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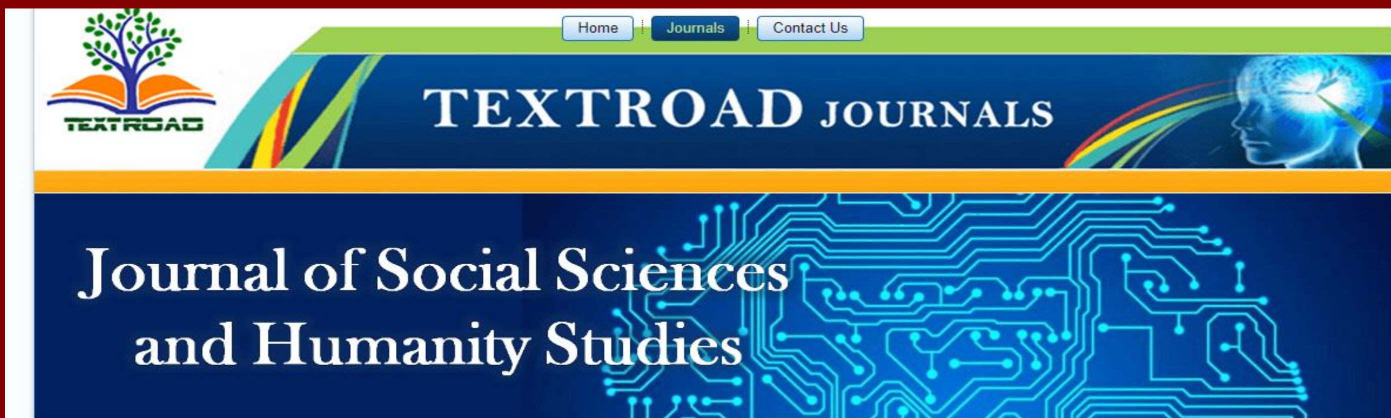


An International Peer-reviewed journal

Number of issues per year: 6
ISSN: 2356-8801 (Print)
ISSN: 2356-8852 (Online)

Volume 4, Issue 4, August 2018

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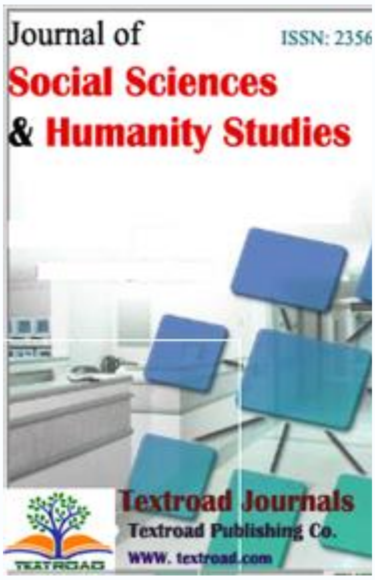
# Journal of Social Sciences and Humanity Studies

*J. Soc. Sci. Hum. Stud. 2018.*, **Vol. 4 No. 4: pp. 1-14, Year 2018**

**Journal of Social Sciences and Humanity Studies (JSSHS)**
Bimonthly Publication

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ISSN: 2356-8801 (Print)
ISSN: 2356-8852 (Online)

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*J. Soc. Sci. Hum. Stud.*, 4(4)1-6, 2018

ISSN 2356-8852
**Journal of Social Sciences and Humanity Studies**
*www.textroad.com*



# Pakistan's Nuclear Security Measures and International Apprehensions

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*Received: April 19, 2018*
*Accepted: July 3, 2018*

**ABSTRACT**

After provocative Indian nuclear detonations in May 1998, Pakistan officially became seventh nuclear weapons state on 28 May 1998. Since then, numerous claims have made that Pakistan's nuclear assets are unsafe and rogue elements within and outside the state could breach the security of Pakistan's nuclear assets and could use this lethal technology against international peace. Although, Islamabad rejected all kinds of speculations regarding weak nuclear command, control and security systems but the regional and domestic situation made it difficult to be acceptable to the international community. The article will assess the claims made by US and International Atomic Energy Agency (IAEA) officials regarding the nuclear security concerns. Furthermore it will also discuss the security measures taken by Pakistan to address the concerns of the international community in making its nuclear assets secure as other states have.

**KEYWORDS:** Pakistan, NCA, DCC, SPD, PNRA**,** IAEA**,** CPPNM

## INTRODUCTION

After 9/11, America and its allies, especially policy institutes, print and electronic media initially raise questions regarding the protection of Pakistan's nuclear assets. "On September 18, 2001, the Institute for Science and International Security (ISIS) raised concerns that increased instability in Pakistan could make Pakistan's nuclear weapons and stocks of nuclear explosive material dangerously vulnerable to theft by militant groups." [1]. It also emphasized the likelihood of an armed assault on Pakistan's nuclear assets by radical actors associated with Taliban or Al-Qaida, and the function of armed forces personnel compassionate to the religious fundamentalists.

On November 11, 2007 the Washington Post and New York Times published an intelligence report, which affirmed that United States had prepared eventuality plans to prevent Pakistan's nuclear weapons fall into the harmful elements. The very next day in response to the statement official from foreign office Islamabad stated that "the country had sufficient retaliatory capability to protect its nuclear weapons; it was also affirmed that there was no risk of the weapons being taken by any group, and if another country tried to intervene, Pakistan was ready to defend its nuclear arsenal" [2].

The specific concerns often raised by U.S authorities as well as expressed in the international medium, which raised reservations over Pakistan's nuclear safety and security, can be summed up as following:

- Thievery of nuclear arms or substance by radical groups.
- Susceptibility of nuclear armaments during conflict, transportation, and deployment
- The internal insecurity could abate the authorities control over its nuclear weapons whereby Islamic fundamentalists could hold control on them. Particularly, fears that Pakistan could suffer a further military overthrow and that a radical leadership would seize nuclear arms
- Scientists within facilities could steal imperative information or assist other states or rogue groups on nuclear technology
- An insider can join forces with a interloper to disrupt nuclear installations
- Some security experts hoist apprehensions on unintentional or illicit use of nuclear arsenals [3].
- "A Congressional Research Service (CRS) report of February 2005 says that there are two basic nuclear risks in South Asia: first, that terrorist will acquire nuclear material or nuclear weapons, and second, that nuclear war will erupt through miscalculation, through preemption, or through sudden escalation" [4].

To eradicate these fears, Pakistani Foreign Office and security representatives have given numerous special briefings on Pakistan's nuclear safety to Western ambassadors and correspondents. Although Pakistani officials have refused all of mentioned concerns but the measures taken by Islamabad to address these concerns must be highlighted.

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**Measures to Protect Nuclear Arsenals**

The nuclear safety program for nuclear assets is now fifteen years old and it is frequently developing. Ever since the 1998 nuclear explosions, Islamabad has taken special actions to protect the state's nuclear belongings. The primary measure was the formation of the National Command Authority (NCA) in 1999 to administrate and preserve nuclear materials and associated facilities. "The NCA has a three-tiered structure with two committees, the Employment Control Committee (ECC) and the Development Control Committee (DCC), constituting one tier; the Strategic Plan Division (SPD), the permanent secretariat of the NCA, second tier; and the three services Strategic Force Command, the final tier" [5].

The SPD plays a significant role as a managing entity and supervises nuclear assets by working together with all strategic organizations. It also has devised a standard operating system to regulate the pattern of strategic organizations. "It has established a system which requires approval, reporting and monitoring of travel for all scientific personnel, especially those that possess sensitive information or expertise" [6]. "On May 28, 2009, the Director of Arms Control and Disarmament Affairs at the SPD, Air Commodore Khalid Banuri, claimed that Pakistan has a force of nearly 10,000 people deployed to keep a tight vigil on the country's nuclear arsenal" [7]. Under the SPD Pakistani authorities have taken countless measures in the last twelve years to secure its nuclear assets compatible to the standard international procedures for nuclear security.

**Screening Programs for Individuals**

To make sure individuals' dependability stands on commonly established security standards, Pakistan has instituted Personnel and Human Reliability Programs for all officials and scientists working on key assignments. The program is governed by SPD along with three intelligence organizations (ISI, MI, and the IB). "The procedures were established in the early 2000s; it took two years to do so, and the reform had to overcome resistance" [8]. "Two different programs exist: a Human Reliability Program (HRP) for civilians and a Personnel Reliability Program (PRP) for military" [9]. "The PRP and HRP makes sure that personals accountable for handling or guarding nuclear materials or weapons are reliable, trustworthy, psychologically stable and moderate" [10]. Underneath these programs a person assign to a sensitive assignment now go through a safety approval by the Inter-Services Intelligence (ISI), the Military Intelligence, the Intelligence Bureau, and the SPD.

The program has been scrutinized nearly 2500-4500 persons. "This includes about 2,000 scientists or engineers working in particularly sensitive areas or having critical knowledge; they continue to be monitored after retirement" [11]. There are approximately ten thousand personnel having access to vital information and SPD plans to expand programs to all these employees. "After primary screening, there are periodic clearance rechecks every two years or when an individual is relocated from one location of the program to another" [12]. In addition, arbitrary verifications can be performed if necessary. This procedure comprises absolute background check of an individual, including lifestyle, family, friends, political associations, educational career, and inclinations. "Furthermore, the 2007 National Command Authority Ordinance, grants SPD power to investigate distrustful conduct, and can send for up to 25 years of sentence any serving and retired personnel, including military personnel, notwithstanding any other laws" [13].

**Physical Security and Surveillance**

As much as physical safety measures of Pakistan's nuclear assets are concerned, the nuclear installations are spread physically. There are various systems of protection over nuclear assets. "This includes highly trained Special Forces at the inner perimeter, air defense systems, no fly zones, fencing of structures, monitoring by state of the art equipment, close-circuit cameras, sensors, and check posts at second and third level, and counterintelligence teams to identify any threat to nuclear installations" [14].

In year 2001, President Musharraf ordered relocation of nuclear arms to nearly 06 new clandestine sites, and rationalized the armed lapse of nuclear security services. It is widely believed that Pakistan acquired approximately 100 nuclear weapons kept detached from their deliverance means, with the core detached from detonators. Former head of SPD General Khalid Kidwai stated that, the weapon can be accumulated rapidly when the requirement occurs. Additionally to their detached position, nuclear warheads are operational with Permissive Action Links (PALs), also verified by General Kidwai in 2006. For the detonation of the weapon the PALs requires code. "According to Brigadier (retired) Naeem Salik, Pakistan has developed its own PAL systems which obviously ensures that even if an unauthorized person gets hold of a weapon, he cannot activate it unless he also has access to the electronic codes" [15].

There are different levels of nuclear protection. "The first level (inner ring) is directed by the SPD, which supervises some 9,000 workforce devoted to this task, the SPD's directorate in charge of nuclear security is led by a two-star general and is endowed with its own counter-intelligence team" [16]. It has a unit in all key laboratories managed by the NCA, each leaded by a high ranked military officer. The next level known as outer ring is observation and

screening of apprehensive events outside the facility, with ISI association. The SPD has a procedure of responsive material control and accounting. It is based on usual and surprise examinations. To track the apparatus of warhead the SPD adopted inventory systems it also set up a special response fore along with advanced and secured containers for transportation.
According to Inter-Services Public Relations (ISPR), a nuclear security appraisal was carried out in 2011. United States has assisted Islamabad to solidify such procedures with the sharing of expertise and perhaps equipment.

**Security of Non Military Nuclear Installations**

Pakistan's civilian nuclear sites protection is administrated by the Pakistan Nuclear Regulatory Authority (PNRA), established in 2001, "The PNRA regulates all aspects of civilian nuclear energy which include licenses for imports and exports, to create necessary legislations and regulations, and to ensure the physical protection of nuclear installation and nuclear material" [17]. PNRA has 200 expert members Director General SPD (DGSPD) is also an associate of the PNRA. The military and other intelligence agencies play their part to implicate its policies and laws. In 2002, “the PNRA streamlined nuclear disaster management by announcing a host of new measures for protecting the plant and society from hazards that could be man-made or natural” [18]. A five-year Nuclear Security Action Plan (NSAP), deployed to improve protection of nuclear substances and radioactive materials of all nuclear amenities was implemented by the PNRA in 2006. A security review of existing and under construction nuclear sites was carried out in 2011. "Under the NSAP, the PNRA has established safety and security training centers, the National Security Emergency Coordination Centre (NSECC), launched campaigns to locate and secure orphan sources and provision of detection equipment at strategic points to help prevent illicit nuclear smuggling" [19]. "All identified sources are said to have been cataloged, orphan sources have been recovered, and two protected storage sites have been set up" [20]. To improve nuclear safety, Islamabad is also collaborating with IAEA. Furthermore, Islamabad endorsed the Convention on the Physical Protection of Nuclear Materials (CPPNM) in 2000. In 2008, the expert judgment review showed satisfaction on civilian complex security of Pakistani nuclear sites.
"As pointed out earlier, Pakistani nuclear weapons are in de-mated status with warhead and fissile cores stored separately; and, besides other physical security measures, the technical design features supplement safety against unauthorized or accidental launch" [21]. On November 27, 2007 DGSPD stated that:

> “Pakistani nuclear controls include some functional equal to the two-man command and Permissive Action Links (PALs) that the United States and some other nuclear-weapons states rely on to protect against loss of control, inadvertent weapons use, accidents, and other mishaps" [22].

"Pakistan adopted a two-man rule to validate the codes that call for the release of the weapons; it may in fact be a three-man procedure in some cases; such verification processes are standard in advanced nuclear-weapon States" [23]. "Some observers believed that on three man rule, the three men are the missile launch team commander, a representative from the Strategic Plans Division (SPD) with the missile team, and the head technician from the strategic organizations" [24]. Pakistan also employed some permutation of technical procedures to make sure ritual measures are being in practice. The fundamental part of debate on Pakistan’s nuclear arsenals includes PALs. "Luongo and Salik, citing a 2004 television interview with former Pakistani nuclear scientist Samar Mubarakmand, state that every Pakistani warhead is now fitted with a code-lock device, which requires a proper code to enable the weapon” [25]. Former SPD officials, Air Commodore Khalid Banuri and Adil Sultan sum up the control structure in less fail-safe terms:

> "To preclude any possibility of inadvertent or unauthorized use of nuclear weapons, Pakistan has developed physical safety mechanisms and firewalls both in the weapon systems themselves and in the chain of command; no single individual can operate a weapons system, nor can one individual issue the command for nuclear weapons use" [26].

Islamabad's efforts on nuclear safety have been silently supported by the Washington. Therefore, officials from United States stated that the programs have enhanced protection, as in May 2009 Admiral Mullen commented that “the United States, have invested fairly significantly over the last three years, to work with Pakistan, to improve that security; and we’re satisfied, very satisfied with that progress.” Furthermore, American Deputy Secretary of State Richard Armitage, said,

> "We have spent considerable time with the Pakistani military, talking with them and working with them on the security of their nuclear weapons. I think most observers would say that they are fairly secure. They have pretty sophisticated mechanisms to guard the security of nuclear assets." [27]

New York Times also reported that the Washington provided nearly $100 million worth of aid to Pakistan for training and equipments for security measures [28]. PALs did not emerge as part of any assistance; because of American legal limits and also for Islamabad's sensitivity that US technological support may endanger Pakistan’s liberty of action through an intense crisis. As said by Feroz Khan,

> "In 2001, US Secretary of State Colin Powell offered nuclear security assistance to Pakistani President Gen. Pervez Musharraf. The SPD carefully examined the offer and accepted training but declined technology transfers, which they perceived as intrusive or likely to compromise program secrecy…. There has been no further acceptance of any assistance [beyond training], especially permissive action links (PALs)…." [29].

**Participation in Nuclear Safety Programs**

Pakistan is an active member of international non proliferation regime and known as a conscientious nuclear power. Islamabad is a member to the below mentioned conventions and security measures on nuclear security:

- The convention on nuclear safety
- Convention Physical Protection of Nuclear Materials (CPPNM),
- IAEA code of Conduct on Safety of Radioactive Sources
- United Nations Security Council Resolution (UNSCR) 1540.

"It was one of the key members which presented a report to United Nations to complete its commitments under UNSCR 1540, which requires enactment of legislation to prevent the proliferation of nonconventional weapons and their means of delivery, and recognized the continuing importance of the IAEA and its nuclear material security guidelines and activities" [30]. Until now Pakistan has submitted four reports to the United Nations commission, managing the implementation of Resolution 1540. Almost all civilian nuclear facilities are under the purview of the IAEA, through PNRA. "Islamabad is an dynamic member in the of the Global Initiative to Combat Nuclear Terrorism (GICNT), especially on issues related to nuclear forensics and efforts to upgrade the international community's ability to identify nuclear and other radioactive resources in order to prevent nuclear trafficking" [31]. In March 2006, It also become member of the United States backed Container Security Initiative (CSI) for the training and assistance in nuclear security.

In 2012 Seoul nuclear security summit Pakistan promised to create a training center related to nuclear security furthermore Islamabad also became a signatory to the Joint Statement on Nuclear Security Training and Support Centers. "The center is intended to serve as a regional and international hub for training in nuclear security; in the joint statement, Pakistan joined with 22 other countries in forming what will amount to an international network on that issue; it also developed a radiation emergency response mechanism and a Nuclear Security Emergency Coordination Center" [32] . It is also preparing to advance physical safeguard of civil nuclear power plants.

## CONCLUSION

After analyzing security concerns on Pakistan's nuclear program it has become clear that the country is facing a distressed period and facing multiple issues including an unstable neighbor Afghanistan which has a past of political unsteadiness; and rebel activities. Despite a notable inventory of actions for its nuclear protection, efforts regarding highlighting of security efforts are not sufficient. This has added to the continuous disbelief about Pakistan's aptitude to secure its nuclear facilities. These characteristic make the safety of nuclear program a global anxiety. "As a result, all acts of terrorism in the country, especially those directed at military targets, are going to raise concerns and invite scrutiny and skepticism of official assurances of control" [33].

Islamabad has taken serious actions regarding its accountability for nuclear protection. The misinformation by lobbyists and media aligned with the safety of Pakistan's nuclear program is groundless. Islamabad is collaborating with Washington on personnel screening and training on nuclear security. It is also taking part in global forums committed to averting terrorism and developing nuclear safety. Pakistan also took necessary measures domestically and improved the authoritarian system for prevention of proliferation of nuclear resources and knowledge. Authorities in Pakistan recognize that its weapon program is intensely intertwined and safety of nuclear assets is a top precedence. The existing command and control structure emerges to be premeditated to tackle most conceivable circumstances with regards to internal unsteadiness. "While the international system should continue efforts to stabilize Pakistan in part so that scenarios that currently seem implausible do not become more likely analysts looking at Pakistani nuclear risk should not assume state failure" [34]. The adopted screening program and other procedural safeguards make sure that a person or group of peoples cannot gain access of nuclear warhead without the consent of established authority and strict protocols.

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*J. Soc. Sci. Hum. Stud.*, 4(4)7-14, 2018

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ISSN 2356-8852
**Journal of Social Sciences and Humanity Studies**
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# Economic Analysis and Production Efficiency of Dark Sun Cured Rustica Tobacco Production A Case Study of Punjab, Pakistan

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*Received: April 6, 2018*
*Accepted: July 1, 2018*

## ABSTRACT

Using a comprehensive primary dataset collected from 210 farmers of two (Dera Ghazi khan and Rajanpur) districts of Punjab Province in Pakistan. The objective of this study was to explore the technical, allocative and economic efficiencies and subsequently to estimate the determinants of inefficiency of tobacco farmers in Punjab, Pakistan. The technical, allocative and economic efficiencies were assessed by using data envelopment analysis (DEA) technique. The mean technical, allocative and economic efficiency scores for the tobacco farms were 0.90, 0.82 and 0.75 respectively. Results based on tobit regression analysis were highly significant for all three efficiencies. Thus, divulge that the age of household, education, agricultural credit access and contact with extension staff had a significant and negative effect on inefficiency score. The government should take steps for the improvement in the technical education of farmers, meetings with extension agents, insure the quality of inputs and provide a subsidy to small farmers in the purchase of inputs.
**KEYWORDS:** Tobacco, Efficiency, DEA Approach, Tobit Model

## 1. INTRODUCTION

Government of Pakistan endorsed new technologies for the enhancement in agriculture sector. Agriculture occupied a major (19.5%) share in the gross domestic product of Pakistan which involved 42.3% labor force [19]. Increase in the production as well as yield of agricultural crops is a need of time [16, 17].

Cash crops are considered as an essential part of agriculture because these are a source of livelihood and foreign exchange. Major problems faced by developing countries were unemployment and poverty. The sector of cash crops can tackle these problems in short period of time. Their short growing period was also helpful in the cultivation of many crops in a particular season [2].

Tobacco considers as an important cash crop occupied only 35251 hectares with the production of total 86.22 million kg tobacco and an average yield of 1900 kg per hectare [18]. Tobacco products included price earnings ratio of top fifteen companies in Pakistan. Tobacco in Pakistan was on growing value trend throughout the review period but declining trend in value term from past five years. Pakistan exported tobacco 1233.86 million rupees in 2016 which was less than half 2732.29 million rupees in 2012 [21] and posting negative growth of 2.6 percent in 2017 as compared to last year due to decrease in area [19]. Tobacco is a labor-intensive crop supporting 1.2 million persons [5].

Smokeless tobacco is popular with a name of Dark Sun Cured Rustica or black leaf, occupied an area of 7000 hectares with a production of 21 million kg [20]. Its product is consumed as snuffing and chewing. Snuff is fine-grain tobacco that often comes in teabag-like pouches that users "pinch" or "dip" between their lower lip and gum. Chewing tobacco comes in shredded, twisted, or "bricked" tobacco leaves that users put between their cheek and gum. [20].

Production of smoked and smokeless tobacco is nearly similar but the processing of smokeless tobacco is different than the smoked tobacco. Researchers who have explored economic analysis of smoked tobacco [22, 32, 36, 40], calculating all costs, output and profit. Production function, mathematical programming and frontier function techniques were used for the measurement of the technical efficiency of agricultural farms [7, 11, 28, 38]. They

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pointed out toward the improvement of efficiency and productivity by using different factors such as improvement in the land, seed quality, pesticide and fertilizer availability, labor skills, extensions services and credit Education. In the light of above studies, smokeless tobacco production is also said to be an important contributor to livelihood in terms of labor and revenue generation. But the literature was insufficient about smokeless tobacco is grown in Punjab, Pakistan. Therefore, a comprehensive study is required about the economic analysis and modeling of production efficiency of smokeless tobacco and checked the opportunity of input reduction keeping output level as constant or opportunity of obtaining more output keeping the input use level constant.

## 2. METHODOLOGY AND DATA SAMPLING

### 2.1 Study Area

Punjab province is located between 24-37ºN and 62-75ºE in the fertile land of five south flowing rivers [14]. The region is blessed with good climate, suitable for agricultural production [34]. The study was conducted in two smokeless tobacco growing districts of Punjab (Rajanpur and Dera Ghazi khan, based on their shares of total smokeless tobacco in the province following the statistics from [10]

### 2.2 Sampling

Multistage random sampling technique was applied to collect the data. In first stage Punjab province was selected. In second stage two district was selected. In third stage five villages from each district were selected. In fourth and last stage 20 to 22 tobacco farmers were selected. About 105 farmer's data was collected from each district, total 210 respondents were interviewed. Respondents were divided into three sub-groups such as small, medium and large farmers. Total operational land was less than 12.5 acres for small farmers; more than 25 acres for large farmers; and between 12.5 and 25 acres for medium farmers [23]. Small, medium and large farmers were 59.52%, 25.72% and 14.76%, respectively.

### 2.3 Analytical procedure

For the present study, software like Microsoft Excel, SPSS-15, DEAP-2.1 and Stata 13.0 were used for empirical analysis. For economic analysis, total revenue (TR) and total cost (TC) were estimated smokeless tobacco production. The total variable cost in the form of nursery cost, land preparation, seed, transplantation, fertilization, earthling up, hoeing, irrigation, pesticides, picking and marketing. The total fixed cost was the sum of land rent (six months) and administration charges [2]. Benefit-cost ratio, gross margin and net income were calculated with given formulas [6].

#### 2.3.1 Data Envelopment Analysis

Efficiency means comparison between the existing and maximum productivity of a firm [15]. Production frontier was used to the determined Maximum productivity of a firm. Production frontier was developed by using two different techniques such as stochastic frontier analysis (SFA) and data envelopment analysis [24]. The technique of linear programming was used in DEA model. The increasing difference among actual data and frontier explored the presence of increasing inefficiency of a firm [9, 33] mentioned both output and input oriented nature of DEA model but a farmer has more control on inputs. Therefore, input oriented DEA model was used in this study. According to [12], constant returns to scale DEA model was only feasible when all firms were working at an optimal scale but it is not possible in agriculture in Pakistan due to many constraints such as financial constraints, imperfect competition etc. in order to accommodate this [8] incorporated convexity constraint in proposed variable returns to scale in DEA model. According to [33] , technical efficiency is the achievement of maximum output by utilizing given input resources on the basis of the production model. DEA model based on a variable return to scale was used for the estimation of technical efficiency.

The present study calculated technical allocative and economic efficiency by using DEA model based on a variable return to scale. Total farm income (Y) was considered as an output variable in the calculation of efficiency scores. Land (X1), tractor (X2), seed (X3), labor (X4) fertilizer (X5), irrigation (X6) and chemical (X7) were used as input variables in the analysis.

#### 2.3.2 DEA Model for technical efficiency estimation

Input oriented variable return to scale DEA model was applied for technical efficiency estimation as mentioned by [33] like:

$\min_{\theta, \lambda} \theta,$

subject to: $-y_i + Y\lambda \geq 0, \theta x_i - X\lambda \geq 0, \lambda \geq 0$ (1)

Where:

$Y$ represents the output matrix for N smokeless tobacco farmers.

$\theta$ represents the total technical efficiency.

$\lambda$ represents Nx1 constants.

*X* represents input matrix for N smokeless tobacco farmers.
*yi* represents the total revenue (Rs.)
*xi* represents the vector of inputs $X_{1i}, X_{2i} \ldots\ldots X_{7i}$
$X_{1i}$ represents the area under smokeless tobacco (acres)
$X_{2i}$ represents the total tractor used (hours) in farm operations
$X_{3i}$ represents the total quantity of seed (kg)
$X_{4i}$ represents the total labor man days required for all farm operations
$X_{5i}$ represents the weight of fertilizer (kg)
$X_{6i}$ represents the total irrigation (hours)
$X_{7i}$ represents the total chemical (liter)

### 2.3.3 Economic Efficiency Estimation

Cost minimization DEA model is considered as the first step for the estimation of economic efficiency and it is simply a ratio between minimum to observed cost as mentioned by [33]. Cost minimization DEA model was expressed as:

$\min_{\lambda,\, xi^E} wi\, xi^E$

subject to: $-yi + Y\lambda \geq 0,\ xi^E - X\lambda \geq 0,\ N1\lambda = 1,\ \lambda \geq 0$ (2)

Where:
*wi* represents input price vector $W_{1i}\ W_{2i}, \ldots\ldots, W_{7i}$
$xi^E$ represents the vector of cost minimizing input quantities
N represents the total smokeless tobacco farmers
$W_{1i}$ represents land rent in Rs.
$W_{2i}$ represents total money spent on tractor use in Rs.
$W_{3i}$ represents the total cost of seed in Rs.
$W_{4i}$ represents the total cost of labor in Rs.
$W_{5i}$ represents the total cost of fertilizer in Rs.
$W_{6i}$ represents the total cost of irrigation in Rs.
$W_{7i}$ represents the total cost of chemical in Rs.
Economic efficiency is simply a ratio between minimum cost and observed cost.
Economic Efficiency = minimum cost/observed cost

$EE = wi\, xi^E / wi\, xi$ (3)

### 2.3.4 Estimation of Allocative Efficiency

Allocative efficiency is obtained by dividing economic efficiency with technical efficiency. AE = EE/TE (4)

### 2.3.5 Tobit Regression Model

Efficiency improvement studies also explored the causes of efficiency variations between different farmers [26]. The score of inefficiency for each farmer was obtained by subtracting their efficiency score from 1. The technical, allocative, and economic inefficiency score were separately regressed on selected variables. The range of efficiency score by using DEA model was from 0 to 1. It shows that the dependent variable in the model was not normally distributed. Biasness in results becomes a hurdle for the use of ordinary least square technique [33]. So, the current study used Tobit regression model proposed by [39]. Socio-economic and farm related variables were age of farmer, education, land under tobacco, distance from output market, agriculture credit and contact with extension agents. Tobit regression model used by [33] for the determinants of inefficiency was expressed as:

$E_i = E_i^* = \beta_0 + \beta_1 Z_{1i} + \beta_2 Z_{2i} + \beta_3 Z_{3i} + \beta_4 Z_{4i} + \beta_5 Z_{5i} + \beta_6 Z_{6i} + \mu_i$ If $E^* > 0$ (5)

$E = 0$ if If $E^* \leq 0$

Where
i represents $i^{th}$ farmer in the sample
$E_i$ represents the technical, allocative, and economic inefficiency
$Ei^*$ represents the latent variable.
$Z_{1i}$ represents the age (years)
$Z_{2i}$ represents the education (years)
$Z_{3i}$ represents the area under smokeless tobacco (acres)
$Z_{4i}$ represents the distance from the market (Km)
$Z_{5i}$ is a dummy variable having a value equal to one if a farmer has access to credit otherwise zero.
$Z_{6i}$ is also a dummy variable having a value equal to one if a farmer has access to extension services otherwise zero.
ß's represents unknown parameters, $\mu_i$ represents the error term.

## 3. RESULTS AND DISCUSSION

Table 1 depicts the average variable cost incurred in per acre production for smokeless tobacco. On average, expenditures of small farmers were high in nursery growing cost (1428.12). Total cost was more for small farmer (Rs. 76499.81) followed by large (Rs. 74110.44) and medium farmer (Rs. 71824.32). The small farmer paid more uprooting and transportation cost (Rs. 1658.12), gap filling cost (Rs. 148.34), hoeing cost (Rs. 2560.68) and harvesting cost (Rs. 1046.15) as compared to the large farmer.

**Table 1. Total production cost acre-1 (Rs.) for smokeless tobacco**

| Production Practices/Costs | Sub Groups | | | Standard Error of Mean |
|---|---|---|---|---|
| | Small | Medium | Large | |
| **Total Nursery Cost** | 1428.12 | 711.84 | 484.13 | 49.69 |
| **Uprooting and transportation cost** | 1658.12 | 1626.79 | 1727.03 | 12.55 |
| **Gap filling cost** | 148.34 | 73.45 | 58.51 | 5.16 |
| **Manual ridge making cost** | 270.94 | 244.64 | 245.95 | 5.38 |
| **Fertilizer and FYM application Cost** | 1085.78 | 1007.85 | 1009.38 | 19.21 |
| **Pesticide insecticide application charges** | 241.20 | 313.39 | 263.51 | 7.80 |
| **Total Hoeing Charges** | 2560.68 | 2548.21 | 2448.65 | 33.53 |
| **Manual Topping and de-suckering Charges** | 3973.50 | 4137.50 | 4059.46 | 33.47 |
| **The labor cost of irrigation and water course cleaning** | 730.66 | 574.85 | 711.62 | 26.07 |
| **The labor cost of Harvesting** | 1046.15 | 1057.14 | 1024.32 | 11.01 |
| **Cost of picking tying and loading** | 1251.28 | 1296.43 | 1278.38 | 12.89 |
| **Stick replacement cost** | 3637.61 | 3805.36 | 3732.43 | 25.63 |
| **Total Labor Cost** | **16604.27** | **16685.61** | **16559.24** | **126.54** |
| **Total Land Preparation Charges** | 6395.34 | 4841.19 | 4446.24 | 113.37 |
| **Total Fertilizer and FYM Cost** | 24473.78 | 23724.95 | 25982.99 | 399.90 |
| **Total Pesticide insecticide cost** | 984.19 | 1030.36 | 1258.11 | 25.32 |
| **Total Irrigation Cost** | 7027.78 | 6962.50 | 7131.08 | 88.71 |
| **Total Curing Cost (Plastic)** | 526.50 | 564.29 | 518.92 | 13.82 |
| **Land rent** | 19059.83 | 17303.57 | 17729.73 | 150.81 |
| **Total Cost** | **76499.81** | **71824.32** | **74110.44** | **968.18** |

Table 2 describes that the small farmers get more leaf production (31.52 40kg/acre) and price (Rs.3955.98/40kg). The small farmers also get more stick production 7.88 40kg/acre. Total revenue was also more for small farmers (Rs.1276290.00 40kg/acre). GM (Rs.70189.02 40kg/acre) was more for medium and large farmer. BCR was high for medium farmers (1.22) followed by large (1.18) and small (1.07) farmer. It depicts that medium farmer received Rs.1.22 in return by investing rupee one in smokeless tobacco production.

**Table 2. Economic Analysis of per acre smokeless tobacco Production**

| Indicator/Unit | Sub-Groups | | | Standard Error of Mean |
|---|---|---|---|---|
| | Small | Medium | Large | |
| Leaf Production (40 kg/acre) | 31.52 | 31.21 | 30.92 | 0.33 |
| Average Price (Rs. /40kg) | 3955.98 | 3875.89 | 3945.95 | 28.44 |
| Stick Production (40 kg/acre) | 7.88 | 7.80 | 7.73 | 0.08 |
| Stick Price (Rs. /40kg) | 294.66 | 292.86 | 303.11 | 2.57 |
| Total Cost (40 kg/acre) | 76499.81 | 71824.32 | 74110.44 | 968.18 |
| Total Revenue (Rs.) | 127629.00 | 124680.80 | 124814.26 | 1822.58 |
| Gross Margin (Rs.) | 70189.02 | 70160.06 | 68433.55 | 1481.69 |
| Net Income (Rs.) | 51129.19 | 52856.49 | 50703.82 | 1475.85 |
| BCR | 1.07 | 1.22 | 1.18 | |

Table 3 also represents the descriptive statistics of the variables used in the DEA model. Findings show that usage of inputs fluctuates across farms as it depends on financial status of tobacco farmers. The average yield on tobacco farm is about 20086.67 kg. In monetary terms, the average revenue per tobacco farm is about Rs. 1619169.24. On average, a farmer pays Rs. 18357.14 in terms of land rent calculated for six months in tobacco production. Average farm machinery cost is Rs. 77893.38, the average cost of seed is Rs 5124.29, mean of irrigation cost is Rs. 91180.48, mean of fertilizer cost per farm is Rs. 325689.95, and the average chemical cost is Rs. 15900.00 per farm. Farming of tobacco crop is a labor-intensive activity and average labor cost is Rs. 215469.14 per farm

**Table 3. Descriptive statistics of the variables used in the DEA**

| DEA variables | Units | Mean | SD | Min | Max |
|---|---|---|---|---|---|
| **Tobacco Yield (Stick plus Leaf)** | Kg | 20086.67 | 15708.90 | 2600.00 | 81900.00 |
| **Land under Tobacco** | Acre | 13.05 | 10.46 | 1.50 | 63.00 |
| **Labor** | man-days | 861.93 | 686.60 | 102.00 | 3707.00 |
| **Farm Machinery** | Number | 98.25 | 77.87 | 16.00 | 445.00 |
| **Seed** | Kg | 17.08 | 16.25 | 2.00 | 100.00 |
| **Irrigation** | Number | 197.94 | 152.23 | 30.00 | 824.00 |
| **Fertilizer** | Kg | 7510.69 | 6697.73 | 6697.73 | 44280.00 |
| **Chemical** | Liter | 79.50 | 84.09 | 8.50 | 640.00 |
| *Input Cost and Output* | | | | | |
| **Overall revenue** | PKR | 1619169.24 | 1274689.06 | 196560.00 | 5876325.00 |
| **Opportunity value of Land** | PKR | 18357.14 | 2185.44 | 14000.00 | 24000.00 |
| **Labor Cost** | PKR | 215469.14 | 171649.80 | 25570.00 | 926750.00 |
| **Machinery Cost** | PKR | 77893.38 | 55796.85 | 14600.00 | 369450.00 |
| **Seed Cost** | PKR | 5124.29 | 4876.42 | 600.00 | 30000.00 |
| **Irrigation Cost** | PKR | 91180.48 | 74889.27 | 12750.00 | 327600.00 |
| **Fertilizer cost** | PKR | 325689.95 | 289316.55 | 30800.00 | 1745100.00 |
| **Chemical cost** | PKR | 15900.00 | 16817.95 | 1700.00 | 128000.00 |

Table 4 reveals that the mean total technical efficiency in the production of smokeless tobacco was 90.7% with minimum (62%) and maximum (100%). It depicts the possibility of 9.3% reduction in inputs for working at technical efficient level while output and technology remain unchanged. Results showed that 59.05% smokeless tobacco growers had more than 90% value of technical efficiency and 40.95% remaining falls between 60% and 90%. Average value of allocative efficiency was 82.8% with lowest (62.8%) and highest (100%). It depicts the possibility of 17.2% reduction in total cost for an allocative efficient farmer keeping the level of output and technology constant. A score of allocative efficiency was more than 70% for 89.05% farmers. Economic efficiency was 75% on average with minimum (49%) and maximum (100%).

**Table 4. Frequency distribution of Technical, Allocative and Economic Efficiencies**

| Efficiency Range | Technical efficiency | | Allocative efficiency | | Economic efficiency | |
|---|---|---|---|---|---|---|
| | N | % | N | % | N | % |
| **0.4<E≤0.5** | - | - | - | - | 2 | 0.95 |
| **0.5<E≤0.6** | - | - | - | - | 12 | 5.71 |
| **0.6<E≤0.7** | 4 | 1.90 | 23 | 10.95 | 60 | 28.57 |
| **0.7<E≤0.8** | 21 | 10.00 | 70 | 33.33 | 79 | 37.62 |
| **0.8<E≤0.9** | 61 | 29.05 | 55 | 26.19 | 28 | 13.33 |
| **0.9<E≤1.0** | 124 | 59.05 | 62 | 29.52 | 29 | 13.81 |
| **Total** | 210 | 100.00 | 210 | 100.00 | 210 | 100.00 |
| **Mean** | 0.90 | | 0.82 | | 0.75 | |
| **Minimum** | 0.62 | | 0.62 | | 0.49 | |
| **Maximum** | 1.00 | | 1.00 | | 1.00 | |
| **Sd.** | 0.08 | | 0.09 | | 0.11 | |

*Note: E= Efficiency*

Table 5 explores the impact of farm size efficiency scores. All production efficiency scores were found for small, medium and large smokeless tobacco farmers. The mean of total technical efficiency was 92.3% for large farmers followed by small (91.40%) and medium (88.3%) farmers. The average allocative efficiency was higher for medium farmers (86.5%) followed by large (84.7%) and small (80.7%) farmers. Economic efficiency was more for large farmers and it was 77.9% average while its value was 76.5% and 73.6% for medium and small farmers, respectively. Small farmers were more in Pakistan and their prosperity was also important for the uplift of Pakistani society [1].

**Table 5. Estimation of production efficiency with respect to farm size**

| Efficiency | Farm size Category | | |
|---|---|---|---|
| | Small | Medium | Large |
| **Technical efficiency** | 0.914 | 0.883 | 0.923 |
| **Allocative efficiency** | 0.807 | 0.865 | 0.847 |
| **Economic efficiency** | 0.736 | 0.765 | 0.779 |

Table 6 reveals average age of smokeless tobacco growers was 41.44 years with minimum (22 years) and maximum (61 years). Mean value of education was 5.22 years. Average land allocated for tobacco 13.052 with minimum (1.5 acres) and maximum (63 acres). Extension services and agriculture credit access offered (44.3%) and (55.7%) respectively to smokeless tobacco growers in the study area.

**Table 6. Descriptive statistics of the variable in Tobit regression**

| Variables | Unit | Mean | Maximum | Minimum | Standard Deviation |
|---|---|---|---|---|---|
| **Age** | Year | 41.44 | 61 | 22 | 8.24 |
| **Education** | Year | 5.22 | 14 | 0 | 4.46 |
| **Land under tobacco** | Acre | 13.05 | 63 | 1.5 | 10.46 |
| **Distance from market** | Km | 15.41 | 36 | 2 | 8.17 |
| Dummy Variables | | | **Category** | **Frequency** | **Percent** |
| **Agri. Credit access** | | | No | 117 | 55.70 |
| | | | Yes | 93 | 44.30 |
| **Extension services** | | | No | 93 | 44.30 |
| | | | Yes | 117 | 55.70 |

Table No. 7 showed the results of the study indicated that old farmers were technically less inefficient than the young farmers in the study area. Education was included to test the hypothesis that a farmer with more schooling is more efficient in smokeless tobacco production. The results revealed a negative and significant education coefficient for technical and allocative inefficiency. Therefore, it confirmed from hypothesis to show a decrease in technical and economic inefficiency with an increase in education. The coefficient of smokeless tobacco area was positive and significant for allocative and economic inefficiency. It showed an increase in the value of inefficiency due to more area under control. Distance from the market was included to test the hypothesis that a distant farm had more value of inefficiency. The coefficient of distance from smokeless tobacco market was significant and positive for technical inefficiency. A distant farm bears more labor cost and transportation cost. Results of the study revealed that access to credit coefficient was negative and significant for technical and economic inefficiency. It is therefore recommended that farmers should be provided assistance in the form of soft loans to enable them to cope with ever increasing prices of inputs. Extension services are important for a new technique and it was included to test the hypothesis that there is a negative impact on production inefficiency in the presence of extension services. The coefficient of contacts with extension agents was significant and negative for technical and economic inefficiency. It showed that the value of inefficiency decreases when farmers increase the contact with extension staff.

**Table 7. Factors affecting of Inefficiency**

| Variables | Unit | Technical inefficiency | | Allocative inefficiency | | Economic inefficiency | |
|---|---|---|---|---|---|---|---|
| | | B | Std. Err. | β | Std. Err. | β | Std. Err. |
| **Age** | Year | -0.00461*** | 0.00072 | -0.00088 | 0.00091 | -0.00355*** | 0.00094 |
| **Education** | Year | -0.00706*** | 0.00128 | 0.003888** | 0.00160 | -0.00047 | 0.00166 |
| **Land under tobacco** | acre | 0.000372 | 0.00051 | -0.00303*** | 0.00066 | -0.00258*** | 0.00068 |
| **Distance from market** | km | 0.002953*** | 0.00064 | -0.00048 | 0.00083 | 0.000811 | 0.00086 |
| **Agri. Credit access** | Yes/no | -0.03458** | 0.01136 | -0.012 | 0.01466 | -0.03423** | 0.01520 |
| **Extension services** | Yes/no | -0.05331*** | 0.01142 | -0.00742 | 0.01493 | -0.05275*** | 0.01548 |

## 4. DISCUSSION

Tobacco is a profitable activity and the findings were in line with the results of [13, 22, 32, 37, 40] and [29]. Significant education coefficient was in line with previous studies [25, 30] and [29]. An educated farmer has the ability to understand new technology and learns about better production practices [4, 3, 31, 35]. The significant coefficient of extension services was in line with [30] and [29]. The mean value of technical efficiency was 77% and 87.4% as found by [7, 38] respectively, and Tobit results showed that the education, experience of crop cultivation, contacts with extension agents had a significant and negative effect on production inefficiency. The negative effect of education on inefficiency was also explored by [38]. The impact of extension service was in line with the findings of [11, 27, 28]. Result confirmed a significant potential for the improvement of technical, allocative and economic efficiency in smokeless tobacco production.

## 5. CONCLUSION

The findings of the study showed that the average technical, allocative and economic efficiencies of tobacco farmers were 0.90, 0.82 and 0.75 respectively. All the inputs were found to be contributing to tobacco productivity with labor and fertilizer making up most of the shares of total cost in small, medium and large farms. The reason behind that large farmers are more efficient in tobacco farming was due to better education, easy access to credit, more finance to purchase inputs like pesticide, fertilizer, irrigation, plant protection measures, etc. along with better managerial practices and extension facilities. Tobit regression analysis of the determinants of technical, allocative and economic inefficiencies was carried out which showed that the age of household, years of schooling, number of contacts with extension agents and access to credit had negative impact on technical, allocative and economic inefficiencies of tobacco farms in Punjab. Small farmers were technically less inefficient. Results of the study also indicated that those farmers which were located closer to the market were technically less inefficient than the farmer located away from the main markets. It was also found that farm to market distance variable had insignificant impact on the allocative and economic inefficiencies of tobacco farmers. Therefore, it is suggested that government should work on development of markets and road networks in the rural areas. Government should also strive to stabilize the prices of numerous inputs like fertilizers, hybrid seed, diesel, pesticides, and weedicides. The quality of inputs like seed, pesticide sprays and fertilizers should also be monitored. Government institutes like PTB (Pakistan tobacco board) should pay attention to this issue and produce low cost seed which is easily accessible to all farmers.

**Conflict of interest**
Authors would hereby like to declare that there is no conflict of interests that could possibly arise.

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* Photographs should be of high quality (Minimum 300-600 dpi)
* Graphs should be in clearly visible form so that it may become easy to redraw
* The manuscript must be submitted in MS-WORD file format.

## INSTRUCTIONS TO AUTHORS

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The title should be a brief phrase (capitalize first letter of each word in the title) describing the contents of the paper. The Title Page should include the authors' full names and affiliations, the name of the corresponding author along with phone, fax and E-mail information. Present addresses of authors should appear as a footnote.

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All manuscripts should not exceed 250-300 words and should describe the scope, hypothesis or rationale for the work and the main findings. Complete sentences, active verbs, and the abstract should be written in the past tense. Standard nomenclature should be used and abbreviations should be avoided. No literature should be cited.

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This section should include sufficient background information, provide a clear statement of the problem, the relevant literature on the subject, and the proposed approach or solution. The aims of the manuscript should be clearly stated. The introduction should not contain either findings or conclusions. It should be understandable to colleagues from a broad range of scientific disciplines.

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Results should be presented in a logical sequence in the text, tables and figures; repetitive presentation of the same data in different forms should be avoided. The results should not contain material appropriate to the Discussion. It should be written in the past tense when describing findings in the authors' experiments. Results should be explained, but largely without referring to the literature.

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The discussion should consider the results in relation to any hypotheses advanced in the Introduction and place the study in the context of other work. Results and Discussion sections can be combined.

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If an optional conclusion section is used, its content should not substantially duplicate the abstract.

### Acknowledgment

The acknowledgments of people, grants, funds, etc should be brief.

### References

Bibliographic references in the text appear like [1, 2, 5, 6], using square brace in superscript. References should be numbered consecutively, with style:

### Journal paper:

1. Hadjibabaie, M., N. Rastkari, A.Rezaie and M. Abdollahi, 2005. The Adverse Drug Reaction in the Gastrointestinal Tract: An Overview. Intl. J. Pharmacol., 1 (1): 1-8.

### Books:

1. Daniel A. Potter, 2002. Destructive turfgrass insects: Biology, diagnosis and control. Wiley Canada Publishers, pp: 24-67.

### Chapters in Book:

1. Bray R.A., 1994. The leucaena psyllid. In: Forage Tree Legumes in Tropical Agriculture (eds R.C. Gutteridge and H.M. Shelton) pp. 283–291. CAB International, Oxford.

Titles of journals should be given in full. ‘In press' can only be used to cite manuscripts actually accepted for publication in a journal. Citations such as ‘manuscript in preparation' or ‘manuscript submitted' are not permitted. Data from such manuscripts can only be mentioned in the text as ‘unpublished data'.

### A Report:

1. Makarewicz, J.C., T. Lewis and P. Bertram, 1995. Epilimnetic phytoplankton and zooplankton biomass and species composition in Lake Michigan, 1983-1992. U.S. EPA Great Lakes National Program, Chicago, IL. EPA 905-R-95-009.

### Conference Proceedings:

1. Stock, A., 2004. Signal Transduction in Bacteria. In the Proceedings of the 2004 Markey Scholars Conference, pp: 80-89.

### A Thesis:

1. Strunk, J.L., 1991. The extraction of mercury from sediment and the geochemical partitioning of mercury in sediments from Lake Superior, M. S. thesis, Michigan State Univ., East Lansing, MI.

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Tables and equations should not be submitted in a format exceeding the A4 page size (in portrait form). **All tables should be embedded within the manuscript, and must be captioned and numbered sequentially.** Each table should be on a separate page, numbered consecutively in Arabic numerals and supplied with a heading and a legend. Tables should be self-explanatory without reference to the text.

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• Figures are at least 300 d.p.i.

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