No. of Regular Faculty Items: 264

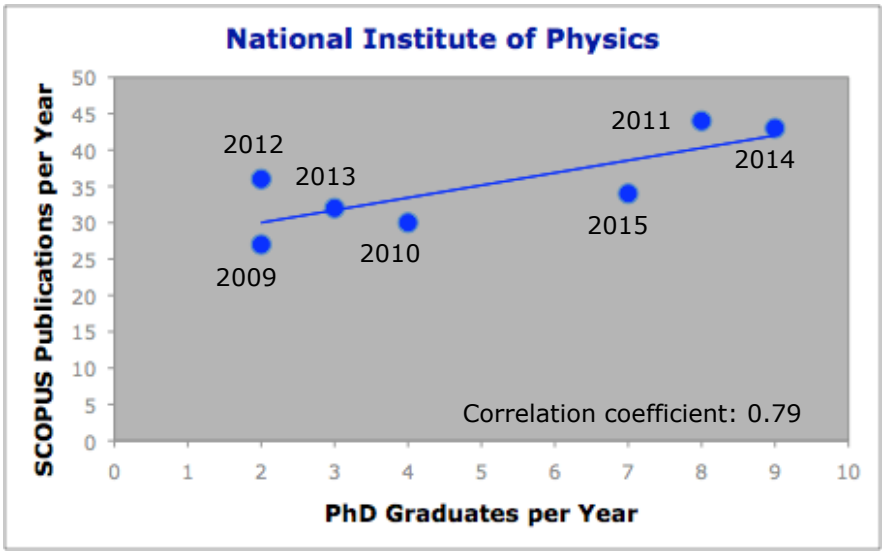
Research Productivity and PhD Graduates per Year

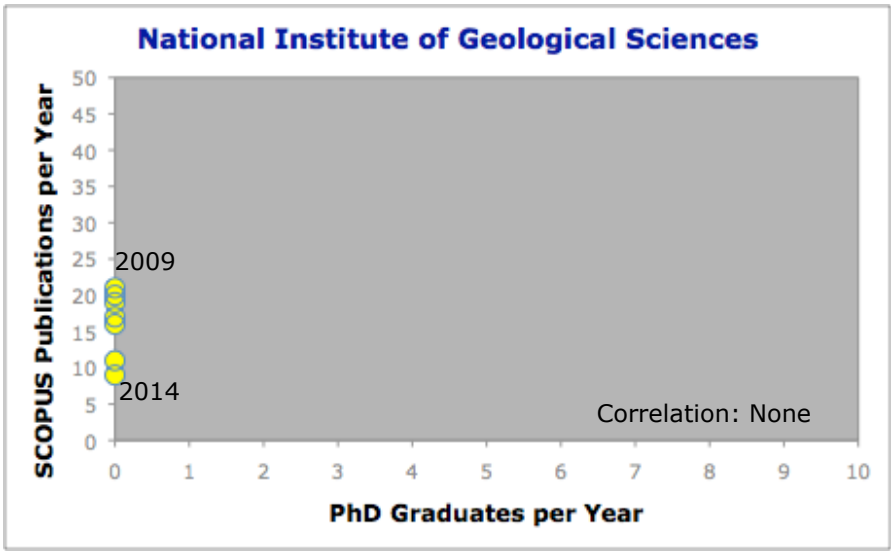




Research Productivity and PhD Graduates per Year







PhD Production Efficiency Index (PPEI)

$$\text{Performance Indicator} = \frac{\text{Output}}{\text{Input}}$$

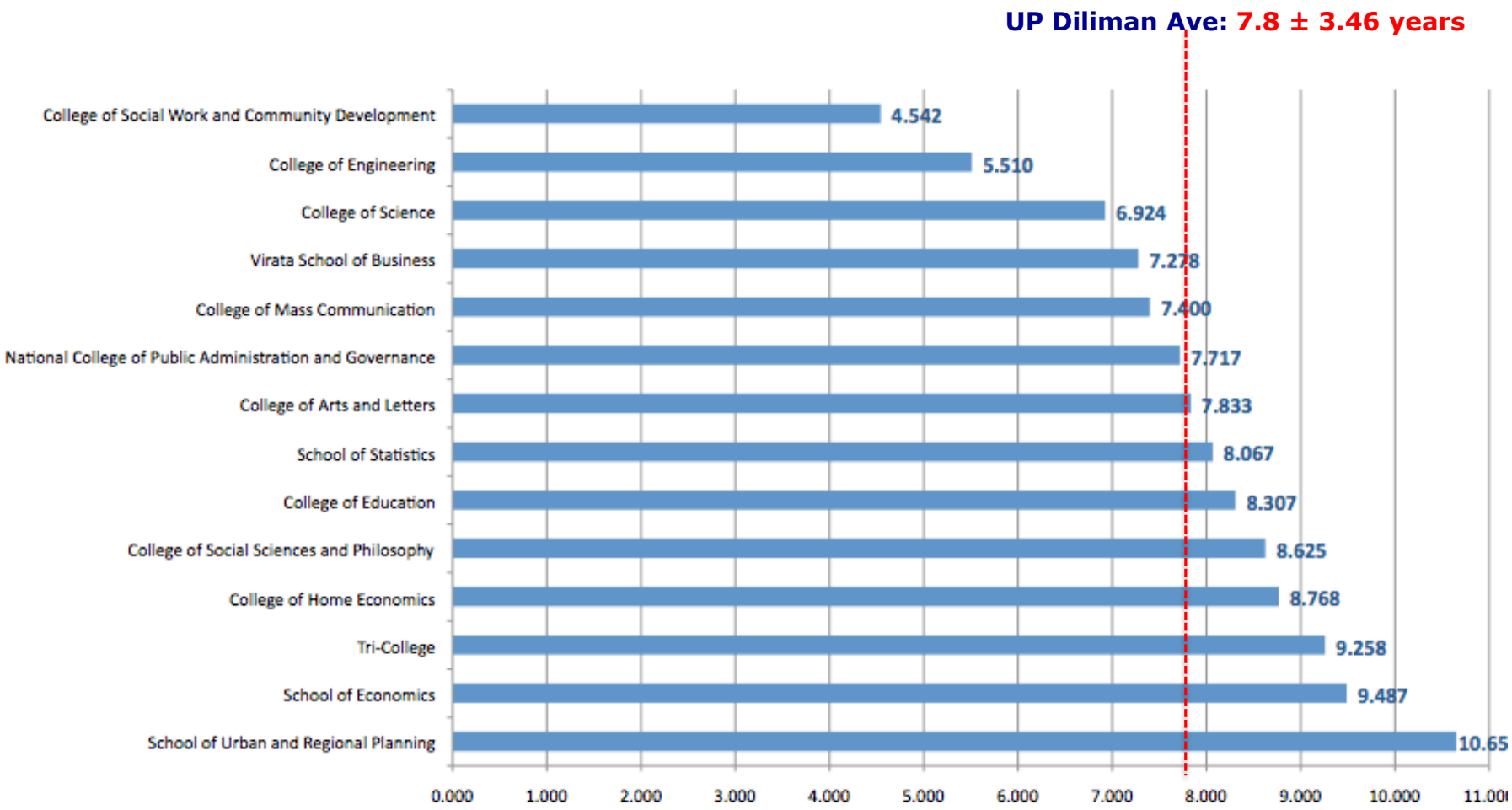
$$PPEI = \frac{\left(\frac{N_{PhDmin}}{N_{PhDmax}}\right) + \left(\frac{(N_{PhD} - N_{PhDmin})}{N_{PhDmax} - N_{PhDmin}}\right)}{1 + \left(\frac{N_{year(avg)} - N_{year(avg)min}}{N_{year(avg)max} - N_{year(avg)min}}\right)}$$

N_{PhD} = No. of PhD graduates produced in degree program

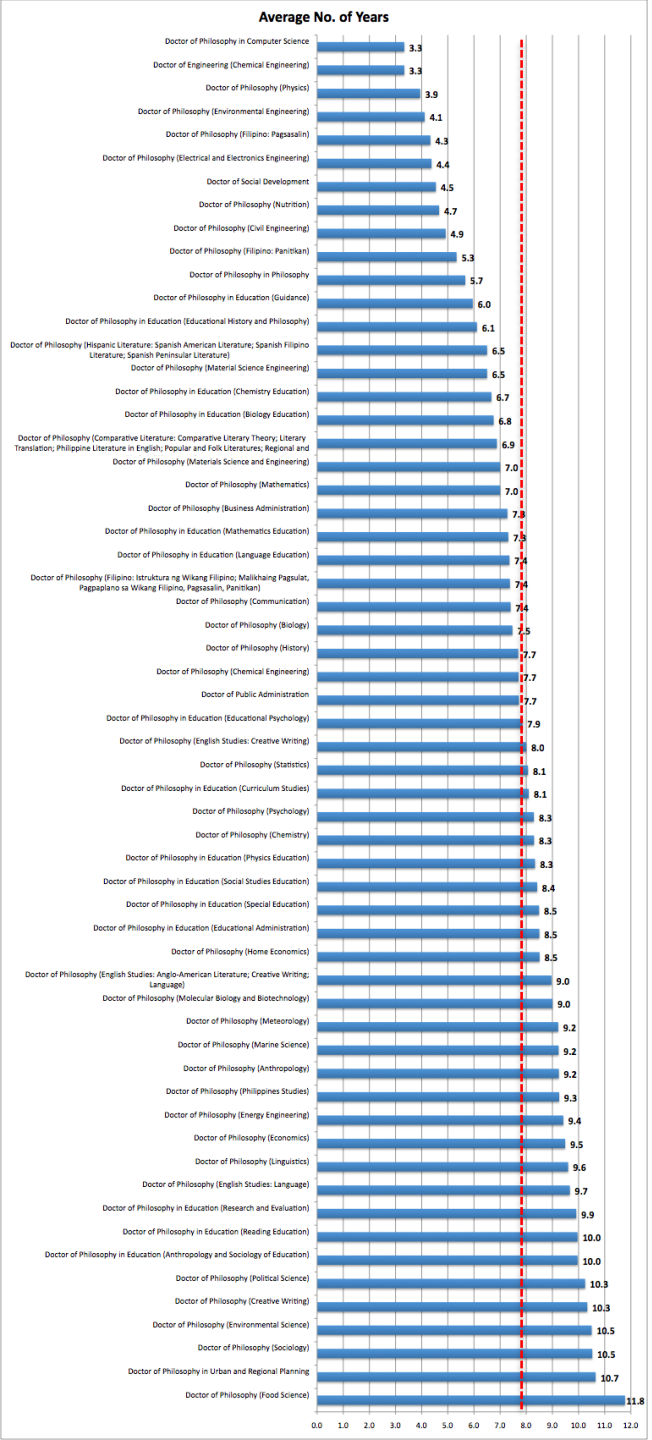
N_{year} = No. of years spent by student to finish PhD degree

Average Duration of PhD Study in UP Diliman

1st Sem AY 2003 - 2004 to Mid-Year 2015 (835 PhD Graduates)



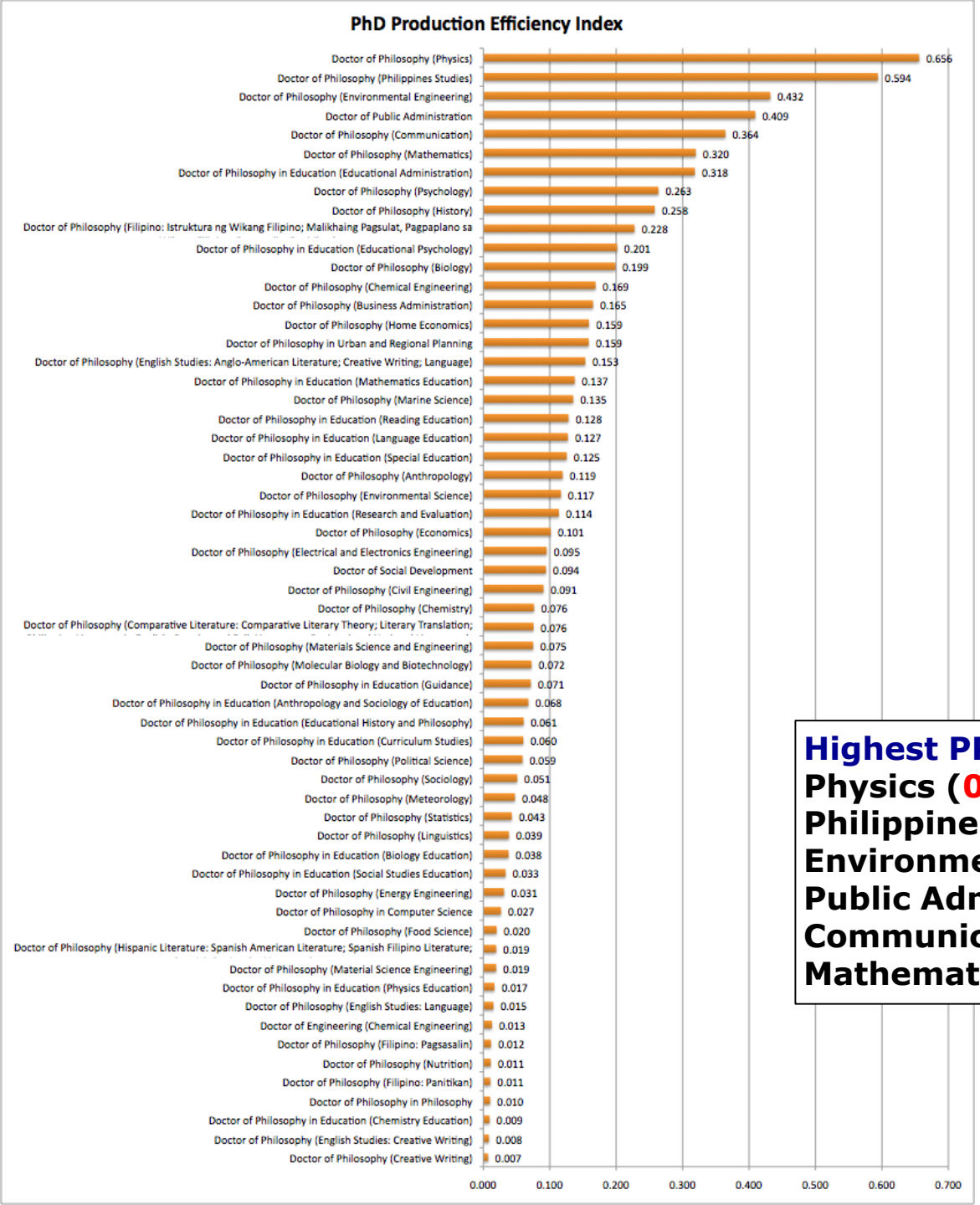
Source: Primary data from OUR



Completion Time by PhD Degree Program

Coverage: 1st sem AY 2003 - 2004 to Mid-Year 2015
Sample Size: 835 PhD Graduates
No. of PhD degree programs: 59

- **Average Completion Time:** 7.8 ± 3.46 years
- **Shortest Average Duration (3.3 ± 0.94 years)**
  Computer Science (No. of PhD Graduates: 2)
- **Longest Average Duration (11.8 ± 0.69 years)**
  Food Science (3)
- **Most Number of PhD Graduates**
  Philippine Studies (75)
  Physics (52)
  Public Administration (46)
  Communication (40)
  Educational Administration (38)



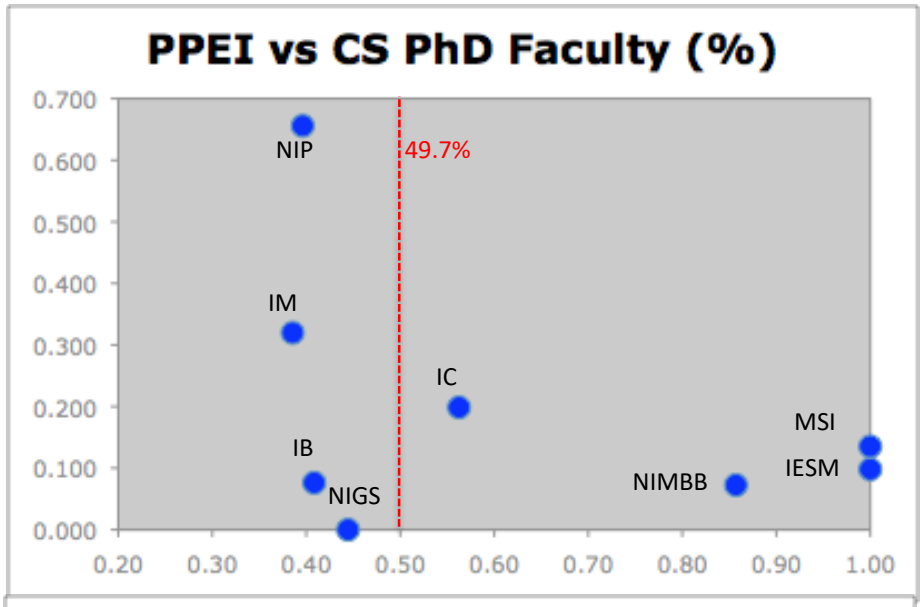
PhD Production Efficiency Index Scores

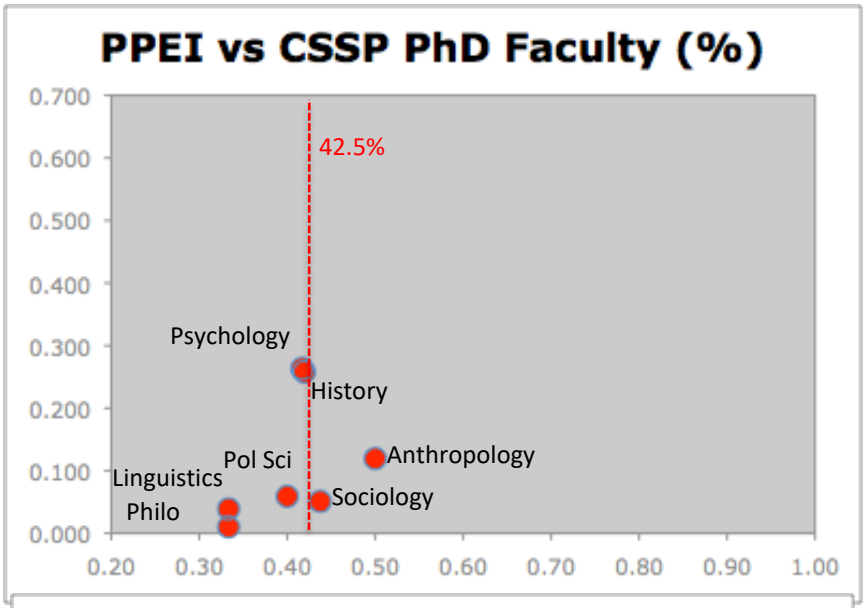
Highest Possible Score: 1.013
Lowest Score: 0.007

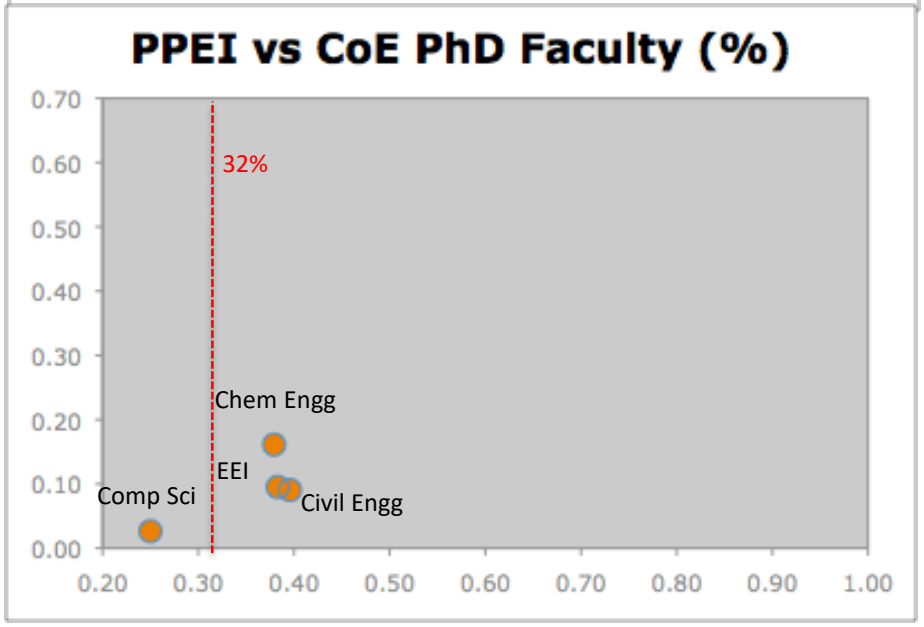
Highest PPEI Scores

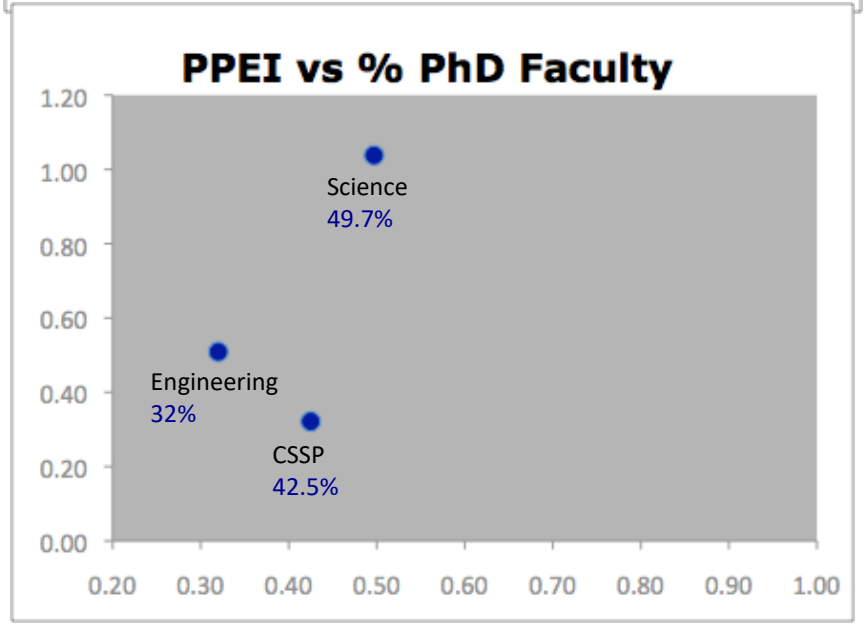
Physics (0.656)
Philippine Studies (0.594)
Environmental Engineering (0.432)
Public Administration (0.409)
Communications (0.364)
Mathematics (0.32)

PPEI Scores and Percentage of PhD Faculty

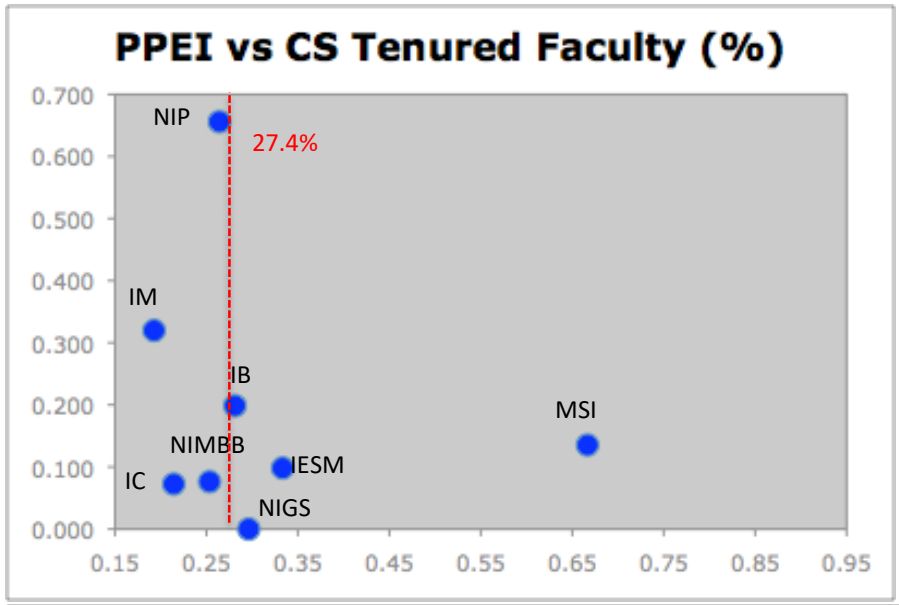


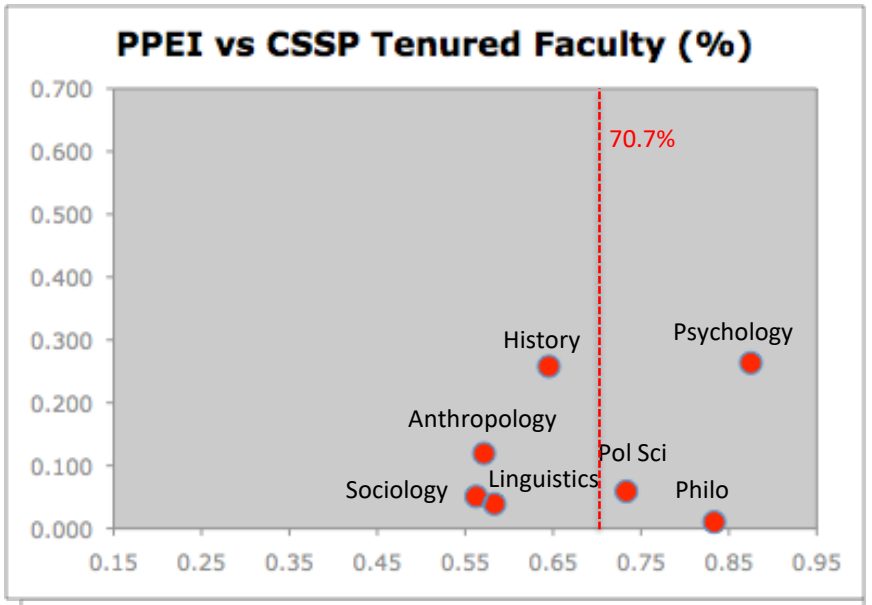


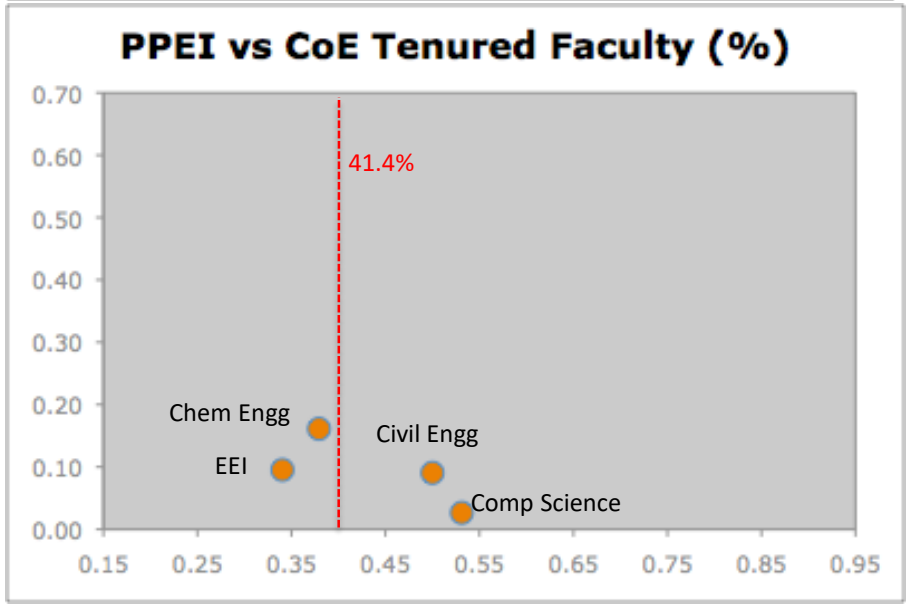


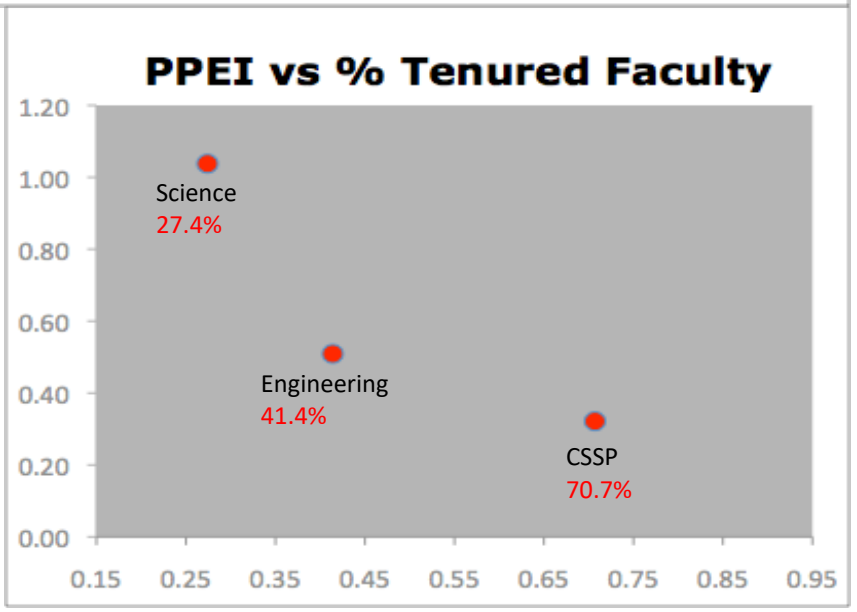


PPEI Scores and Percentage of Tenured Faculty









Policy Recommendations

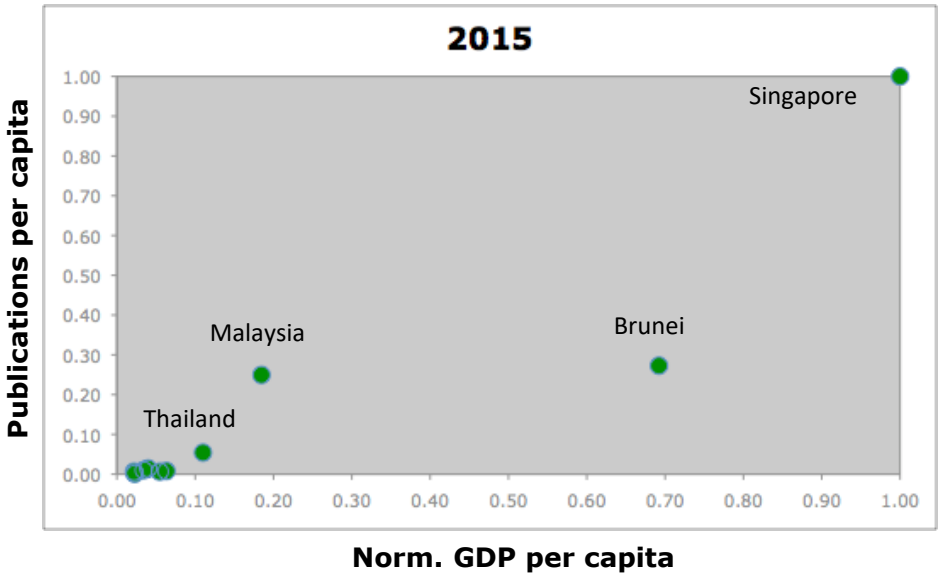
For government (DOST, UP, etc.)

- **Awareness that correlation between R&D outputs and national prosperity for PH is not similar to that in more prosperous ASEAN economies.**

GDP per capita (in current USD)

Country	2009	2014	2015
Singapore	38,577.6	56,007.3	52,888.7
Brunei Darussalam	27,726.5	40,979.6	36,607.9
Malaysia	7,312.0	11,307.1	9,766.2
Thailand	4,231.1	5,969.9	5,816.4
Indonesia	2,262.7	3,499.6	3,346.5
Philippines	1,836.9	2,872.5	2,899.4
Vietnam	1,232.4	2,052.3	2,111.1
Lao PDR	948.0	1,751.4	1,812.3
Myanmar		1,203.8	1,203.5
Cambodia	690	1,094.6	1,158.7

Threshold



For DOST and CHED

- **PhD scholarships in the social sciences and economics.**
- **Funding for postdoctoral research abroad to PhD graduates from ERDT and ASTHRDP member-institutions.**

Return-service obligation: To work in the country within three years from start of postdoctoral fellowship.

No requirement regarding prior affiliation with a public HEI or government agency.

For DOST and SUCs

- **Procurement system (IRR) for scientific R&D purposes.**

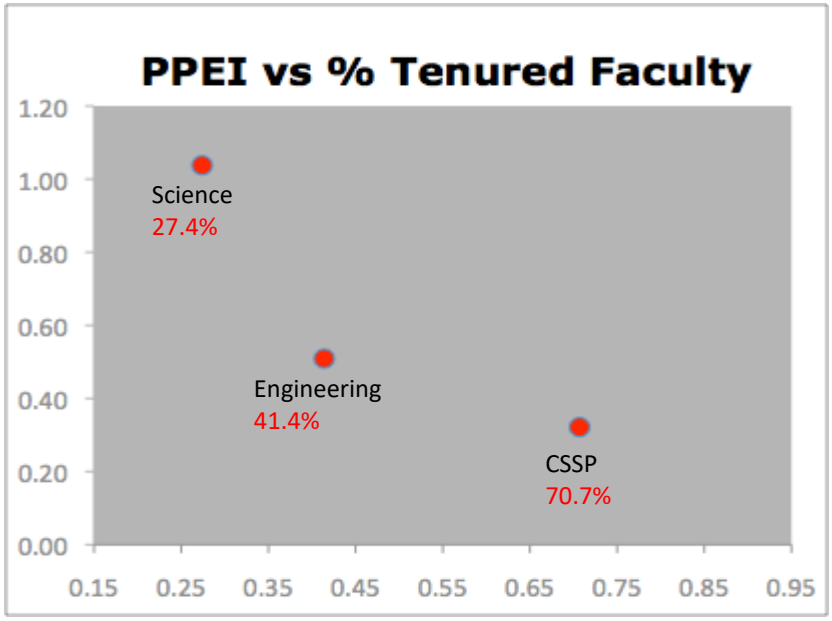
Depreciation formula for research equipment.

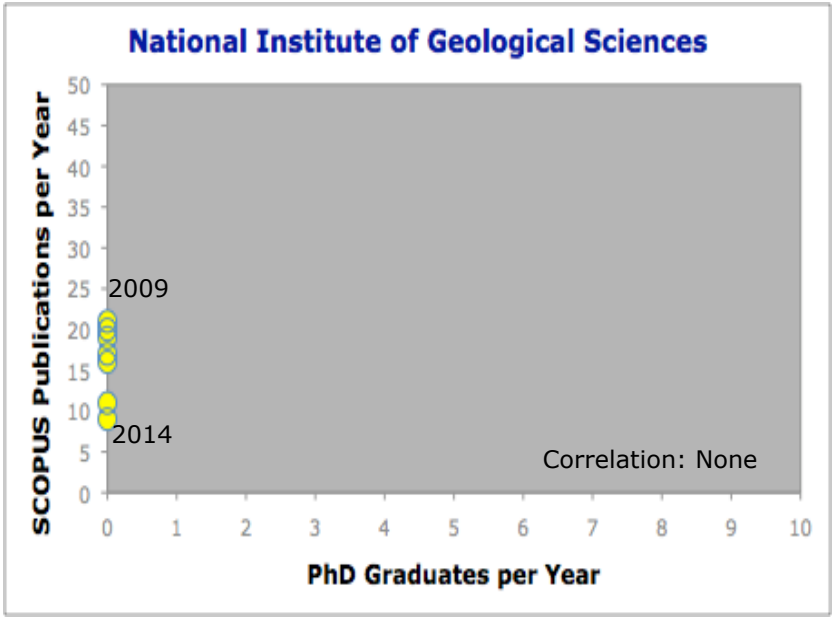
Direct duty-free acquisition of equipment and technical services from manufacturers and service providers.

Automatic regular adjustment of price ceiling for shopping and small-value procurement that factors in variations in inflation rate, consumer price index and foreign exchange rate.

For SUCs and other institutions

- **To align institutional interest with individual recognition (tenure, promotion, titles, awards, grants, administrative appointments, etc.) for faculty members, researchers and staff.**





For SUCs

- **Use of analytics in measuring the productivity of constituent units, colleges, institutes and departments**

$$\text{Productivity Index} = \frac{\text{Output}}{\text{Input}}$$

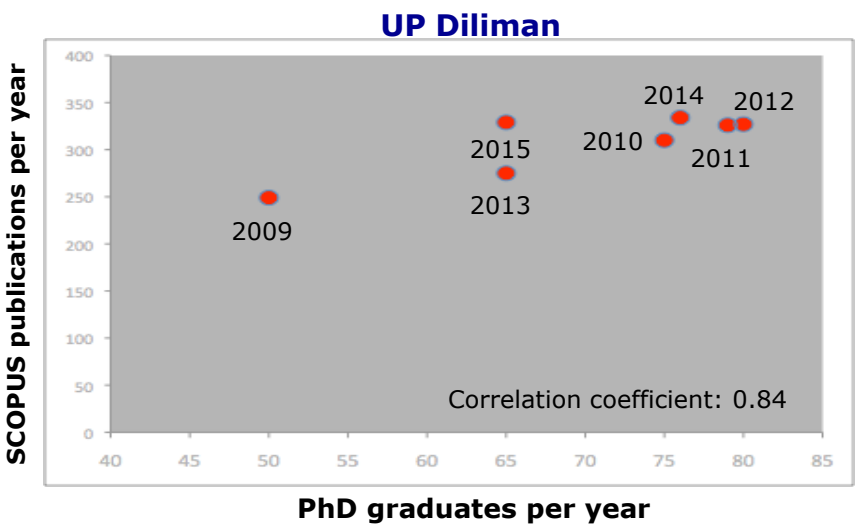
Outputs: **Peer-reviewed publications (research productivity), PhD graduates per year (human resource generation)**

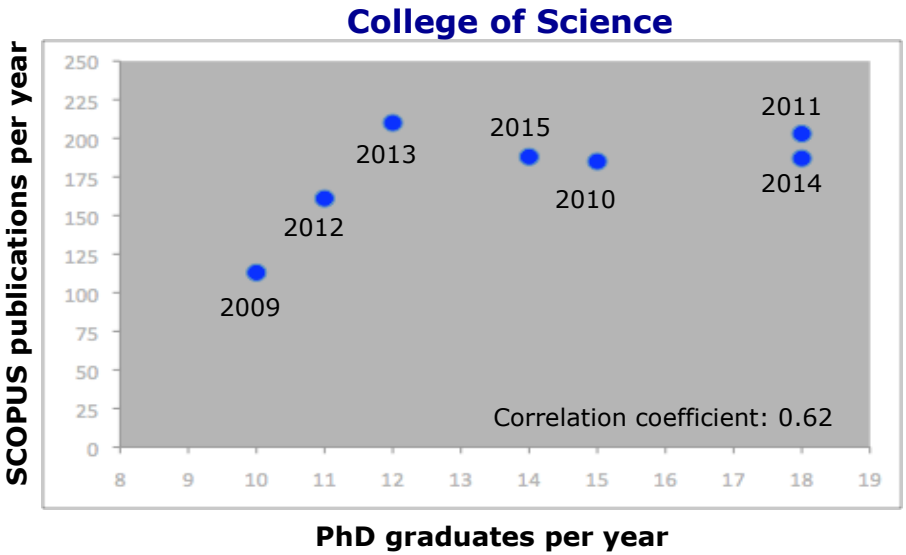
Inputs: **Budgetary allocation, graduate scholarships, regular faculty items, PhD faculty members, duration of PhD study, research load**

Advantages: **Transparency, predictability, meritocracy, common good**

For SUCs

- **Better correlation between PhD graduation rate and peer-reviewed publications in academic units.**

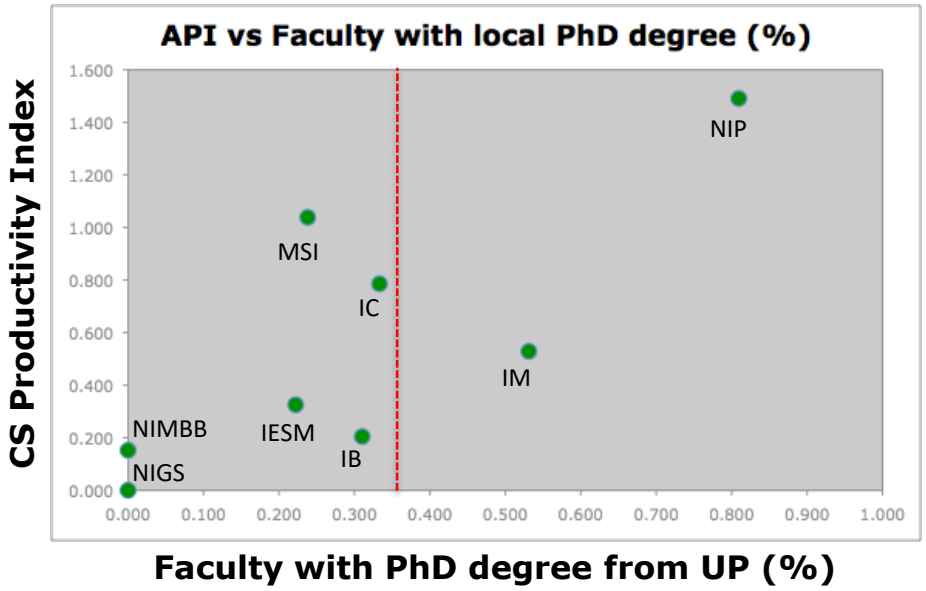




For UP

- **Use of metrics in determining the best practices among its constituent units, colleges, institutes and departments.**

- **Learn best practices from better performing UP units.**



Goal: Transparency, predictability, meritocracy, common good

For UP

- **To enhance maintenance and safety culture in its campuses.**

  Increase the MOOE allocation for the maintenance and operations of the National Science Complex.

  Complete the Engineering Complex.

- **To develop a nurturing and enabling environment such that tenure is granted only to a PhD faculty who produced a PhD graduate as sole adviser.**

- **To decouple academic rank from salary grade.**

Rough Estimates: PhD Production

Colleges with STEM PhD Programs

College of Science
PhD faculty: 154
PhD graduation rate (1984 – 2015): 13 ± 4.1 per year
Target: 50 (one faculty one graduate per 3 years)

College of Social Sciences and Philosophy
PhD faculty: 74
PhD graduation rate (1990 – 2015): 7.68
Target: 25

College of Engineering
PhD faculty: 78
PhD graduation rate (1990 – 2015): 4.32
Target: 25

Pandaigdigang
Araw ng Liwanag

Ika-16 ng Mayo

Measuring the Performance of the Philippine Scientific Enterprise System

DOST NAST Luzon Regional Scientific Meeting
Royce Hotel & Casino, Clark Freeport Zone
9-10 May 2018