Journal of Research and Development
ISSN: 2311-3278

Khiyami et al., J Res Development 2018, 6:2
DOI: 10.4172/2311-3278.1000164

Research Article Open Access

Comparing the Impact of Supporting Grant Type on the Quality of Research Output

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Abstract

This paper attempts to evaluate the impact of the types of grants, large (LG) or small (SG), funded by King Abdul-Aziz City for Science and Technology (KACST). Specifically, this research attempts to compare grants with regard to their scientific outputs as represented by the number of published articles, the number of reputable journals published within, and the number of citations achieved by the published papers. In addition, the study investigates the number of patents produced, the number of conferences and symposiums attended by the funded researchers, and the number of published abstracts in conference proceedings. Data collection was conducted via a questionnaire distributed to 600 KACST funded principle investigators whose research had been completed within the last five years. 311 recipients responded to the questionnaire corresponding to 311 funded projects. Overall results indicate that the funded projects 215 LGs and 96 SGs produced 421 published papers that were cited 1389 times. There were also 30 patents produced from these grants, 27 of which were from LGs and 3 from SGs. The results showed a greater number of published papers-292 and number of citations-1278 for the LGs as compared to 129 papers and 111 citations from SGs. However, the ratio of projects to published papers from LGs and SGs is nearly equivalent at a ratio of 1.358 and 1.344 respectively. Papers produced from SGs were published in journals with high impact factors at a rate of 0.51, which is greater than that of the large grants at 0.3562. This seems to point to the possibility that increasing the monetary size of grants' does not lead to better outcomes in terms of numbers of publications, prestige of journals published in, or total number of citations. In sum, the analyses indicate that the measurement of grant impacts is sensitive to how research performance is defined and tested using bibliometric indicators. In addition, when compared by the amount of funding for a project used to produce each paper, it was found that SG are more productive than LG with the cost of a LG published paper equal to 7.5 times that of a SG published paper. It is recommended that future funds should be allocated according to more strict regulations and standards. We recommend that outputs resultant of the research funding should be thoroughly documented. Finally we also recommend further studies to determine appropriate research output metrics to evaluate projects. This is to aid monitoring future funding more efficiently and productivley.

Keywords: KACST; GDRG; Support type; Large grants; Small grants; Research output; Published papers; Impact factors journals; Citations; Patents

Introduction

Scientific research has a critical role in the modern world, and is heavily dependent on financial support. Thus, scientific research in developed societies enjoys the generous support of formal and informal beneficiary institutions, this is because investment in scientific research translates into beneficial economic and social development. The United States spends $373.1 billion (2.7% of GDP), Japan $147.9 billion (3.4% of GDP), and the European Union $264.9 billion (1.8% of GDP) on scientific research. In contrast, Arab countries spend only $4.7 billion, barely 0.2% of GDP. The estimated participation of Arab Countries in the total global spending on research and development is approximately 0.4% whereas the contribution of the United States alone is 32.6%, Japan comes next with 12.9%, and China comes third with 8.9% [1]. The literature on research evaluation addresses several comprehensive kinds of questions about relationships between the research inputs and outputs of academic investigation [2,3]. The first question regards the amount of money on scientific output. "Does more money produce more publications? And, what is the kind of the link between the two?" The second and third questions are about the impact of funding on research quality. "Do large amounts of money guarantee publishing in the best journals?" "Does the industry funding of university research have any impact on industry–university relations? Or could this type of funding helps strengthen cooperation between companies and universities?" [4-9]. Several studies and reports have been published regarding evaluation of the influences of funding on the quality of research output. For example, Payne and Siow studied the effects of federal research funding on research outcomes at 68 research universities. Payne and Siow found that a rise of one million dollars in federal research funding ($1996) to an institute resulted in 10 additional published papers and 0.2 extra patents. The alteration in citations per publication was found to be negatively correlated, however this relation was minor and roughly measured. As a primary estimate, marginal increases in federal research funding resulted in additional research output but not necessarily of greater quality [10-13]. Patents from Universities have resulted from more substantial research output in the previous few decades. A rise in the number of faculty patents and personal-scientist registered inventions on patent applications has also been observed [14-16]. The efficient share of funds

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Received February 28, 2018; **Accepted** March 22, 2018; **Published** March 31, 2018

Citation: Khiyami MA, AlHareqy LA, Aldahmash A (2018) Comparing the Impact of Supporting Grant Type on the Quality of Research Output. J Res Development 6: 164. DOI: 10.4172/2311-3278.1000164

to universities is of considerable concern to officials. In this context Tahmooresnejad L et al. [17] evaluated if a raise in governmental funds for the scientists in the academia improves the achievement of investigators in both scholarly publications and academic patents or if this only increases publications in the academic field. They provided summary statistics that presented data in Quebec matched with other provinces in Canada, and made econometric models of different publication, patenting, and grant databases. Their analysis illustrated the solid connection between funding and publication output in addition to the citation impact of publications. Other studies such as Wang and Shapira [18] have supported this finding. In view of research and patenting accomplishments of academics, Tahmooresnejad and Beaurdy empirical study found a solid impact on the number of patents. Additionally, improved funding seemed to support the citation impact of patents in Quebec, which affected the citation impact of patenting activities. Other studies [19-21] about the association between funding and quality of published research have concluded that the quality of published research is associated with study funding. In a study conducted by Benoit Godin [21] for the Natural Sciences and Engineering Research Council of Canada (NSERC) during the 2002, the author concluded that the researchers supported by NSERC were accountable for the mainstream of Canadian publications in natural sciences and engineering and that these publications were published in high-quality journals. He noticed that the NSERC grants program has a measurable impact on research in Canada; that is the number of publications increased with the increasing level of monetary support. However, this correlation distinguished merely those researchers who were categorized as having 'high levels' of funding. The other inference was that the level of funding did not have any effect on the quality of the journals that were used by the researchers to publish their papers. Irrespective of the funding level, the quality of the journals remained the same and only the number of papers varied. King Abdulaziz City for Science and Technology (KACST) supports and supervises a number of funding programs including large research project funding programs and small research project funding programs. The large research project is the type of research that is concerned with a comprehensive and in-depth study of a particular subject. The accomplishment of this research requires the participation of a number of specialists. This type of research might be basic, applied, or developmental research. The amount of funding can reach up to two million Saudi Riyals and covers a period of up to two years. The small research project fund is intended to achieve specific objectives in one area of science, whether it be basic, applied, or developmental research. The amount of funding does not exceed two hundred thousand Saudi Riyals and the length of the research does not exceed one year.

The main objective of this paper is to compare the effect of supporting large and small grants on the quality of the research outputs. The specific objectives include:

1. Comparing the number and quality of published scientific papers that come out from both large and small grants.
2. Comparing number of produced patents resulting from both large and small grants.
3. Studying the effect of funding of both large and small grants on attendance and participation in international scientific conferences and workshops.
4. Investigating the nature of the distribution of the small and large grant's funds over the institutions and fields of disciplines around the Kingdom of Saudi Arabia.

Sample and Methodology

Sample

A representative sample of 600 grant winners in different fields of supported research that was completed in the past five years was electronically surveyed. All grant winners were funded by KACST via the General Directorate of Research Grants (GDRG).

Methodology

The data employed here are from a questionnaire that was E-mailed to the winners of large and small grants from various disciplines in Universities and institutions in the Kingdom of Saudi Arabia. To improve the response rate, two-reminder e-mails were sent to researchers who had not responded to the survey. Questions focused on projects' contributions to the fields. Three of the questions focused on "how many papers had each grant recipient published in peer-reviewed journals?" and "whether these peer-reviewed journals have impact factors or not?" in addition to the question about the number of citations each published paper achieved up to the point of the survey distribution. There were other questions that had relevance to participation in conferences and seminars, publishing papers and abstracts in the conferences' proceedings, resulted patents, and if the grant has resulted in any type of application of the research results.

Results

The number of the returned questionnaires was 311 out of a total 600 surveyed. The return rate reached 51.83%. The returned questionnaires were categorized into four disciplines; agriculture, engineering, health and sciences (Figure 1). The present study demonstrates the distribution of the large and small grants among institutions and disciplines as the well as the productivity of each. It also presents the outputs of the two types of grants (large grants = LGs and Small grants = SGs), which include the number of patents, the number of publications of scientific papers in journals with or without impact factors, and the number of citations that have been achieved by these papers. The participation in local, regional and international conferences, symposiums, and publications of abstracts in the conferences proceedings is also reported. The results also dealt with answers to questions posed about the application of the recommendations of the researcher's results (Table 1) shows the distribution of LGs and SGs recipients by institution. Most of the twenty-five institutions were universities (22). The others were Specialized Hospitals (2), and the last was the Ministry

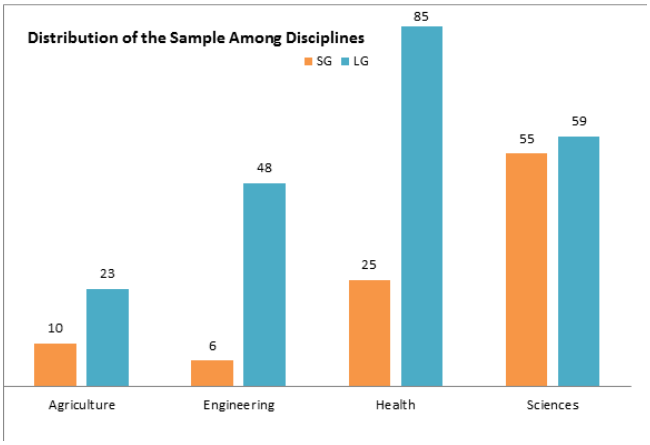


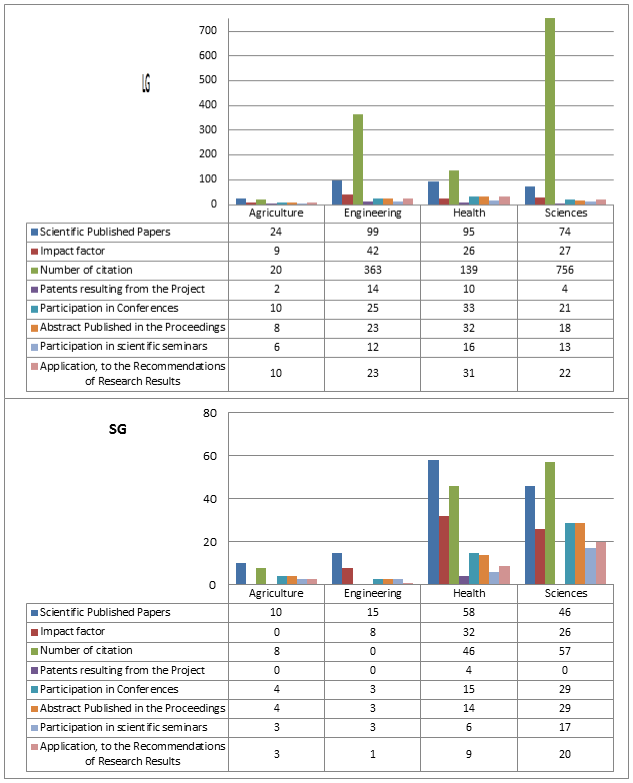
Figure 1: Distribution of the sample among disciplines.

Institution	Grant type	N	Fund, SR	Published papers	# of Impact Factors J	Citations	Patents
King Saud University	L	41	61128284	44	15	89	0
	S	28	3924168	38	13	66	0
King Abdulaziz University	L	40	45408898	33	11	25	2
	S	8	765000	4	3	3	0
King Fahd University of P&M	L	47	47833560	118	52	344	16
	S	1	148200	0	0	0	0
King Faisal University	L	16	15817673	27	12	148	1
	S	4	441000	3	0	5	0
Umm Alqura University	L	7	6637200	3	0	3	0
	S	7	928000	1	0	0	0
Hail University	L	5	4938000	2	0	0	0
	S	9	1195548	4	0	0	0
Imam University	L	5	3997002	1	0	0	0
	S	1	60000	1	0	3	0
Majmaa University	L	0	0	0	0	0	0
	S	2	236750	0	0	0	0
King Khalid University	L	11	8989408	20	4	566	0
	S	2	269215	2	1	0	0
Dammam University	L	4	5149201	2	0	3	3
	S	5	334800	4	1	0	1
Taibah University	L	5	3282600	2	0	6	1
	S	5	485400	25	22	1	1
Najran University	L	2	1336200	1	0	0	0
	S	0	0	0	0	0	0
King Faisal Specialized Hospital	L	8	10392278	9	1	4	0
	S	2	142000	0	0	0	0
Qassim University	L	4	12298170	2	0	20	0
	S	3	376200	6	1	2	0
Taif University	L	0	0	0	0	0	0
	S	6	553100	0	0	0	0
King Abdullah University	L	3	1920249	9	2	6	1
	S	1	188000	0	0	0	0
Princess Nourah bint Abdulrahman University	L	5	7336060	1	1	0	0
	S	0	0	0	0	0	0
Jazan University	L	1	901200	0	0	0	0
	S	7	794000	4	0	10	0
Tabuk University	L	2	3282600	2	0	6	1
	S	2	485400	25	25	1	1
Prince Sultan University	L	3	464100	6	1	0	0
	S	0	0	0	0	0	0
Ministry of Health	L	1	833000	0	0	0	0
	S	1	84000	4	0	20	0
Jouf University	L	1	532400	1	1	53	0
	S	0	0	0	0	0	0
King Fahd medical research Center	L	2	5394400	9	4	5	0
	S	0	1007200	8	0	0	0
King Saud Bin Abdulaziz University for Medical Science	L	1	1557000	0	0	0	1
	S	2	0	0	0	0	0
National Nanotechnology Center	L	1	499600	1	0	0	1
	S	0	0	0	0	0	0
Total	L	215	249929083	292	104	1278	27
	S	96	12417981	129	66	111	3
Sum		311	261699264	421	170	1389	30

Table 1: Frequencies for each institution supported by grants and their research outputs.

of Health (1). From Table 1, it appears that three major universities received about 59.53% of the LGs and 38.54% of the SGs. King Saud University (KSU) ranked first in terms of the number of received grants. The university received a total of 69 grants, 41 of which were LGs, and 28 were SGs. King Abdul-Aziz University (KAU) comes in the second rank with 48 grants, 40 of them were LGs and eight were SGs. King Fahd University of Minerals and Petroleum (KFUPM) held the third position with 48 grants (47 LGs and one SG). The rest of the grants were distributed among the other 22 universities'. The output of the received grants represented as the number of published papers is dominated by the same three universities. The three universities have published 195 papers from LGs, which is equal to 66.78% of the published papers from total LGs. The same three universities also published 37 papers that were a result of SGs. However, KFUPM alone has published 118 papers all of them were produced from 47 LGs. On average, KFUPM has almost produced 2.5 papers from each received grant. This publishing rate makes KFUPM the first in rank among the other universities. However, we note that of these papers, only 52 (44%) were published in impact factor journals; the published papers have been cited 344 times. The second in rank in terms of published papers was KSU, which published 82 papers (44 from LGs and 38 from SGs). Only 15 (34%) and 13 (34%) papers were published in impact factor journals from LGs and SGs respectively. The published papers have been cited 155 times. KAU however, has published 37 papers most of them were produced from LGs (33 papers) and 4 from SGs; only 14 of those papers were published in impact factor journals. The published papers have been cited 28 times most of them (25) were for the papers resulting from LGs.

The fourth ranked university in terms of grants received was King Faisal University (KFU). It received 20 grants, 16 of which were LGs and 4 were SGs. KFU has published 30 papers (27 from LGs and 3 from SGs). Only 12 papers were published in impact factor journals all of them a product of LGs. The published papers have been cited 148 times from LGs and 5 times from SGs papers. King Khalid University (KKU) holds the fifth position with 13 grants received (LGs 11 and SGs 2). The number of published papers is 20 from the LGs and two from the SG. Only 4 out of the 20 published papers were published in impact factored journals and one from the SGs. However, the number of citations gained by KKU's published papers was the highest among all institutions totaling 566 times. Tabuk and Taibah Universities rank in sixth place with 27 published papers for each of them (25 from small grants and 2 from large grants), of these papers, 22 from Taibah and 25 from Tabuk university were published in journals with impact factors. Regarding the number of patents output, 30 patents were produced from all types of grants (27 from LGs and 3 from SGs). KFUPM again comes first with 16 registered patents. Dammam University comes second with 4 patents, and KAU third for (2), Taibah University (2), and Tabuk University (2) patents. The other 4 patents are distributed among 4 universities (Figure 2) presents the supported four main disciplines and their research outputs. The outputs have been categorized in terms of number of published papers, number of impact factor journals used for publication, and total number of citations recorded. The outputs also include number of patents that were produced from each discipline, participation in conferences and scientific seminars, in addition to the number of published abstracts and application of the recommendations resulting from the projects' results. It could be assumed from the results exhibited in Figure 2 that the health discipline takes the lead in terms of the total number of the published papers. The health discipline has produced 153 papers from the total 110 supported (85) LGs and (25) SGs. The number of published papers resulting from LGs was 95 papers



LG	Agriculture	Engineering	Health	Sciences
Scientific Published Papers	24	99	95	74
Impact factor	9	42	26	27
Number of citation	20	363	139	756
Patents resulting from the Project	2	14	10	4
Participation in Conferences	10	25	33	21
Abstract Published in the Proceedings	8	23	32	18
Participation in scientific seminars	6	12	16	13
Application, to the Recommendations of Research Results	10	23	31	22

SG	Agriculture	Engineering	Health	Sciences
Scientific Published Papers	10	15	58	46
Impact factor	0	8	32	26
Number of citation	8	0	46	57
Patents resulting from the Project	0	0	4	0
Participation in Conferences	4	3	15	29
Abstract Published in the Proceedings	4	3	14	29
Participation in scientific seminars	3	3	6	17
Application, to the Recommendations of Research Results	3	1	9	20

Figure 2: Frequencies of grants numbers for each variable as distributed by fields and grant types.

and 58 papers from SGs. Figure 2 shows that out of 153 published papers, there were 54 papers that were published in impact factor journals, 26 (27.37%) of which were from LGs and 32 (55.17%) papers were from SGs. Though the overall percentage of the SGs' papers that were published in impact factor journal is greater than that of the LGs' papers, the total number of citations were greater for papers resulting from LGs (139 citations) as compared to only 46 citations for the papers published from SGs. Moreover, the health discipline has filled out 14 patents 10 of which were from LGs and 4 from SGs. The Health discipline also reported greater participation percentages in conferences, scientific seminars and published abstract in conferences' proceedings by the SGs holders than that by the LGs' holders. However, 31 (36.47%) of the LGs' holders reported the application of their recommendations while only nine (36%) of SGs holders reported the same. Science disciplines came in second in terms of number of published papers. There were 120 papers published of which 74 papers were from LGs and 46 papers from SGs. From the 74 papers published from LGs, 27 papers were published in impact factor journal (36.49%) in comparison to 26 papers from the SGs which were published in impact factor journals (47.27%). Moreover, the LGs projects in science discipline resulted in a higher percentage of publications (125.42%) as compared to SGs (83.64%). These published papers gained 756 and 57 citations for large and small grants respectively. Science discipline research resulted in four patents from large grants only with no patents from small grants. Figure 2 indicates how many science discipline grants' holders participated in conferences. The number of participants in conferences was 21 and 29 from large and small grants respectively. 18 and 29 abstracts were published in conferences' proceedings from large and small grants respectively. Participation in scientific seminars was also

relatively encouraging. There were 30 participations in such activity and it is observed that SGs' holders made greater participations (17) as compared to 13 participations made by LGs' holders. Forty-two grants' (LGs= 22 and SGs=20) holders have reported applications of their recommendations based on their research results. Regarding the engineering discipline Figure 2 shows that the discipline has been categorized as the third in terms of the total LGs (48) and SGs (6) received and in the total number of published papers (114 papers). The number of the published papers from the LGs constitutes 99 papers, which reflects about 206.25% out of the total number of received LGs. However, only 42 papers were published in impact factor journals, which represents only 42.42% of the published papers. SGs have published 15 papers (250% of the total received SGs) and 8 of them were published in impact factor journals (53.33%). The number of citations achieved by the papers published by the engineering discipline was a total 363 citations all from the LGs published papers. The discipline achieved first rank in terms of the number of patents produced. The 14 patents that resulted from the discipline were produced from the LGs only. Participation of the grants' holders of the engineering discipline in conferences was almost equal in both types of grants (LGs' holders, 52.08% and SGs holders 50%). The same applied for publishing abstracts in the conferences' proceedings. Figure 2 shows that 23 LGs' holders (47.92%) published abstracts in the conferences' proceedings compared to 50% of the SGs' holders. The LGs holders have also participated in scientific seminars (25%) while the percentage of the SGs' holders that participated in the same activity were relatively (50%) greater than the participation of the LGs' holders. The number of researchers who reported the application of their recommendations were 23 resulting from LGs' and one from SGs. In regards to the agriculture discipline. Figure 2 indicates that it ranks last in terms of total received large and small grants (23 and 10 respectively). The total number of published papers was 34 papers, 24 of which were from LGs and 10 from SGs. Only 37.5% of the LGs' published papers were in impact factor journals with none being published from SGs. The number of citations for the published papers in general was 28 citations 8 of which were for the published work of the SGs. A total of two patents were produced from the LGs. The percentage of large and small grants' holders who participated in conferences was 42.42% and less than that participated in scientific seminars (27.27%). Ten researchers from the LGs reported applications of their recommendations that resulted from their research results while only three researchers holding SGs reported the same. Over all, the 311 large and small grants resulted in a total 421 published papers of which only 40.38% were published in impact factor journals. The published works have been cited 1389 times. Additionally, there have been 27 patents resulting from LGs and only 3 patents from SGs. Of total researchers responding to the survey, 140 participated in conferences and 76 participated in scientific seminars. The number of published abstracts in conferences' proceeding was 131 abstracts. Only 119 researchers reported the application of recommendations that resulted from their scientific work show the relationship between funded research outcomes and amount of funding. Figure 3 shows that the health discipline received the most funding of both types of grants (40.19%). The engineering discipline was the second (25.96%), science the third (22.49%) and last was the agriculture discipline with 11.36% of the total amount of funding. In each discipline, the amount of funds of the small/large grants is less than the total amount of the large grants. In the engineering discipline, the small/large grants represent only 1.06%. Similarly, the proportions of the small/large grants in the other fields or disciplines are 5.00, 5.79, and 12.57% for agriculture, health and science disciplines respectively. Over all, the small grants of all disciplines represent only 5.85% of the total funds of the large grants of the

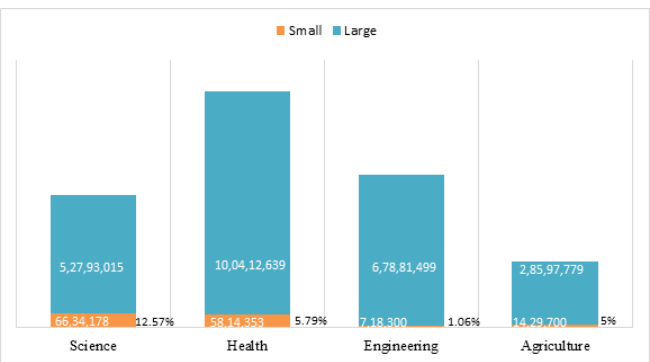


Figure 3: The amount of fund for small and large grants across disciplines.

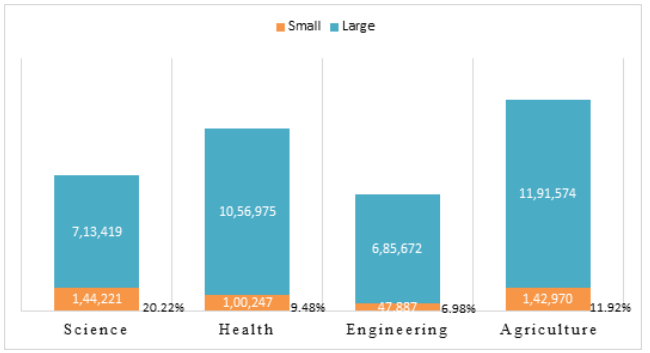


Figure 4: Cost of a publishing a paper across disciplines (cost/paper).

disciplines. Figure 4 shows that the average cost of one published paper in the agriculture discipline is 1,191,574 SR as based on the total amount of funds that have been submitted for the LGs of the discipline (28,597,779 SR). Conversely, the average cost of the published paper from the SGs was only 142,970 SR. Not only that but also it is clear that the cost per paper produced from the LGs in the agriculture discipline is greater than any other cost of the papers produced by any other discipline. Similarly, the cost of the produced paper from the SGs of the agriculture discipline comes second after the cost of the paper produced from science discipline SGs. The order of the highest to lowest cost of the produced paper resulting from disciplines' LGs is agriculture, health, science and then engineering (Figure 4). The order of the cost of the produced paper from SGs of the disciplines from highest to lowest is science, agriculture, health, and then engineering. Similarly, Figure 4 shows that the percentages of the average cost of the published papers from the SGs of the disciplines were 6.98, 9.48, 11.92, and 20.22% from that of the LGs of the engineering, health, agriculture, and science disciplines respectively. The overall average cost of the published papers from the SGs was only 13.23% of that of the LGs. However, the average cost of the patent produced from the LGs (9,247,590 SR) is greater than that of the patent produced from the SGs (4,865,510 SR). The cost of the patent produced from SGs represents 52.61% of that produced from LGs.

Discussion and Conclusion

This study does not aim to provide thorough statistics regarding all funds provided by KACST since its establishment nor the complete outcomes of those funds. Rather it is aims to assess the difference in outcomes between large and small grants. Thus, the question that should be answered is which type of grant is more effective in

producing outcomes with better quality. The quality is represented by the number of publications and type of the journal used for publishing, number of citations achieved, number of patents produced, number of participations in conferences and seminars, in addition to the number of published abstracts, and the applications of the results recommendations. The results indicate that the very well-established universities such as KSU, KAU, and KFUPM were the leaders in receiving most of the funds and therefore have the most outcome of the research such as producing published papers and patents. These three universities have gained almost 59.53% of the LGs and 38.54% of the SGs. The number of the published papers of the same universities composed 66.78% of the total published papers from LGs and 32.56% of the total published papers from the SGs. The average cost of a single published paper was calculated as the total funds received by the total number of grant type divided by total number of published papers. In other words, if the total number of SGs, which is 96 grants, has produced 129 papers and the total cost of these grants was 14,596,531 SR, then average cost of the produced paper would be (14,596,531/129) which equals to 113,151 SR. On the other hand, the average cost of the published papers from LGs would be (249684932/292) and equals to 855,085 SR. Of course, the cost of the paper produced from LGs is higher than that produced from SGs. The SGs are more productive because the percentage of the produced papers is 134.38% of total funded projects. On the other hand, the percentage of the produced papers from the LGs is only 135.81% of the total funded projects. The difference is very small and negligible between the two types of grants though the cost of the produced paper from LGs equals 7.56 times of that produced from SGs. More than that most of the published papers from SGs were published in impact factor journals (51.16%) as compared to that published (35.62%) from the LGs. In addition to that, KFUPM alone produced 16 patents, which represents 53.33% of the total patents that have been produced from all grants. These figures might allow us to bring to attention that LGs are more promising in patents production than SGs, since all KFUPM funded projects were LGs. These results match with previously cited research such as Payne and Siow. This indicates that LGs apparently are more effective than SGs in terms of number of produced patents. In general, variance in publishing and patents number and quality from both types of grants is greatly affected by the disciplines of the researchers. For instance, researchers in the health discipline have more outcomes than science, engineering and agriculture. They filed 10 patents seven of which were from LGs and 3 from SGs. The discipline also has greater percentage of participation in conferences especially by the SGs holders (60%) as compared to their colleagues of the LGs' holders (38.82%). Also, the trend in publishing in impact factor journals is the same as it was found in overall publications; that is the SGs surpass the LGs in publishing in impact factor journals but in terms of just the total number of citations the LGs surpass the SGs. In sum, it is recommended that future funds should be based on more strict regulations and standards. We also recommend that data coming out of the grant awarded projects should be clearely filed in so that more productive studies could be done to help improve future funds. We strongly recommend conducting a study that identifies the determinants of KACST research outputs, and how to use those determinants in the decision-making regrading funding research projects. This could help in making future monitoring of funding and the over all productivity outcome.

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