Development of Key Performance Indicators and Impact Assessment for Research and Development (R&D) Sector in Palestine

Rabeh Morrar[1]

Abstract

We empirically address the determinants of R&D performance in Palestinian R&D institutions using Ordinary Least Square (OLS) regression analysis. The results show that the number of technicians holding a Ph.D. degree is one of the most significant determinants of R&D outcomes measured by the number of research studies. We found that the increase in the number of researchers with a master degree negatively impact the research outcomes. One of the important results is that part-time researchers have better research performance than full-time researchers. Meanwhile, we find very weak performance of R&D sector in regards with patents, national and international prizes. We found that the funding mechanism for R&D in Palestine to be inefficient; neither of the research fund sources have an impact on the number of research studies (basic, applied or experimental research). Finally, we discover no crowding-out effect from government funding and funds from NGOs to private investment.

Keywords: R&D, R&D management, R&D crowding out, basic research, applied research, Innovation.

Introduction

It becomes clear that the economic growth of any country based on the strengthen of its education system, innovation performance and its ability to compete. Research and Development (R&D) sector becomes the

[1] Assistant Professor, Economic Department, An-Najah National University, Palestine.
E-mail address: Rabeh.morrar@najah.edu

cornerstone in the flow of innovation and the increase of competitiveness in modern economics in the era of globalization and openness. It is also critical to enhance the economic growth and contribute to improving the standards of living and social welfare in both advanced and developing countries.

In Palestine, educational and economic situations are constrained or governed mainly by the political situation. Palestine is an isolated and geographically divided country, and its resources are controlled and its economy is dependent on the occupation. As a consequence, the Palestinian economy is weak, unsustainable and mainly dependent on donations. However, Palestinians in the past decades have invested remarkably in human capital through education and career professionalism. Palestine is a young nation, where a large portion of the population is young and under fifteen years old. In 2016, this portion was 36.8% in the West Bank and 42.7% in Gaza (PCBS, 2016). Palestinian businesses have a reputation for professionalism and product quality. Moreover, the challenge to the occupation and the imposed hard living conditions have created a resilient, determined and innovative Palestinian community. Consequently, more and more well-educated and passionate young people are turning to entrepreneurship as a means to create their own job opportunities and improve their communities. Numerous organizations are emerging to support this trend, and many of these businesses address local gaps and needs within the community. Combined with exceptional technical talent, Palestinian entrepreneurs are the key to advancing economic development.

R&D sector in Palestine has gradually shed more attention from researchers and policy makers in both private and public sectors, despite the fact that it is still not translated into policies and acts. This is consistent with increasing debate focusing on R&D, technology and innovation development at regional and international levels mainly to face the fast growth of globalization and competition.

Like any other economic activity in Palestine, R&D activities are affected highly by the existing political and economic instability mainly due to the Israeli occupation, which sharply influences the business environment and makes the Palestinian economy unattractive for both local and foreign direct investment. Also, the Palestinian industrial sector grows slowly (shrinking for some years) and Palestinian people still mainly depend on imports for most of their goods and services. Despite the increasing concern

about the importance of R&D for economic development by different stakeholders in Palestine – as indicated by the increasing in the number of scientific publications in the Palestinian universities, participation of Palestinian researchers in local and international conferences– the R&D sector still remains very small, new and not in the agenda of public policies and not on top priority for private institutions. This reality is manifested in various R&D indicators.

Previous literature found a link between R&D and the economic development at micro (firm) and macro levels, and also that R&D stimulus patents, and the number of publications and innovations (Bound, Cummins, Griliches, Hall, & Jaffe, 1984; Griliches, 1984; Hall, Griliches, & Hausman, 1986). This work explores the determinants of R&D performance and studies the outcomes of R&D activities in term of the number of research, patents, prizes and honors in the Palestinian non-private institutions. It also explores whether public funding for R&D crowds out private funds. Before the estimation of previous relationships using econometric models, using descriptive statistics, the performance of R&D in Palestine based on different indicators is diagnosed. In the first, a survey of the literature about R&D in Palestine and the world is presented. In the second part, the performance of the R&D sector in Palestine in regards to a set of indicators is described. In the third part, the methodology for finding the determinants of R&D in terms of total number of researches and investigating the impact of R&D on patents, national and international prizes is shown. Also, the methodology for testing if the private fund crowding out the public R&D fund is described. The fourth part includes the main results of the empirical models and the conclusion.

1. Literature review

Many of the previous literature have confirmed on the role of innovation and technological revolution, driven by R&D on the economic growth and welfare of society. Forced by openness and international competition, many firms have adjusted their development strategies based on R&D globalization.

Frascati Manual (OECD, 1993, paragraph 57) defined R&D as follows: “Research and experimental development (R&D) compromise creative work undertaken on a systematic basis in order to increase the stock of

knowledge, including knowledge of man, culture, and society, and the use of this stock of knowledge to devise new applications". He classifies R&D into "basic research, applied research, and experimental development". Basic research denotes the theoretical work which explores new knowledge about a phenomenon without any application works. Applied research is oriented to obtain new knowledge on a specific or particular objective. While the experimental development is the systematic development of new material or products based on the knowledge obtained from research and particular experiment, new processes, systems, and services. It improves the substantiality of the existing products and services. Khurana (2006) provide that the definition of R&D includes six types of R&D activities: basic and applied research, new product development (NPD), extension of an existing product, product support engineering, and process engineering. Basic and applied research are classified as "research" and the other four as "development." Djellal, Francoz, Gallouj, Gallouj, & Jacquin (2003) introduced a distinction tool between R&D and other related activities; R&D necessarily includes "an appreciable element of novelty and the resolution of scientific or technological uncertainty".

The economic consequences of R&D at the macro and micro level have long been empirically explored by researchers since the 1960s (Mansfield, 1962; Griliches, 1984; Edquist, 2000). Sandu and Modoran (2008) study the influence of R&D on the development of the economic productivity of Romania between 1996 and 2006 using total factor productivity as an indicator. They found a negative influence of government R&D investments on the growth of the total productivity. Meanwhile, a highly significant positive influence is found for private R&D investment. Sakurai, Joannidis, & Papaconstantinou (1996) estimate the effect of R&D on the economic performance of 10 OECD countries using a pooled regression model and total factor productivity as an indicator for economic performance. Results indicate that R&D variables (direct and indirect R&D) have positive rate of return. Johansson and Lööf (2008) using a sample of 1767 manufacturing firms in Sweden, investigated the impact of R&D on the productivity and profitability at firm level. They reveal that firms with persistent R&D activities have more productivity compared with firms with occasional R&D.

Regarding cooperation for R&D, previous literature discuss the role of

inter-firm partnership on the ability of firms to improve their learning and knowledge absorption (Gulati, 1995, 1997; Uzzi, 1997, Morrar, 2011; Morrar, Gallouj & Hammadou2012). Hagedoorn, Frankort, & Letterie (2006) explore the impact of knowledge flows in inter-firm R&D networks for 152 ICT companies in Netherland between 1975-1999. They use patent citations as a proxy to measure the flow of technological knowledge between firms with common R&D projects, finding that R&D networks efficiently foster the mutual flow of knowledge between partners. Lopez (2008) found that the main motivation for R&D cooperation is to share cost and risk.

In literature, more than one indicator is used as a proxy for R&D outcomes, for example, number of patents, new product development, number of publications, and number of citations. Bogner and Bansal (2007) as well as Cardinal and Hatfield (2000) find that firms' ability to generate inventions measured by patents is positively related to R&D spending. Hagedoorn and Duysters (2002) find a significant relationship between R&D and patents in computer industries, and Ahuja and Katila (2001) find the same outcome in chemical industries. Peeters and De la Potterie (2006) found that the firms which implement more basic and applied research experience more patents and find a positive impact of R&D expenditure in the patent. Kendall, Patricia, Donald, & Cardinal (2010) find that the R&D spending is positively correlated with both patents and product innovation. Meo and Usmanit (2014) found that the investment in R&D in European countries lead to a high rates of scientific progress and research outcomes. In another studies, we find that R&D spending has negative influence on number of inventions (Acs and Audretch, 1990; Adams and Brock, 1986).

There is no one opinion if the public fund for R&D crowds out private fund or not, it is controversial issue in many of the previous related theoretical and empirical works. Diamond (1998) find a 1.04 coefficient of additionality for federal basic research funding on the private funding in US macro time series data between 1953-1993. Guellec and De la Potterie (2003) found a 0.08 coefficient of additionality for public funding on business funded research in 17 OECD countries between 1981-1996. Görg and Strobl (2007) find a negative coefficient of additionality of large public grants on private R&D investment for Irish manufacturing firms, and positive additionality effect for the small public fund. Economic Insight

(2015) studies how much the private investment in R&D is triggered by the public investment at both macro and micro level analysis in the UK. They find a crowding-in effect of public expenditure on R&D, which means that increasing of public R&D expenditure on private R&D investment.

In Palestine, the studies about R&D and innovation are limited (El-Jafari, Abu Hantash, & Al-Haj Ali, 2008; Morrar and Gallouj, 2016; Morrar and Abdelhadi, 2016, Morrar, Arman, & Mousa, 2017; Morrar, Haj Hamad, & Arman). El-Jafari, Abu Hantash, & Al-Haj Ali (2008) are one of the first authors in Palestine who discussed R&D activities in the Palestinian private sector based on two questionnaires: one is for the R&D providers and the second is for the beneficiaries using the research. They classify R&D providers into "research centers in Palestinian universities, specialized local research institutions, ministries of the Palestinian National Authority, the General Federation of Palestinian Industries, Pal-trade, and unions of specialized industries (mines, paper, pharmaceutical, food, IT systems, etc.)". This study reveal that the institutional use of R&D is determined by the level of private sector involvement and persuasion of research, the potential return on R&D investment, the selection of qualified research team, R&D budgeting and allocation method, and the availability of equipment (used in R&D).

Morrar and Gallouj (2016) investigated the performance of Palestinian R&D sector between 1995 and 2009. They found that until recently (mid-1990s), the R&D sector either did not exist or was very small. They also found that the performance of the R&D sector was very low in comparison to other service sectors in most of the performance indicators used. For example, in 2009 the value added of the R&D sector represents only 0.36% of the total value added of the service sector. Output contributes to 0.32%; it employs only 0.19 of the total employees in the service sector and only 0.05% of the total service firms. They find that the information and communication technology firms are the highest in R&D activities (32%), followed by financial intermediation with 21%. of the percentage of Palestinian industrial firms which implement R&D activities is very low with only 1.6%.

2. The main R&D indicators in Palestine

R&D activities in Palestine are affected highly by the political and economic instability that exists mainly due to the Israeli occupation that sharply influences the business environment and makes the Palestinian economy unattractive for both local and foreign direct investment. The Palestinian industrial sector grew slowly in the last 20 years and Palestinian people still mainly depend on imports for most of their goods and services. Despite the increasing concern about the importance of R&D for economic development by different stakeholders in Palestine, R&D sector is still very small, new and does not shed enough concern by both private and public sectors in Palestine. This reality is manifested in various R&D indicators.

In the 2013, R&D survey implemented by the Palestinian Central Bureau of Statistics (PCBS), R&D personnel into: (1) researchers who are directly involved in R&D activities, including PhD students and persons who introduce indirect service like general service employees and skilled staff. (2) Administrators who are engaged in the management and administration of a business, such as managers, accountants, administrative staff. (3) Technicians and equivalent. (4) and finally the support staff like secretarial and clerical staff, and craftsmen who participating or directly associated with R&D projects.

Table 1 below shows that in 2013, only 8,715 employees were in the R&D sector in Palestine, amongst which the 4,533 researchers showed a distribution of 3,510 male and 1,023 female. Only 2,492 researchers were with full-time equivalent (FTE), which means that the number of researchers with FTE per million of inhabitants is only 566. The total expenditure on R&D per researcher with FTE is about 24,600 US dollars. It is important to denote that these figures and data do not include R&D personnel in the private sector because the survey was oriented to the non-private sector (governmental, NGOs and higher education institutions), which is one of the limitations of this study.

Table 1: Main indicators for R&D in Palestine in 2013

Indicator	Number/Value
R&D Personnel	8,715
R&D Personnel with Full-Time Equivalent (FTE)	5,162
Researchers in R&D	4,533
Researchers (Males) in R&D	3,510
Researchers (Females) in R&D	1,023
Researchers in R&D with FTE	2,492
Researchers in R&D with FTE per Million Inhabitants	566
Total expenditure on R&D (USD 1000) per Researcher with Full-Time Equivalent (FTE)	24.6

Source: PCBS (2013), PCBS (2014).

R&D personnel is distributed in different Palestinian sectors as following: 2,873 persons (33%) in the governmental sector, 1,148 (13%) in non-governmental organizations, and 4,694 (54%) in higher education institutes (Table 2). Numbers denote that the majority of R&D personnel are employed in the higher education institutions. This is expected, knowing that Palestine includes more than 29 universities and community colleges in the West Bank and Gaza with 7,000 faculty members; 3,000 are Ph.D. holders in different disciplines. Numbers in Table 2 may be misleading; they exaggerate the R&D activities in the governmental sector since there are no real public R&D institutions. This might be mainly impeded by the methodology of the R&D survey in Palestine mentioned earlier. Thus, we expect that R&D personnel in the governmental sector are mainly providing an indirect R&D service such as coordination, management and administration services, laws and regulations, and funding issues.

Table 2: R&D personnel in Palestine by sector of employment and gender, 2013

Sector of employment	Total	Gender	
		Male	Female
Governmental	2,873	2,103	770
Non-Governmental Organizations	1,148	729	419
Higher Education	4,694	3,714	980

Source: PCBS (2013), PCBS (2014).

Researchers in R&D in Palestine are distributed in all academic fields and disciplines (Table 3). Humanities and social sciences have the highest ratio of R&D researchers with 34.2% and 27.7%, respectively. This might be explained by the high demand for such research disciplines by local and international NGOs which have intensively studied the Palestinian social, political and economic situations over the last three decades in order to allocate their fund resources. Therefore, we find many NGOs in Palestine specialized in producing research and consultancy in political sciences, political economic, social sciences. Also, humanities and social sciences in universities are among the oldest disciplines. Medical sciences, engineering & technology have a low rate of employment of researchers in R&D, which might be contributed to by the novelty of these fields in Palestine and due to more than 40 years of occupation of the Palestinian territories. Amongst the 8,715 R&D personnel in Palestine, only 4,533 (52.5%) are researchers in R&D, 2,113 (24%) are administrators, 1,276 (14.5%), and 793 (9%) are in other related activities.

Table 3: Researchers in R&D in Palestine by academic field, 2013

Academic field	Percentage	No. of Researchers
Physical Sciences	16.5	749
Engineering & Technology	11	494
Medical Sciences	5.8	265
Agriculture Sciences	4.8	219
Social Sciences	27.7	1,255
Humanities Sciences	34.2	1,551

Source: PCBS (2013), PCBS (2014).

3. Methodology and data

Here, we use a quantitative analysis (econometric approach) to trace the determinants of R&D performance in the Palestinian R&D institutions. Performance outcomes are tracked for a sample of 87 institutions in 2013. The model for estimating this relationship should take into account that the relationship between R&D expenses and its outcome is a multi-dimensional process which must be understood from multiple perspectives. Therefore, the outcome of R&D is measured by a set of indicators like the number of researches, patents, prizes from national and international parts. Also, R&D activities are measured through a large set of variables.

We use a simple process of analysis depending on the multiple regression approach and cross-sectional data, taking into account the problems of multicollinearity, normality, and autocorrelation. The econometric equation is as follows:

$$Num\_Research = B_0 + B_{0*}TOT\_exp + B_{0*}MA\_researcher + B0*PhD\_researcher + B0*MA\_Tech, B0*PhD\_Tech + B0*MA\_admin + B0*PhD\_admin + B0*FTE\_90 + B0*FTE\_70 + B0*FTE\_50 + e_i$$

Where:

Num_Research is the dependent variable and denotes the total number of research and represents the performance of the R&D sector.

Regarding the dependent variables:

- TOT_exp is the total expenditure on R&D activities inside the institutions;
- MA_researcher is the number of researchers in the institutions holding master degree;
- PhD_researcher is the number of researcher holding Ph.D. degree;
- MA_Tech is the number of technicians holding master degree;
- PhD_Tech is the number of technicians with Ph.D. degree;
- MA_admin measures the number of administrators holding master degree;
- PhD_admin represents the number of administrators holding Ph.D. degree;
- FTE_90 is the number of researchers with 91%-100% full-time equivalent;
- FTE_70 is the number of researchers with 71%-90% full-time equivalent;
- FTE_50 is the number of researchers with 51%-70% full-time equivalent.

Because R&D is a multidimensional construct, three other R&D performance indices will be employed in this study: patents, national prizes for researchers and inventors, and international prizes for research and inventors. Each one of them will be considered as the dependent variable and will be regressed separately against three main variables: the total number of researches, total expenditure on R&D and the total number of researchers.

In the second part of this work, we measure the efficiency of fund structure for each type of research (basic research, applied research, and experimental research). In other words, we test the significance of each research fund on the number of produced research studies in basic research, applied research, and experimental research. It is important to reveal the most efficient funding mechanism for each type of research. Here we also use a simple methodology depending on multiple regression analysis.

The econometrics model for basic research, applied research and experimental research are given consequently as follows:

$$Basic\_Res = B_0 + B_1 * fund\_HE + B_2 * fund\_Gov + B_3 * fund\_NGO + B_4 * Fund\_priv + B_5 * fund\_aborad + B_6 * fund\_self + B_7 * Num\_researcher + B_8 * TOT\_exp + I$$

$$Applied\_Res = B_0 + B_1 * fund\_HE + B_2 * fund\_Gov + B_3 * fund\_NGO + B_4 * Fund\_priv + B_5 * fund\_aborad + B_6 * fund\_self + B_7 * Num\_researcher + B_8 * TOT\_exp + I$$

$$Experm\_Res = B_0 + B_1 * fund\_HE + B_2 * fund\_Gov + B_3 * fund\_NGO + B_4 * Fund\_priv + B_5 * fund\_aborad + B_6 * fund\_self + B_7 * Num\_researcher + B_8 * TOT\_exp + I$$

Where:

- Basic_Res is the number of researches in basic science;
- Applied_res is the number of researches in applied science;
- Experm_Res is the number of researches in experimental science;
- fund_He is the percentage of funds from higher education enterprises;
- fund_gov is the percentage of funds from government enterprises,
- fund_NGO is the percentage of funds from non-profit nterprises;
- find_priv is the percentage of funds from private enterprises;
- fund_abroad is the percentage of funds from abroad,
- fund_self is the percentage of funds from self;
- num_researchers is the total number of researchers;
- Tot_exp is the total number of expenditures on R&D.

Another important estimation implemented here is whether other sources of R&D funding institutions (public fund, higher education institution, NGOs) are crowding-out private funding or not. In other words, we see if the funds from government, NGOs, and higher education institutions negatively affect the propensity of private firms to spend money on R&D activities.

A simple regression model will be estimated for private funding against each other type of funding, as follows:

$Priv\_fund=B_0+B_1* HE\_fund +e_i$

$Priv\_fund=B_0+B_1* Gov\_fund +e_i$

$Priv\_fund=B_0+B_1* NGO\_fund +e_i$

Such that:

Priv_fund is the % of funds from private enterprises; HE_fund is the % of funds from higher education; Gov_fund is the % of funds from the government; NGO_fund is the % of funds from nonprofit institutions.

We use a cross-sectional data to answer the main inquires in this study, which is provided by the Palestinian Center Bureau of Statistics. In 2014, PCBS implemented the R&D survey which covers the R&D activities in R&D institutions during 2013[2]. The sample was limited with institutions with material R&D expenses, i.e. which implement R&D activities and expense. This provides a sample of 143 institutions including higher education institutions, non-profit organizations, and government institutions. The response rate is 79% of the institutions, over-coverage was 15%. Weights and adjusted weights are calculated for each sampling unit and designed to reflect the sampling procedures and to reduce the bias resulting from non-responses and also to take account of changes since the Establishments Census 2012 is conducted. Thus, a sample of 87 firms is obtained to implement this study.

4. Results

In Table 4 below, the analysis shows that the number of technicians holding Ph.D. degrees is one of the most important variables that are

[2] R&D survey 2013 is the third round conducted by PCBS, which aims to provide up to date statistical indicators on research and development in all institutions engaged in research and development. It also assesses key aspects of knowledge accumulated regarding financial and human resources and the outputs of research. As there are no clear differences and borders between research and development activities in Palestine, the mentioned survey considered studies and consultations as part of R&D and its activities; the number of studies and consultations, staff, and expenditures are included.

responsible for research generation in the Palestinian R&D institutions. An increase by one in the technicians holding Ph.D. degrees will lead to an increase by 8.65 in the number of researches, which might be explained by the fact that Ph.D. technicians are mainly working in scientific fields like physics, chemistry, engineering, pharmacy and medicine, which are considered very productive in the Palestinian higher institutions compared with social sciences and arts.

Also the increase in the number of researchers holding a Ph.D. degree will positively affect the performance of R&D institutions measured by the number of researches introduced, i.e. an increase by one in the number of Ph.D. holders leads to only an increase of 0.61 in the number of R&D researches. The low productivity of Ph.D. holders can be related to the fact that a large percentage of Ph.D. holders mainly in the higher education institutions do not engage in research, due to the lack of research fund or motivations from the university or other sources of funding. This is clear in the social sciences and art faculties which are less productive in R&D than life sciences and engineering.

One of the unexpected results is the negative influence for the master degree researchers on the number of researches conducted in the Palestinian R&D institutions. This reflects a kind of diseconomies of scale in the number of researchers holding a master degree, which might be explained by the weak research performance of master degree holders who mainly graduated from local higher education institutions with weak research skills and capabilities. Also, many master researchers are mainly working as assistants for Ph.D. researchers and Ph.D. technicians with more administrative tasks and routine works.

Table 4 also shows that there is no positive advantage for full-time researchers over part-time researchers. For example, the number of researchers with 51% to 70% full-time equivalent shows better research performance than full-time researchers (number of researchers with 91-100% full-time equivalent). This might be explained by the fact that most researchers in higher education institutes are not full-time researchers; they have teaching and administrative tasks instead of research activities, which is also true for public institutions and NGOs.

Table 4: Determinants of R&D performance measured by total number of research

	Dependent variable	
	Total # of research	
	Coefficient	Sig.
(Constant)	*3.68	0.05
Total Expenditures	1.51E-06	0.21
#of Researchers, Master	***-1.08	0.00
#of Researchers, Ph.D.	***0.61	0.00
#of Technicians, Master	0.84	0.45
#of Technicians, Ph.D.	***8.65	0.00
#of Researchers, 91%-100% FTE	***0.22	0.006
#of Researchers, 71%-90% FTE	0.22	0.42
#of Researchers, 51%-70% FTE	***0.73	0.00
#of Administrators, Master	-0.55	0.17
#of Administrators, Ph.D.	-0.10	0.89
R^2	0.895	0.000
Adjusted R-squared		0.88
D.W	2.08	

Sig. at 0.01 ***, Sig. at 0.05**, Sig. at 0.10*.

Moreover, in Palestine, much of R&D research studies are consultations, reports, etc. The results show that the number of R&D researches positively influences the number of patents that R&D institutions can obtain, but the slope coefficient is very small; a one thousand increase in R&D research achieves only two patents. The same result is true for the number of R&D researchers; it has a positive impact on the number of patents, but a one thousand increase in the number of researchers will lead into one patent only. This clearly shows the inefficiency and low quality of research in Palestine and the disconnection between research outcomes, innovation, and reality. Many of the R&D research studies in the universities are not applied research but mainly for academic objectives in order to ascend in the promotion degree.

The total R&D expenditure has no significant impact on the number of

patents, which denotes that the R&D expenditure is misallocated, fragmented and not connected to an R&D, innovation and development plan. Researchers at the university who are responsible for a high percentage of R&D activities are obtaining little funding for their R&D activities from their institutions. According to the data, the average R&D expenditure in government institutions is US$ 987,412 but the average number of research studies is only 19, while the average expenditure in higher education institutions is US$742,994 and the average number of research studies is 111. This reality also reflect on the patents.

The results in Table 5 also denote that, except for the relationship between total R&D research and international prizes, we find that the total R&D research, the total R&D researchers, the total R&D expenditure are all not efficient in regards with national and international prizes for researchers and inventors. This explains the disconnection between the R&D research system and research awards.

Table 5: Determinants of R&D performance represented by patents, national and international prizes

	Dependent variable					
	Patents		**National prizes for researchers and inventors**		**International prizes for researches and inventors**	
	Coefficient	**Sig.**	**Coefficient**	**Sig.**	**Coefficient**	**Sig.**
Constant	-.037-	.395	.632	.069	.274	.154
Total number of researches	**.002	.009	.010	.071	***.010	.002
Total expenditures on R&D	1.977E-9	.930	-7.124E-8	.69	3.403E-8	.73
Total number of researchers	***.001	.028	.004	.47	.002	.55
R^2	0.45	0.00	0.175	0.00	0.334	0.00
Adjusted-R^2	0.42		0.145		0.31	
Durbin Watson	1.77		2.15		2.09	

Sig. at 0.01 ***, Sig. at 0.05**, Sig. at 0.10*.

In many countries, public sector is the main sponsor for basic research because the private sector is not concerned with financing raw knowledge, novel ideas, theories, and prototypes which have no immediate commercial use. On the other hand, applied research is primarily implemented by private firms, which convert basic research into new products (Gersbach, Sorger, & Amon, 2009).

As mentioned earlier, research is classified into three main types – basic research, applied research and experimental research – and the efficiency of the research fund structure for each type is studied. In other words, the investigation is whether the R&D fund structure in Palestine is efficient for each type of research.

Table 6 shows that regarding basic research, none of the fund sources are efficient. In other words, the increase in the percentage of funding from the government, higher education, the private sector, NGOs, abroad and self-funding will not improve the performance of basic R&D research activities. This might be explained by the fact that basic R&D research studies are mainly implemented in higher education enterprises which are mostly not funded and are mainly for the promotional purposes of academic staffs. Results also show that the total number of researchers has a positive impact on the number of basic R&D researches. This reality might be explained by the fact that around 50% of workers in R&D are in higher education institutes which mainly yield basic R&D research. Finally, none of the research fund sources are efficient in the case of applied and experimental research. Only the total R&D expenditure is effective in experimental research.

Table 6: The relationship between research funding and research performance measured by number of basic, applied, and experimental researches

	Dependent variable					
	Number of researches in basic research		Number of researches in applied research		Number of researches in experimental research	
	Coefficient	Sig.	Coefficient	Sig.	Coefficient	Sig.
(Constant)	-8.19	0.75	1.17	0.97	-8.04	0.40
% of Funding from Higher Education	0.28	0.43	0.25	0.58	0.19	0.15
% of Funding from Government	0.018	0.94	-0.07	0.83	0.05	0.56
% of Funding from Non-Profit Enterprises	0.10	0.70	0.001	0.99	0.08	0.39
% of Funding from Private Enterprises	0.21	0.58	0.26	0.59	0.15	0.26
% of Funding from Abroad	0.10	0.70	0.06	0.85	0.10	0.30
% of Funding from Self	0.09	0.73	0.019	0.95	0.16	0.12
Number of Researchers Total	***0.31	0.00	***0.18	0.00	0.005	0.58
Total Expenditures	-6.01E-07	0.69	1.15E-06	0.55	**1.23E-06	0.03
R^2	0.698	0.0	0.35	0.0	0.19	0.02
Adjusted- R^2	0.66		0.29		0.10	
D.W	1.92		1.84		1.55	

Sig. at 0.01 ***, Sig. at 0.05**, Sig. at 0.10* .

One of the most important questions that have been asked in the literature is whether public funding and funds from NGOs crowd-out private investment in R&D. In Table 7 below, the impact of other sources of funding on private R&D investment in the private sector is investigated to see if any crowding-out effect exists. Results show that there is no crowding-out effect either from government funds or from NGO funds to

private investment. Meanwhile, the results show that funds from higher education institutions motivate private investment in R&D. This might be embedded to the development in the last years of R&D networks and collaboration relationships between the private sector and universities.

Table 7: The crowd-out effect between private and other types of fund

	Dependent variable					
	Private fund to R&D		**Private fund to R&D**		**Private fund to R&D**	
	coefficient	**Sig.**	**coefficient**	**Sig.**	**coefficient**	**Sig.**
Constant	2.2	0.06	4.3	0.02	4.2	0.02
Fund from higher education institute	***0.37	0.001				
Fund from NGO's			-0.034	0.321		
Fund from government					-0.03	0.35
R^2	0.119	0.001	0.012	0.332	0.01	0.35
Adjusted- R^2	0.10					
D.W	2.175					

Sig. at 0.01 ***, Sig. at 0.05**, Sig. at 0.10*.

5. Conclusion and policy implications

The determinants of R&D performance in Palestinian R&D institutions are addressed in this study. The R&D performance index is measured by a set of indicators like number of research studies, patents, prizes from national and international bodies. The results show that the number of technicians holding a Ph.D. degree is one of the most important determinants of R&D outcomes measured by the number of research studies, i.e. one more Ph.D. technician will increase the number of researches by 8 units. However, one more Ph.D. holder only increases the number of researches by 0.66. This huge gap between technician Ph.D. holders and overall Ph.D. holders is due to how technicians mainly work in the fields of engineering, physics, chemistry, computer science, and pharmacy, which are considered highly productive in research in Palestinian

universities in comparison with Ph.D. holders in social sciences and arts. In an unexpected result, we found that the increase in the number of researchers with a master degree negatively impact the research outcomes, which might be explained by the weak performance of master students who have mainly graduated from local higher education institutions with weak research skills and capabilities. One of the important results is that part-time researchers (researchers with 51% to 70% full-time equivalent) have better research performance than full-time researchers (number of researchers with 91-100% full-time equivalent), which might be explained by the fact that most researchers in higher education institute are not full-time researchers, they also have teaching missions.

Other indicators for R&D performance such as patents, local and international prizes for R&D are regressed separately against three main independent variables: total number of research studies, total expenditures on R&D and total number of researchers. Despite the positive and significant sign for the coefficients of the two variables: number of research studies and the number of researchers, their impact on the number of patents is still very low (very low slopes). For example, the increase in the number of R&D researchers by one thousand increase the number of patents by only one. Also each one thousand of R&D researches generates only two patents. Total expenditure on R&D has no significant impact on the number of patents, which denotes that R&D expenditure is misallocated and not connected with an innovation plan.

In the second part of the empirical analysis, the funding mechanism for R&D in Palestine is inefficient; neither of the research fund sources have a significant impact on the number of basic, applied and experimental research studies. This indicates that R&D institutions in all sectors should adopt new strategies or policies of R&D funding which are linked with R&D outcomes. This reality means that the funding is increasing the number of produced research studies.

Finally, we discovered no crowding-out effect from government funding and funds from NGOs to private investment. Meanwhile, we found that funding from higher education institutes motivates private investment in R&D.

Here are some policy instruments that can be used to prompt R&D

performance and to allocate R&D resources efficiently. The very low R&D expenditure in Palestine requires a comprehensive plan for reforming and prompting the R&D sector; government subsidies should be the cornerstone of this plan. In other words, the government should use the public funding as an efficient tool to foster and prompt R&D in the private sector through. This is consistent with a key finding in this study, that public support for R&D tend to stimulate non-private R&D (private sector, universities and NGO's), which means that public fund is not substitute but complement to private R&D fund.

Policy makers should intervene to fix the system of knowledge generation and diffusion to be more productive regarding patents and innovation. For example, the government should create an awareness about R&D among different economic sectors and institutions and form a well-developed network among the various members of the R&D system which eases the flow of knowledge among them, minimizes R&D risk and ensures a market-based R&D strategy. In other words, the government role should extend beyond direct funding for educational system to enabling the linkages and enhancing the dynamism between the key members of R&D and innovation system. Also, the government should strengthen the institutional framework to protect patents and intellectual property rights, improve the business climate to attract foreign R&D investment, and to ensure the efficient allocation of R&D resources among recipients. The private sector should improve its internal R&D environment in order to create a threshold level of absorptive capacity in order to tap into the R&D activities developed by universities and public research centers, and also to create R&D-led production. Also, the development of national innovation policy is crucial to mobilize for R&D investment, coordinate between different stakeholders, and to realize efficient and effective R&D outcomes in terms of patents, new product development, new innovation, which should be reflected in more economic growth and social welfare.

While it is well-known that the master degree usually lays the ground work for Ph.D. studies and future researchers, this study found that R&D researchers in Palestine holding a master degree negatively influence R&D performance, thus indicating a need to reform the educational system in Palestinian universities. Master programs in Palestinian universities produce thousands of graduates every year, and it is necessary for these programs to

adapt a mixed method of research-based approaches and course-based (taught) approaches to ensure that the students obtain both structured course modules through lectures and seminars, and cultivate the necessary research skills to succeed in their Ph.D. and future research work.

International prizes for research and inventors are one of the important factors which motivate and inspire Palestinian researchers to proceed in R&D, but this is not the case for national prize systems for R&D. Therefore, policymakers in R&D, particularly within the government and universities, should come to view that the institutionalization of a prize system for R&D is crucial for R&D activities in Palestine; it channels R&D researchers toward valuable endeavors. Such prizes might be introduced through financial support for R&D, the incubation of R&D output into new patents and innovations, funding the participation of researchers in international conferences, direct links between R&D performance and the promotions and awards system in the universities and research centers.

Reference List

Acs, Z.j., & Audretsch, D. (1990). Innovation in large and small firms: An empirical analysis, *American. Economic Review*, 78(4), 678-690.

Adams, W., & Brock, J. (1986). *The bigness complex*. New York: Pantheon Book.

Ahuja, G., & Katila, R., (2001). Technological acquisitions and the innovation performance of acquiring firms: longitudinal study. *Strategic Management Journal*, 22, 197–220.

Bogner, C., & Bansal, P. (2007). Knowledge management as the basis of sustained high performance. *Journal of Management Studies*, 44(1), 165-188.

Bound, J., Cummins, C., Griliches, Z., Hall, B., & Jaffe, A. (1982). Who Does R&D and Who Patents? *National Bureau pf Economic Research (NBER),* Cambridge, working paper.

Cardinal, L., & Hatfield E. (2000). Internal knowledge generation: The research laboratory and innovative productivity in the pharmaceutical Industry. *Journal of Engineering and Technology Management*, 17(3-4), 247-271.

Diamond (1998). Does federal funding crowd out private funding of science. *Contemporary Economic Policy*.

Djellal, F., Francoz, D., Gallouj, C., Gallouj, F., & Jacquin, Y. (2003). Revising the definition of research and development in the light of the specificities of services. *Public policy*, 30(6).

Economic Insight (2015). What is the relationship between public and private investment in science, research and innovation? A report commissioned by the Department for Business, Innovation, and Skills.

Edquist, C. (2000). 'Systems of Innovation', invited contribution to Michie, Jonathan (ed.) Reader's Guide in the Social Sciences, *Cambridge University Press* ,Cambridge, UK.

El-Jafari, M. Abu Hantash, I., & Al-Haj Ali, S. (2008). The role of R&D in enhancing the competitiveness of Palestinian private sector. *Palestinian Economic Policy Research Institute (MAS)*.

Gersbach, H., Sorger, G., & Amon, C. (2009). Hierarchical growth: Basic and applied research. CER-ETH Working Papers 118, CER-ETH—*Center of Economic Research at ETH Zurich*.

Görg, H. & E. Strobl (2007). The effect of R&D subsidies on Private R&D. *Economica*, 74, 215- 234.

Griliches, Z. (1984). Some empirical findings: Comment. *R&D and Innovation.* In Griliches, ed., 94-148.

Guellec, D., & De la Potterie, B.V. (2003). The impact of public R&D expenditure on business R&D. *Economic of Innovation and New Technology*.

Gulati, R. (1995). Social structure and alliance formation: A longitudinal analysis. *A dministrative science quarterly*, 40, 619-652.

Hagedoorn, J., & Duysters, G. (2002). The effect of mergers and acquisitions on the technological performance of companies in a high-tech environment. *Technology Analysis & Strategic Management,* 14, 68–85.

Hagedoorn, J., Frankort, H., & Letterie, W., (2006). Knowledge flows in inter-firm R&D networks. Department of organization and strategy, Maastricht University.

Hall, B. H., Griliches, Z., & Hausman, J. A. (1986). Patents and R&D: Is There a Lag? *International Economic Review*, 27(2), 265-83.

Helpenny, D., Burke J, McNeill, G., Snow A, & Torreggiani, W.C. (2010). Geographic origin of publications in radiological journals as a function of GDP and percentage of GDP spent on research. *Academic Radiology*, 17(6):768–71.

Johansson, B., & Lööf, H. (2008). The impact of firm's R&D strategy on profit and productivity. *CESIS Electronic Working Paper*, No. 156, CESIS.

Khurana, A. (2006). Strategies for global R&D. *Research Technology Management*, 49(2), 48-57.

Kendall, W., Patricia, M., Donald, E., & Cardinal, L. (2010). A longitudinal Study of the Impact of R&D, Patents, and Product Innovation on Firm Performance. *Journal of Product Innovation Management*, 27, 725-740.

Lopez, A. (2008). Determinants of R&D cooperation: Evidence from Spanish manufacturing firms. *International Journal of Industrial Organization*, 26 (1), 113136.

Mansfield, E. (1962). Entry, Gibrat's law, innovation, and the growth of firms. *The American Economic Review*, 52 (5), 1023–1051.

Meo, S., & Usmani, A. (2014). The impact of R&D expenditures on research publications, patents and high-tech exports among European countries. *European Review for Medical and Pharmacological Sciences*, 18(1), 1-9.

Morrar, R., Gallouj, F., & Hammadou, H. (2012). Public-private innovation networks and innovation activities in French service firms. *Journal of Innovation Economics & Management*, 2, 191-217.

Morrar, R. (2011). *Public-private innovation network in services*. Ph.D. Thesis, Lille 1 University, France.

Morrar, R., & Gallouj, F. (2016). The growth of the service sector in Palestine: the productivity challenge. *Journal of Innovation Economics & Management*, 1, 179-204.

Morrar, R., & Abdelhadi, M. (2016). Obstacles to innovation and innovation capabilities in knowledge intensive business service sector in Palestine. *Journal of Inspiration Economy*, 2, 53-64.

Morrar, R., Arman, H., & Mousa, S., 2017. The fourth industrial revolution (Industry 4.0): A social innovation perspective. *Technology Innovation Management Review*, Vol. 7, Issue 10.

Morrar, R., Haj Hamad, H., & Arman, H. (2018). Can the Triple Helix Model be the Champion for Innovation in the Countries with Low Private R&D Spending? Evidence from the Palestinian Industrial Sector. *35th IARIW General Conference*, Copenhagen, Denmark, August 20-25, 2018.

OECD (1993). Proposed standard practice for surveys of research and experimental development. Frascati Manual, OECD, Paris, Fifth Edition.

PCBS (2007). Information and communications technology statistics in the Palestinian Territory, Ramallah - Palestine.

PCBS (2013). Database of Establishments Census 2012, Ramallah, Palestine.

PCBS (2014). R&D survey report between 2008-2014, Ramallah, Palestine.

PCBS (2016). Palestinians at the End of 2016, Ramallah, Palestine.

Peeters C. & De la Potterie, B. (2006). Innovation strategy and the patenting performances of large firms. *Journal of Evolutionary Economics*, 16(1-2), 109-135.

Sakurai, N., Ioannidis, E., & Papaconstantinou, G. (1996). The impact of R&D and technology diffusion on productivity growth: Evidence from 10 OECD countries in the 1970s and 1980. Working Papers, 2, Directorate for Science, Technology, & Industry, OECD, Paris.

Sandu S., & Modoran C. (2008). The impact of R&D investment on productivity, investment and innovation: An analysis of spill-over channels". In: Annales Universitatis Apulensis, *Series Oeconomica*, 2(10), IDEAS, RePEc.

Tsai, k. (2005). R&D productivity and firm size: A nonlinear examination. *Technovation*, 25 (7), 795-803.

Uzzi, B. (1997). Social structure and competition in inter-firm network. *Organization Science*, 8, 109-125.