Strengthening the S&T Human Resource in the Philippines: An Analysis of the Balik Scientist Program of the Department of Science and Technology

Guada B. Ramos-Dimaya and Reihvelle A. Perez
National Academy of Science and Technology
Department of Science and Technology
Taguig City, Philippines

Rex Aurelius C. Robielos
School of Industrial Engineering and Engineering Management
Mapua University
Intramuros, Manila, Philippines
racrobielos@mapua.edu.ph

Abstract

This study was conducted to evaluate the contribution of the DOST Balik Scientist Program (BSP) awardees for the years 2017-2019 under different terms of engagement to the 6Ps Project Output. Using Analytic Hierarchy Process (AHP), relative weights show that short-term (0.4669) is the most preferred term of engagement by BSP Awardees, followed by long-term and medium-term, respectively. Results also show that BSP awardees with Short-Term engagement focused more on People Services (0.1777), closely followed by Partnership (0.1333) and Publication and Patent/IP, respectively. For the Medium-Term engagement, the highest mark were People Services and Publication both at 0.0572, followed by Partnership (0.2500) and patent/IP (0.1786). While ranks for the Long-Term engagement show that publication of research output and/or books ranked first (0.0938), People Services and Partnership both at second (0.0833) followed by Patent/IP. For the engagements, granting of patents/IPs has the lowest rank among the alternative. Recommendations include, (1) conducting a country needs assessment every three years; (2) revising the existing BSP forms to clearly indicate specific, measurable, achievable, realistic and timely (SMART) outputs; (3) setting a minimum target for each of the project output (alternatives); and (4) revising, expanding, or adopting another set of indicators for the project output; and (5) developing a comprehensive database for the Balik Scientists.

Keywords
Balik Scientist, repatriation, reversing brain drain, AHP, DOST 6Ps

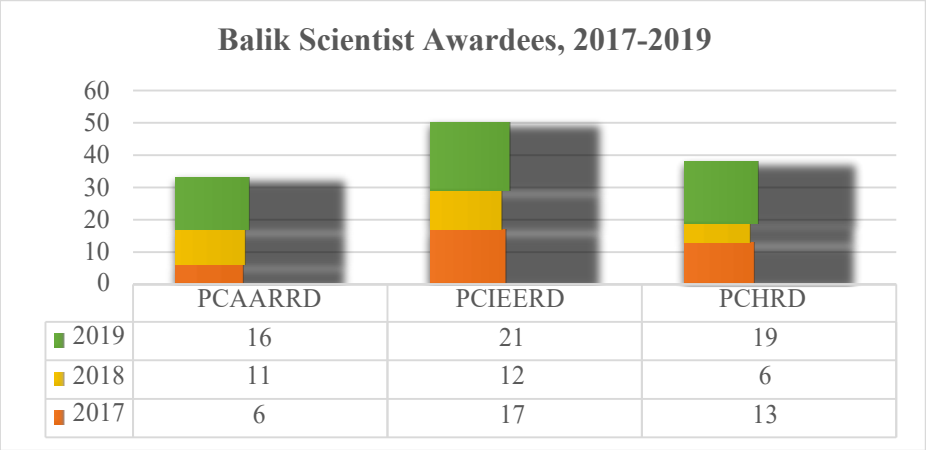
1. Introduction

The Balik Scientist Program (BSP) was established in 1975 under President Decree No. 819 series of 1975 for a period
of five (5) years and was extended until 1986 by Letter of Instruction no. 1044 issued in 1980. Initially, the program allowed any foreign-based scientist, professional, technician, or any person with special skill or expertise who is of Filipino origin or descent to practice his/her profession or expertise in the Philippines provided he/she shall first register with the Professional Regulation Commission (Balik Scientist Program, 2020). When it was revived through Executive Order 130 in 1993 under the Department of Science and Technology (DOST) as part of its Science and Technology Human Resource Development Program, the program utilized the expertise of expatriate Filipino scientists and technologists as a vital component of the Government's industrialization efforts.

In 2018, President Rodrigo R. Duterte signed the Republic Act 11035 also known as the Balik Scientist Act. With the same purpose of encouraging Filipino S&T experts from abroad to return to the Philippines, it now aims to reverse the effects of brain drain, strengthen the scientific and technological manpower of the academe and public and private institutions in order to promote information exchange and accelerate the flow of new technology into the country. The DOST was tasked to survey and identify scientific and technological expertise absent or limited locally, which may be addressed by the BSP. Priority areas include those under the industry, agriculture, and health sectors. The program

offers Short-Term (minimum duration of 15 days to a maximum duration of 6 months), Medium-Term (duration of more than 6 months but not to exceed 1 year), and Long-Term (duration of more than 1 year to 3 years) engagement to those who will participate in the program. Incentives, benefits, and privileges are given based on the scientist's term of engagement.

DOST assisted projects are required to deliver the expected outputs based on the DOST 6Ps Project Output Guide, which stand for Publication, Patent/IP, Product, People Services, Places and Partnerships, and Policies. The BSP is expected to quantify outputs as compared to the total budget of the project. These outputs may either be quantitative or qualitative but must be measurable during a funding period.
A total of 526 Balik Scientist awardees participated in the program. They were encouraged to return to the Philippines to share their expertise in 659 engagements servicing the requirements of the academe, public/government agencies, and the industry (Guevara, 2019). Since the 6Ps Project Output was institutionalized in 2017, this study evaluated only the contribution of the DOST Balik Scientist Program awardees for the years 2017-2019 in different terms of engagement to the DOST 6Ps Project Output. There is a total of 121 participants during the three-year coverage.



	PCAARRD	PCIEERD	PCHRD
2019	16	21	19
2018	11	12	6
2017	6	17	13

Figure 1. Balik Scientist Awardees per Sectoral Council, 2017-2019

At the same time, available data show that since the DOST 6Ps Project Output Guide was used to evaluate the program, only 4Ps were appropriate, these are Publication, Patent, People Service, and Partnership. Product commercialization and policy adoption were not included since considering the length of involvement of the BSP awardees, it takes longer time for these two to be accomplished. The success of this study will have an implication on the evaluation of awardees and their proposed activities under the Balik Scientist Program. The results will hopefully provide insight to the policy and decision makers on where to focus more the resources of the project.

2. Methodology

2.1. Analytic Hierarchy Process (AHP)

This study will use Analytic Hierarchy Process (AHP) in analyzing the BSP data from 2017 to 2019. The AHP is one of the multiple criteria decision-making methods that was originally developed by Thomas L. Saaty (1977). It is used in complex decision making for complex scenarios in which many variables or criteria are considered in the prioritization and selection of alternatives or projects (Vargas, 2010). AHP has been used in different fields, such as but not limited to health, information technology, environment, industry, agriculture, education, and government, to analyze and evaluate criteria and alternatives in decision making (Baffoe, 2019).

Vargas (2010) states that in empirical data are transformed into numerical values for comparison. It was further stated that this capability of converting empirical data into mathematical models is the main distinctive contribution of the AHP technique when contrasted with other comparing techniques.

Vargas (2010) further explained that numerical probability of each alternative is being calculated by comparing the relative weights of each of the criteria to be evaluated. This probability determines the likelihood that the alternative

must fulfill the expected goal. The higher the probability, the better the chances the alternative must satisfy the final goal of the portfolio.

Simply put, the AHP method involves the identification of issue that needs to be addressed, provision of the alternate solutions, and the development of the criteria to evaluate the alternative solutions (Juneja, _____). The study involves the following process:

(1) *Determination of the problem and associated goal*. The evaluation of the program based on 4Ps started only in 2017. Accomplishment report from the three councils show that outputs of awardees were evaluated by getting the percentage increase / decrease of the accomplishments based on the target number per output. Through this study, the authors aim to determine which among the terms of engagement have more weight to the achievement of the overall goal of the program (Level 1).

(2) *Clearly defining the objectives or criteria necessary to achieve the goal*. The terms of engagement of the Balik Scientist awardee in the country, on whether it is a short, medium, or long-term stay, were used as the criteria (Level 2).

(3) *Identifying each alternative or option available to the stakeholders*. The 4Ps, namely, Publication, Patent/IP, People Services, Partnership were used as alternatives (Level 3).

(4) *Construction of a hierarchy tree (*see Fig. 2*) with the goal at the top, the objectives that are necessary to achieve the goal below, and the various alternatives at the botto*m. Using the hierarchy structure, Level 1 contains the goal of the study which is to evaluate the contribution of the DOST Balik Scientist Program awardees for the years 2017-2019. Level 2 or the criteria for evaluation, shows the different terms of engagement—short-term, medium-term, and long-term of the Balik Scientist awardees. The 4Ps – Publication, Patent/IP, People Services, and Partnership was reflected as alternatives in Level 3 (see Fig. 1). To determine the alternatives, accomplishment reports of the program for the last three years were reviewed and evaluated.

(5) *The next is the development of (n × n) sized pairwise comparison matrices for each objective in terms of the goal and each option in terms of each objective*. The Pairwise Comparison (PC) involves one-on-one comparisons between each of the indicators. Saaty's (1980) 9-points scale (Table 2) for measuring the relative importance of each criteria is adopted for the pairwise comparison. Reciprocal values are assigned for each reversed pairwise comparison in each matrix. Objectives are ranked in terms of the goal and options in term of each objective.

A two-part survey was conducted to get the priorities of the different councils in terms of the 4Ps. Respondents were the BSP Secretariat handling the program in their respective councils. Results were analyzed using pairwise comparison of the elements using the rating scale on Table 1 and 2.

Table 1. Rating Scale for Pairwise Comparison

SCALE	DEFINITION	EXPLANATION
1	Equal importance	Two elements contribute equally to the objective
2	Weak	Between equal and moderate
3	Moderate importance	Experience and judgement slightly favor one element over another
4	Moderate plus	Between moderate and strong
5	Strong importance	Experience and judgement strongly favor one element over another
6	Strong plus	Between strong and very strong
7	Very strong or demonstrated importance	An element is favored very strongly over another; its dominance demonstrated in practice
8	Very, very strong	Between very strong and extreme
9	Extreme importance	The evidence favoring one element over another is one of the highest possible order or affirmation

Source: Adopted from Saaty, 1980

According to Satty (1980), odd numbers are used in the table above to provide reasonable distinction among the measurement points. Even numbers on the other hand, should be adopted if there is a need for negotiation between the evaluators, also known as compromise. (Vargas, 2010).

Table 2. Average Random Index (RI) based on Matrix Size (n)

MATRIX SIZE (n)	1	2	3	4	5	6	7	8	9
Random Index (RI) value	0	0	0.52	0.90	1.12	1.25	1.35	1.42	1.46

(6) *Determination of consistency index (CI) as follows: CI = (λmax – n)/ (n – 1), where n is the size of the matrix. Consistency ratio (CR), is the ratio of CI/RI, where RI is the Random Index (see Table 2), which refers to consistency index of a random matrix of order n, where n is the total number of elements being compared.* The CR measures the consistency of judgments and it should always not exceed 0.10, as greater value shows inconsistencies which will demand repetition of all the steps.

(7) *The last procedure is to aggregate the relative weights of the thematic and individual indicators to produce a vector of composite weights for each alternative and ranking them.*

3. Results and Discussion

Table 3 and 4 presents the pairwise comparison results of the alternatives and the criteria with respective consistency ratio (CR). Results from the computation show that all the CRs for the alternatives and criteria are less than 0.10 indicating that the assessment of the BSP Secretariat of the Sectoral Councils is reliable, hence, admissible.

Table 3. Pairwise comparison of alternatives versus criteria

A.1. SHORT TERM ENGAGEMENT					
ATTRIBUTE OR CRITERIA	**PUBLICATION (4)**	**PATENT/IP (3)**	**PEOPLE SERVICES (8)**	**PARTNERSHIP (5)**	
PUBLICATION	1.00	1.33	0.50	0.67	
PATENT/IP	0.75	1.00	0.38	0.50	
PEOPLE SERVICES	2.00	2.67	1.00	1.33	
PARTNERSHIP	1.25	1.67	0.63	1.00	
TOTAL	5.00	6.67	2.50	3.50	
NORMALIZED					
A.2 SHORT TERM ENGAGEMENT					
ATTRIBUTE OR CRITERIA	**PUBLICATION (4)**	**PATENT/IP (3)**	**PEOPLE SERVICES (8)**	**PARTNERSHIP (6)**	**CRITERIA WEIGHT**
PUBLICATION	0.2000	0.1994	0.2000	0.1914	0.1977
PATENT/IP	0.1500	0.1499	0.1520	0.1429	0.1487
PEOPLE SERVICES	0.4000	0.4003	0.4000	0.3800	0.3951
PARTNERSHIP	0.2500	0.2504	0.2500	0.2857	0.2590
CONSISTENCY RATIO (CR) = 0.000597					
B. 1. MEDIUM TERM					
ATTRIBUTE OR CRITERIA	**PUBLICATION (8)**	**PATENT/IP (6)**	**PEOPLE SERVICES (9)**	**PARTNERSHIP (8)**	
PUBLICATION	1.00	1.60	1.00	1.14	
PATENT/IP	0.63	1.00	0.63	0.71	
PEOPLE SERVICES	1.00	1.60	1.00	1.14	
PARTNERSHIP	0.88	1.40	0.88	1.00	
TOTAL	3.50	5.60	3.50	4.00	
NORMALIZED					
B.2 MEDIUM TERM					

ATTRIBUTE OR CRITERIA	PUBLICATION (8)	PATENT/IP (5)	PEOPLE SERVICES (8)	PARTNERSHIP (7)	CRITERIA WEIGHT
PUBLICATION	0.2857	0.2857	0.2857	0.2857	0.2857
PATENT/IP	0.1786	0.1786	0.1786	0.1786	0.1786
PEOPLE SERVICES	0.2857	0.2857	0.2857	0.2857	0.2857
PARTNERSHIP	0.2500	0.2500	0.2500	0.2500	0.2500
CONSISTENCY RATIO (CR) = 0.09678					
C.1. LONG TERM					
ATTRIBUTE OR CRITERIA	PUBLICATION (9)	PATENT/IP (7)	PEOPLE SERVICES (8)	PARTNERSHIP (9)	
PUBLICATION	1.00	1.29	1.13	1.13	
PATENT/IP	0.78	1.00	0.88	0.88	
PEOPLE SERVICES	0.89	1.14	1.00	1.00	
PARTNERSHIP	0.89	1.14	1.00	1.00	
TOTAL	3.56	4.57	4.00	4.00	
NORMALIZED					
C. 2 LONG TERM					
ATTRIBUTE OR CRITERIA	PUBLICATION (8)	PATENT/IP (5)	PEOPLE SERVICES (8)	PARTNERSHIP (7)	CRITERIA WEIGHT
PUBLICATION	0.2809	0.2813	0.2813	0.2813	0.2812
PATENT/IP	0.2185	0.2188	0.2188	0.2188	0.2187
PEOPLE SERVICES	0.2497	0.2501	0.2500	0.2500	0.2499
PARTNERSHIP	0.2497	0.2501	0.2500	0.2500	0.2499
CONSISTENCY RATIO (CR) = 0.00387					

Table 4. Pairwise Comparison of Criteria in view of the Goal

ATTRIBUTE OR CRITERIA	SHORT TERM (7)	MEDIUM TERM (3)	LONG TERM (5)	
SHORT TERM	1.00	2.33	1.40	
MEDIUM TERM	0.43	1.00	0.60	
LONG TERM	0.71	1.67	1.00	
TOTAL	2.14	5.00	3.00	
NORMALIZED AHP				
ATTRIBUTE OR CRITERIA	SHORT TERM (7)	MEDIUM TERM (3)	LONG TERM (5)	CRITERIA WEIGHT
SHORT TERM	0.47	0.47	0.47	0.4669
MEDIUM TERM	0.20	0.20	0.20	0.2001
LONG TERM	0.33	0.33	0.33	0.3335
CONSISTENCY RATIO (CR) = 0				

From here, in terms of the BSP's involvement per term of engagement, the priority criteria result for the first level are as follow:

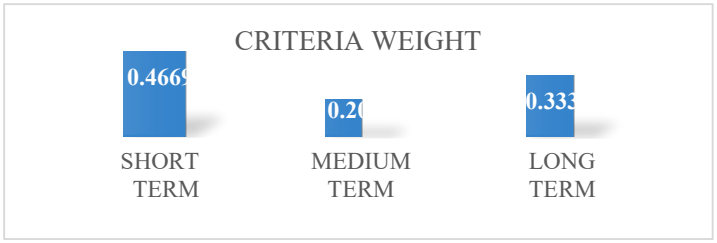


Figure 3. Results of AHP Matrix per Term of Engagement

These are represented by relative weights of short-term: 0.4669; long-term: 0.3335; and medium-term: 0.2001 which can be attributed to the fact that the Balik Scientists awardees have commitments in their respective institutions during the time of participation to the program. Short-term, being the most preferred term of engagement, can be an ideal time for the BSP awardee to travel and be involved in the host institution in the Philippines. Data also show that even if the short-term engagement offers a maximum duration of six (6) months, most of those who avail of this type of engagement stay only in the country for a maximum of 90 days (3 months).

Further, out of the 121 awardees for the period, 19 awardees or 16 percent have returned to the Philippines for at least a second engagement—twelve (12) returned for at least another short-term engagement, five (5) came back under the medium-term engagement and two (2) availed of the long -term engagement. From this, it can be observed that majority of the returning scientist still opted for the short-term engagements. Again, this may be attributed to their commitments in their respective home countries thus preventing them from staying longer in the Philippines. Visiting the Philippines for at least once year for short periods of time is a viable option for these scientists since majority of their output is on People Services.

For the part of DOST, short-term engagement is a good platform to entice young and talented Filipino scientists or scientists of Filipino descent back to our country and share their expertise. It can serve as a take off point for a longer and meaningful engagements in the future. This will hopefully lead to more scientists participating in the program who will opt to stay, thus, eventually reversing brain drain. Since its operation, a number, scientists have stayed in the country and have become very productive members of the scientific community. Some notable examples were: Dr. Jose B. Cruz, Jr., and Dr. Edsel Maurice Salvana.

Dr. Cruz is a brilliant engineer recognized for pioneering and establishing theories, principles, analysis tools, and design methodologies in complex systems with dynamic feedback mechanisms. He actively contributed in the development of the engineering curriculum and the accreditation of the Philippines in the Washington Accord, a multi-lateral agreement between bodies responsible for accreditation or recognition of tertiary-level engineering qualifications within their jurisdictions who have chosen to work collectively to assist the mobility of professional engineers (Washington Accord, 2020).

Dr. Salvana is well known medical doctor specializing in internal and tropical medicine and infectious diseases. He established the first Philippine HIV and AIDS fellowship program to increase care for patients afflicted with HIV and AIDS and is project leader of an online genome library to track Philippine H1N1 online. He has taken his HIV and AIDS advocacy to the international stage, delivering educational, action-oriented speeches about the epidemic to the United Nations and the U.S. Peace Corps (Manila 40 Under 40, 2013).

In terms of the field of expertise of the awardees, it is recommended that DOST should conduct a country needs assessment every three years to determine whether the BSP goal of addressing the needs of the country's S&T manpower is met. After the enactment of the law in 2018, the program identified priority areas under Agriculture, Health, and Industry. By regularly conducting needs assessment, the program can identify the strengths and gaps per sector, thus can make the necessary adjustments in allocating its resources. Emerging issues, e.g., COVID pandemic, should also be taken into consideration. The program can target scientists with specific expertise that can help our scientific community in related research efforts.

Table 5. Different priority areas per sector

HEALTH	AGRICULTURE	INDUSTRY

□ Drug discovery and development □ Diagnostics □ Functional foods □ Hospital equipment and biomedical devices □ Information and communication technology for health □ Dengue and other arboviruses □ Climate change adaptation □ Disaster risk reduction □ Artificial Intelligence □ Big Data Analytics □ Nuclear Medicine □ Omics Technologies for Health and Wellness □ Other research priority areas such as mental health, geriatric care, nutrition, food safety	□ Crops R&D □ Forestry R&D □ Climate Change Adaptation and Risk Reduction □ Natural Resources and Environment R&D □ Technology Transfer □ Socio-economic and Policy Research □ Livestock R&D □ Aquatic R&D	□ Electronic & Semiconductor Industries □ Mining & Minerals □ Metals & Engineering □ Food Processing □ Energy Efficiency □ Transportation □ Materials Science/ Nanotechnology □ Genomics/ Biotechnology □ ICT □ Space Technology Applications □ Photonics □ Artificial Intelligence □ Data Science □ Creative Industries □ Climate Change Adaptation □ Disaster-Risk Reduction & management □ Environment □ Human Security

Table 6 below shows the calculations of the four alternatives with respect to the three types of engagements.

Table 6. Calculation of alternatives with respect to criteria

CRITERIA VERSUS GOAL		ALTERNATIVE	A		B		C
SHORT TERM	0.4669	PUBLICATION	0.1905	x	0.4669	=	0.0889
		PATENT/IPS	0.1433	x	0.4669	=	0.0669
		PEOPLE SERVICES	0.3807	x	0.4669	=	0.1777
		PARTNERSHIP	0.2856	x	0.4669	=	0.1333
			1.0001				**0.4669**
MEDIUM TERM	0.2001	PUBLICATION	0.2857	x	0.2001	=	0.0572
		PATENT/IPS	0.1786	x	0.2001	=	0.0357
		PEOPLE SERVICES	0.2857	x	0.2001	=	0.0572
		PARTNERSHIP	0.2500	x	0.2001	=	0.0500
			1.000				**0.2001**
LONG TERM	0.3335	PUBLICATION	0.2812	x	0.3335	=	0.0938
		PATENT/IPS	0.2187	x	0.3335	=	0.0729
		PEOPLE SERVICES	0.2499	x	0.3335	=	0.0833
		PARTNERSHIP	0.2499	x	0.3335	=	0.0833
			0.9997				**0.3334**

Results show that scientists with Short-Term engagement focused more on People Services (0.1777), which involve giving lectures, conducting seminars, trainings, and workshops and mentoring students. This was closely followed by Partnership (0.1333) where number of linkages established, and number of research collaborations are counted. Publication and Patent/IP ranked third and fourth, respectively. For the Medium-Term engagement, People Services and Publication both at 0.0572 were given the highest mark, followed by Partnership (0.2500) and patent/IP (0.1786). While ranks for the Long-Term engagement show that publication of research output and/or books is ranked first (0.0938), People Services and Partnership were tied at second rank (0.0833) followed by Patent/IP.

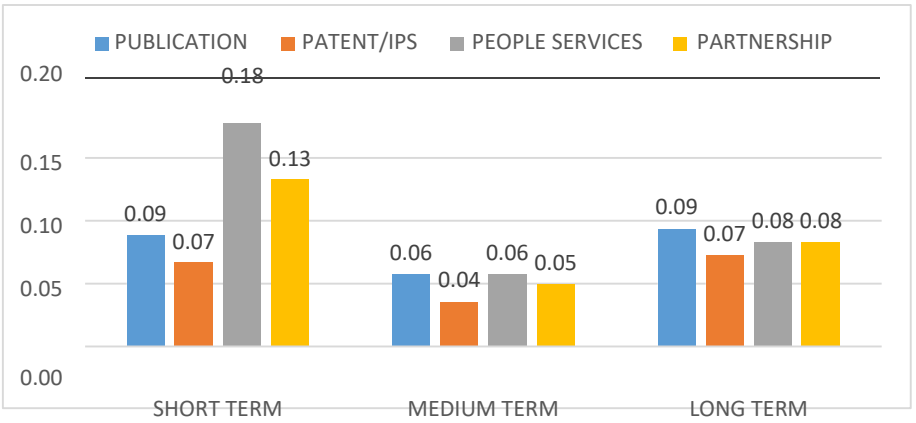


Figure 4. Outputs (4Ps) per Term of Engagement

It is interesting to note that for all the engagements, granting of patents/IPs has the lowest rank among the alternative. This accounts for the patent application procedure in the country. It takes an average of two to three years from the filing date of the application in the Philippines to register a patent. This considers the waiting period of 18 months from the filing date or priority date before the application is published electronically on the Philippine e-Gazette. Results also show that the rank of the alternatives varies for each type of engagement. The rank or weight of each alternative can be used as a measurable performance indicator for each awardee. Based on the application form (BSP Form 001) and on the terms of reference form (BSP 002), there was no set target indicated per engagement. The applicant will indicate his outputs based on his program of activities.

It is recommended that the program set a minimum target reflecting the ranking of alternatives per engagement. The degree of expected outputs will be different per engagement. For example, a scientist under short-time engagement will be expected to have about 40 percent (0.3807) of his total output under People Services, while about 30 percent (0.2856) will be under Partnership. Since he is interacting with students and researcher from the academe and industry, he will be able to form new and additional partnerships and collaborations within and outside his host institution. Expected output under Publication is about 20 percent (0.1905) and 10 percent (0.1433) under patent/IP. Scientist under the medium-term engagement will be expected to equal weight of outputs under Publication and People Services at 29 percent each (0.2856) of the total output, followed by Partnership at 25 percent (0.2500) and by patent/IP at 17 percent (0.17). Lastly, for scientist under long term engagement, 28 percent (0.2812) should be in Publication, 25 percent (0.2499) each for People Services and Partnership, and 17 percent for patent/IP.

The program should clearly indicate these specific, measurable, achievable, realistic and timely (SMART) outputs. The existing forms are recommended to be revised to include the such target per output. This will help the scientist in preparing his program of activities for the duration of his engagement. At the same time, DOST can fully maximize the visit of the scientist by allocating its resources to the prioritized outputs. Further, monitoring and evaluation of the accomplishments individual scientist under the program will be easier.

The adoption of 4Ps as outputs for the program have standardized the outputs across the councils. Under the present arrangement, each output have specific set of indicators (Annex 1). This study recommends revisiting the existing output and its corresponding indicators to make the indicators more suited to the needs of the program.
One example is the revision of the indicators under Patent/IPs and expansion of the indicators under People Services. It was mentioned in the above discussion that Patent/IPs has the lowest rank among the four (4) outputs and it was cited that the long process is one of the factors. For Patent/IPs, the indicators were a) number of patent application assisted; and b) number of utility model grant assisted. However, data reported under this output were on the number of technologies introduced and project assisted by the awardee. There is a need to revise the indicators to clearly define the role of the number of technologies introduced and the project assisted of the awardee vis-à-vis assistance to patent and utility model grant application. The program can also consider another indicator to cover these activities.

For People Services, there were three identified indicators: a) number of trainings, workshops, demonstrations conducted; b) number of students mentored; and c) number of public services adopted. Expansion of these indicators is recommended to mirror the depth of engagements of the awardees. The number of trainings, workshops, demonstrations conducted can be broken down to include the type of audience for each activity. The impact of the

activity will depend on the type of audience. The level of students mentored should be included since, again, impact and the manner of mentorship will be different for BS, MS and PhD students. Likewise, effect of the public services adopted will greatly differ at level of its adoption, i.e., at the barangay level, municipal, provincial or national level. Another recommendation of the study is the development of a comprehensive database for the Balik Scientists. Data from the study were gathered from the accomplishment reports (Form D) from the three councils which were submitted to DOST. The report on the output of the awardees is just part of the report of the whole BSP Secretariat. It is in a semi-narrative format; activities conducted were enumerated but, in some cases, the involvement of the awardees was not mentioned. The format and content of the report were also different from one council to another. In developing the comprehensive database, the personnel concerned should sit down and identify the fields that they would like to include in the database. For future applications, the Secretariat can use online forms which can go directly to a database.

Lastly, this paper recommends the possible use of the results of this study to measure the productivity of an awardee. Due to time and data constraints, the authors were not able to calculate the productivity of the awardee during his/her engagement. This will be very valuable to DOST in evaluating the accomplishments of each awardee and their contribution to the program. Data from this study can be used for further research to come up with a productivity index in order to measure the impact of each awardee.

4. Conclusion

The study was able to utilized AHP in prioritizing the alternatives, which were represented by the DOST 4Ps Project Output, namely, Publication, Patent/IPs, People Services and Partnership in relation to the three types of engagements under the Balik Scientist Program of the Department of Science and Technology (DOST).

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Biographies

Rex Aurelius C. Robielos is the Dean of the School of Industrial Engineering and Engineering Management at Mapua University. Before joining Mapua, he was Section Manager of Operations Research Group, Analog Devices General Trias. He has a BS in Applied Mathematics from the University of the Philippines Los Baños, and a Diploma and MS in Industrial Engineering from the University of the Philippines Diliman. He is pursuing Ph.D in Industrial Management (candidate) at National Taiwan University of Science and Technology in Taiwan. He is the current Secretary of Human Factors and Ergonomics Society of the Philippines and Director of the Philippine Institute of Industrial Engineers and Operations Research Society of the Philippines.

Guada B. Ramos-Dimaya is at present the Chief Science Research Specialist of the National Academy of Science Technology, Philippines. She finished her Master of Development Communication degree from the University of the Philippines (UP) Open University and obtained her Bachelor of Science in Development Communication degree from UP Los Banos. She is currently taking up her Master in Business Analytics at Mapua University.

Reihvelle Ambrosio Perez completed her Bachelor's degree in Zoology at the University of the Philippines Los Baños and currently taking up her Master's degree in Business Analytics at Mapua University. She is working as Senior Science Research Specialist at the National Academy of Science and Technology, Philippines (NAST PHL), an attached agency of the Department of Science and Technology (DOST).