

# EMPIRICAL TEST OF BENFORD'S LAW FOR PHOTOVOLTAIC PRODUCTION AND WAGES IN CENTRAL MEXICO

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## ABSTRACT

*Organizational environment can hold an exceptional commitment from its employees thorough different motivators like good organizational climate, vacations, additional benefits (i.e. food stamps, saving bonus), salary raise, among others. Salary raise inside organizations is one of the main motivators for employees. When there exists a salary raise, compromise and motivation of personnel, also increases. A present paper integrates an analysis to propose and request a salary raise in a Mexican photovoltaic sector industry in 2020. The statistical population of this research included all male and female employees working in the photovoltaic company of Mexico, who were selected randomly as a sample population to generalize to the statistical population. They were recognized the characteristics of employees at the beginning and in the end of one year of observation, which gives a base to a salary raise's proposal, from production management perspective. Results demonstrated that the variable of increasing salaries and promotions based on rank has a significant effect on increasing the efficiency of employees. Acting fairly and equitably in a transparent financial system is an important part of a salary increase proposal. Giving more salary to higher paid employees or making biased decisions can cause friction, conflict and dissatisfaction among employees.*

**Keywords:** Employee Commitment, Photovoltaic Sector, Salary Raise, Production Management.

## INTRODUCTION

Production process management can be a chaotic area, due to different variables or factors, between them: financial resource, material resource, information, and human resources; which are the basement of organizational function. Three of those resources, are manageable, however, the human facto is not that easy.

In several cases, the big amount of personnel, linked to production process, creates a complex network of interaction, making it difficult to motivate employees. Difficulty to motivate human resource, strives in the genuine need of operative personnel (in any country) to reach decorous life levels.

On the one hand, different motivators can be used in organizations to increase

compromise levels of operative personnel, like bonus, extra holidays, prizes, recognize (diplomas), etcetera, however, none of them have a longer impact on employees' motivation. On the other hand, salary raise is a motivator, which presents longer impact on employees' motivation, due to its permanent effect over employees' economy. Some strategies can be used to promote a controlled productive environment and capable and motivated employees, in order to have the possibility to promote salary raises as it is described below.

Quality assurance: control and manage production process to have high quality products; Warehouse control: which mean, even raw material, product on process of final product, must to be controlled to avoid pilferage (or shoplifting). Strict attendance control: to have exact information about workers' attendance, absences and permissions (by hours or by days).

Motivation speeches: even lectured by its boss or by external personnel, motivation speeches, also increase productivity of most of the employees, whit consequent improvement of organizational scopes; Re-arranging of working places: some times, if possible, reorder places inside the factory, promotes a different visualization of activities and tasks, generating a band new productive environment; Ergonomic studies and application: to increase ergonomic working places which increases productivity.

Educative level raising: increasing education level of employees, it is also created a different environment, including health competence and motivation (moving employees whit primary school to secondary school, secondary school to high school, and so on); Multitask employees' development: it gives the opportunity to enterprise for having capable personnel which can solve different problem, more over than the assigned employees' activity or labor, and also creates the chance for employees to have a bigger working and labor scope, even in the enterprise or in another employment. Promote clean working areas: when possible, it is recommendable to maintain clean and ordered areas, to encourage employees to increase productivities.

Direct and free communication all over hierarchical levels: when an operator has the chance to directly been listened by its higher decision makers, if generates a better level of compromise in the organization, increasing also productivity in the production area.

Despite authors argued about differences in gender payment or promotion (Billard, 2017; Jokinen & Pehkonen, 2017), it is not a constant in all of the organizations. In this paper the Solarever, a Mexican solar module manufacturer was considered which uses an equalitarian payment policy. Mexican PV module manufacturer Solarever has started production at its factory in Tecomán, in the state of Colima. The new manufacturing facility was built thanks to an investment of \$20 million and will have three production lines, the first of which is already in operation with a capacity of 500 MW per year and up to 1,500 modules per day. Solarever's factory generates more than 50 sources of employment and will promote the installation of several dozen indirect jobs. They plan to increase its production capacity from 500 MW to 1 GW at its factory in Tecomán, southwestern Mexico.

It can be state than most of the operative personnel in the beginning of 2019 (January 2019), was composed by women, with a 72.55% of the operative personnel, while 27.45% of workers were men. In another hand, at the end of 2019 (December 2019), women in operative production process's personnel was around 75.76%, while men, was around 24.24% of personnel's pay roll. Organization under study not increased the salary of operative personal

since the organization started operations in 2017, despite each year, as a governmental policy, it is stated a general salary raise along all of the country, applicable for each enterprise in the country.

In the following table, they are presented different minimum salary raises since 2017 to 2020, made by government via Minimal Salary's National Commission

Production requires the workers to possess productive skills in addition to the manager's resources (Moon, 2018). That binomial helps the organization to success on production initiatives, objectives and goals. The production manager (PM) in a manufacturing enterprise needs to arrange the production tasks by properly assigning the equipment and determining the starting time of each task (Dai, Cheng, & Guo, 2018). In that scope, production manager's leadership can be seen by the manager ability and capacity to manage four main organizational resources (Financial, Material, Information & Human), (Rodríguez-Espíndola et al., 2022) while production manager's efficiency can be seen by its capacity and ability to use and employ organizational resources in to revenues for the organization (enterprise).

Manager must own certain characteristics which helps itself to create a correct decision-making process. Those characteristics, include some dimensions, namely, manager: Says the truth; Gets on time; Prefers the organization over the client; Talks with a high level of culture; Uses a good lexicon; Has a global businesses' vision; Negotiates with other managers to reach enterprise's objective; Negotiates with subordinates to reach area's objectives; Respects schedules; Respects appointments; Holds meetings with clients by boss' awareness; Tolerates critics from others; Has a university diploma (Bachelor); Makes courses to keep on actualized even in general or specific knowledge fields; Accepts corrections from its subordinates; Accepts suggestions from co-workers; Recognizes credit from co-workers; Recognizes credit from subordinates (Litvaj et al., 2022).

Manager also must avoid to: Fight with other managers; Fight with its subordinates; Lie to avoid problems; Lie to avoid responsibilities; Libel about its boss; Libel about other managers; Libel about its predecessor; Complain about organizational situation when clients or visitors are present; Lie about its academic achievements; Prohibit its subordinates to talk or share whit other areas or managers; Promote gossiping; Recall subordinates' mistakes each possible time (Khan et al., 2022).

(Da-Cunha-Silva et al, 2018), recognize five specific knowledge, which must to own the production engineer, as environment; knowledge management; quality management; product's engineering; organizational engineering. That specific knowledge, also help labor of PM. Moreover, of different suggested characteristics and dimensions observed in literature, like those referred to knowledge, abilities, proactive attitudes, resilience, among others, production manager main characteristic to own is "common sense". In most of the cases, problems, and problematic in the factory, common sense, help to have a better decision-making process. When, in addition, production manager owns proactive abilities, attitudes and knowledge, decisions maked, over finance, material, information and or human organization's resources, have better results and goals reaching scope.

Salary can be considered as the most important motivator for an employee to complete tasks under its scope (responsibility). Access to jobs and occupations is an important determinant of earnings (Said et al., 2022), which fixes employees' salary level inside of an organization,

according to different industries/sectors, labors and activities, employee's abilities, employee's knowledge and employee's attitudes. In (Billard, 2017), it is recognized that salary can be used as an independent variable, which depends of other factors, like years employed, gender, discipline, among others.

Minimal Salary's National Commission (Comisión Nacional de Salarios Mínimos – México) is the Mexican branch's Ministry that regulates changes in the general minimal payment, for employees in Mexico. That Commission is the main reference to establish parameters in salary's raising scope. In the following table can be seen the salary evolution of minimum salary in Mexico, since 2012 (Table 1). Please, explain about the Zones.

Perceptions about the procedures used in determining pay raises make a unique contribution to organizational commitment and trust in supervisor (Lenher et al, 2022). Due to employees' perception in an objective and equitable salary raise also raises the employees' compromise with the organization.

Influence of production manager, over the decisions in factory's production process scope, play a very important roll. On salary decisions, for operative personnel, production manager have a weighted opinion on decision making process, so production manager can promote initiatives, to raise or hold salary levels for operative personnel.

PV system consists of an arrangement of several components, including solar panels to absorb and convert sunlight into electricity, a solar inverter to convert the output from direct to alternating current, as well as mounting, cabling, and other electrical accessories to set up a working system. Solar PV accounted for 8% of Mexico's total installed power generation capacity and 7% of total power generation in 2021. Installed capacity is forecast to increase by 22,397MW from 2022 to 2035, at which point solar PV is expected to account for 20% of total installed generation capacity.

The avoided salary raises started to create a discomfort over employees, which seen other enterprises yearly salaries' increase. In another hand, due to national economic conditions, it was also necessary to start a process to recover the avoided salary raises, in order to support wellbeing of enterprise's employees.

It can be recognized that, previous behavior of employees in the organization was not proactive. Most of the employees get used to arrive the enterprise late, they took some 10 or more minutes to get in the factory from the entrance register machine. There exists a higher level of absenteeism, which means that some employees get absent at least twice a week, or more, with no penalty for them and with the attending of complete payment by enterprise. In some cases, there exist very low productivities, based in 100% productivity, some employees give 50% or less, from its production.

Very little employee's stolen material or tools from factory. Spare parts used in the production process had constantly supplying, so in short periods it was necessary to buy replacements. In Saturdays, there was a bigger lack in productivity, and, sometimes, it was evidenced that employees drunk alcoholic beverages. Employees also took somehow an hour to take their meal. Inside and outside of the factory, there were huge amounts of garbage and disorder.

Thorough different strategies to increase compromise, productivity and motivation, including warehouse control, attendance control, motivation speeches, re-arranging of working

places, multitask employee's development, among others, employees changed its way of working, where taken.

No doubt, enterprise still having improvement opportunities in production process area, however, absences, emergency permissions to go out, unpunctuality, low proactive attitude, longer period of mealtime, among others, have been reduced considerably. In another hand, workforce has increased its productivity rates, compromise with enterprise and working attitude. Those changes imply that production process; have maintained a good level of productivity, reducing cost of material usage and payroll cost.

Most productive employees get used to arrive the enterprise early (some cases 30 minutes before) and start working when they arrive, which gave them the chance to over pass 100% of required productivity; personnel also look for solutions and suggest ideas to improve their own stages.

In the case of most productive employees, when they listen negative comments, they express its opinion to promote a working attitude and invite their partners to keep on mind a working attitude and compromise to enterprise; if there exist a mistake in their work, themselves look for a solution without any excuse; they generally do not overpass lunch time; and, hold an attitude of respect to the enterprise on different scopes like the use of materials, tool, etcetera.

It is necessary to mention that, after strategies taken to increase compromise, productivity and motivation, there still having some cases of low productivity's employees, however, general compromise, productivity and motivation had a dramatically positive change.

## Method

A descriptive, cross-sectional and exploratory study was carried out with a sample of salary contributions for the photovoltaic industry in central Mexico stolen by the Ministry of Economy, considering the most recent labor reform due to the renegotiation of the trade agreement in North America.

The database of the World Bank and the Organization for Economic Cooperation and Development was used in its section related to wages and contributions for paid work corresponding to the period from 2020 to 2023.

The data were processed in the JASP version 14 statistical analysis packages to test the null hypothesis regarding the significant differences between the databases and the descriptive statistical treatment during the analysis period established by the pandemic and the impact of policies. Anti COVID-19 wages on the contribution of skilled labor for the photovoltaic industry.

Quartiles, bias, kurtosis, the Shapiro Wilks test were estimated in order to test the null hypothesis regarding the significant differences between the data provided by the World Bank and the OECD with respect to the salary guidelines applicable to the region of central Mexico.

## Results

According to Brenford's law, the distribution of the first observations must be less than 5% of the remaining observations. Applying the principle, it suggests a more exhaustive

investigation of the data related to the relationship between photovoltaic production with respect to wages (Table 1).

<b>Table 1 BENFORD'S LAW</b>			
<b>Leading digits</b>	<b>Count</b>	<b>Percentage</b>	<b>Benford's law</b>
10	2	2.02%	4.14%
11	1	1.01%	3.78%
12	0	0%	3.48%
13	1	1.01%	3.22%
14	1	1.01%	3%
15	1	1.01%	2.80%
16	2	2.02%	2.63%
17	2	2.02%	2.48%
18	0	0%	2.35%
19	0	0%	2.23%
20	15	15.15%	2.12%
21	0	0%	2.02%
22	0	0%	1.93%
23	1	1.01%	1.85%
24	1	1.01%	1.77%
25	1	1.01%	1.70%
26	0	0%	1.64%
27	0	0%	1.58%
28	0	0%	1.52%
29	1	1.01%	1.47%
30	3	3.03%	1.42%
31	0	0%	1.38%
32	1	1.01%	1.34%
33	0	0%	1.30%
34	0	0%	1.26%
35	0	0%	1.22%
36	1	1.01%	1.19%
37	0	0%	1.16%
38	0	0%	1.13%
39	0	0%	1.10%
40	0	0%	1.07%
41	0	0%	1.05%
42	0	0%	1.02%

43	0	0%	1%
44	0	0%	0.98%
45	0	0%	0.95%
46	0	0%	0.93%
47	0	0%	0.91%
48	0	0%	0.90%
49	0	0%	0.88%
50	3	3.03%	0.86%
51	0	0%	0.84%
52	0	0%	0.83%
53	0	0%	0.81%
54	0	0%	0.80%
55	0	0%	0.78%
56	0	0%	0.77%
57	0	0%	0.76%
58	0	0%	0.74%
59	0	0%	0.73%
60	4	4.04%	0.72%
61	0	0%	0.71%
62	0	0%	0.69%
63	0	0%	0.68%
64	0	0%	0.67%
65	0	0%	0.66%
66	0	0%	0.65%
67	0	0%	0.64%
68	0	0%	0.63%
69	0	0%	0.62%
70	5	5.05%	0.62%
71	0	0%	0.61%
72	51	51.52%	0.60%
73	0	0%	0.59%
74	0	0%	0.58%
75	0	0%	0.58%
76	0	0%	0.57%
77	0	0%	0.56%
78	0	0%	0.55%
79	0	0%	0.55%
80	1	1.01%	0.54%

81	0	0%	0.53%
82	0	0%	0.53%
83	0	0%	0.52%
84	0	0%	0.51%
85	0	0%	0.51%
86	0	0%	0.50%
87	0	0%	0.50%
88	0	0%	0.49%
89	0	0%	0.49%
90	1	1.01%	0.48%
91	0	0%	0.47%
92	0	0%	0.47%
93	0	0%	0.46%
94	0	0%	0.46%
95	0	0%	0.45%
96	0	0%	0.45%
97	0	0%	0.45%
98	0	0%	0.44%
99	0	0%	0.44%
<i>Source: Elaborated with data study</i>			

The goodness-of-fit test supports Benford's law in which inspection of the data is recommended in order to perform more in-depth audit analysis (Table 2).

<b>Table 2</b>					
<b>GOODNESS-OF-FIT TEST</b>					
	<b>Statistic</b>	<b>Value</b>	<b>df</b>	<b>p value</b>	<b>N</b>
Chi-square	X <sup>2</sup>	4487.945	89	< .001	99
Note. The null hypothesis specifies that the first two digits (10 - 99) in the data set are distributed according to Benford's law.					
<i>Source: Elaborated with data study</i>					

## DISCUSSION

The procedures used to make decisions about rewards have substantial impact (Lehner et al., 2022). Because of that, it is important to consider a salary raise, in the organization under study, as a reward to increase compromise, productivity and motivation of employees. In the case of the photovoltaic enterprise, it was respectfully inquired directly to photovoltaic industry's CEO, for its authorization to raise the salary of operative personal in production department



(factory) based in different considerations.

At the end of 2020, Minimal Salary's National Commission – Mexico (Comisión Nacional de Salarios Mínimos – México) have state a 3.4% raise of minimum salary in Mexico, from \$77.04 MXN to \$80.04 MXN per day, around \$4.28 USD to \$4.44 USD, considering an average dollar price of \$18.00 MXN per \$1.00 USD. However, as mentioned before, enterprise have not increased employees' salary since 2017, which represents an accumulative increase of 17.95% or an 18.95%, comparing 2017 minimum salary with 2020 minimum salary (see Table 2). Considering governmental raising on minimum salary since 2017, it would be recommendable to raise the salary of the organization's employees, some 8.34%, which would raise factory's employees form \$1,200 MXN to \$1,300 MXN, per week, around \$66.66 USD to \$72.22 USD per week, considering \$18.00 MXN per \$1.00 USD. In the context of enterprise under study, has reduced its payroll from 51 workers in January 2019 to 33 persons in December 2019. Following table shows the pay roll in the organization on the beginning of 2019 (when there were 51 employees on the production process).

The investigation showed that there was also a change in labor organization; it was created a new supervision; however, the total number of supervisors was reduced from five to four places. It can also be state that two persons were fired and 24 persons quit, and they were contracted 8 new employees, during observation time. Last mentioned payroll reduction implies a saving from \$62,700 MXN, to \$40,800 MXN (no taxes and social load included), it represents a saving of 35%, considering factory's payroll. If CEO would accept proposed salary raise, total saving would be of 30%, in comparison by 2019

Despite it is suggesting a raise of 8.34%, enterprise still having a saving of 30% on salaries' paying. It can be seen that enterprise would invest 5 % of mentioned saving to increase more than 8%'s personnel salary.

## CONCLUSION

PM is the “by excellence” decision maker who can start and supports initiatives over the production process and its resources. Specifically, on human resource scope, production manager can promote initiatives to improve quality life of its employees. PM can support initiatives to raise operative personnel's salary.

Importance of reward for production employees strives in commitment raising level. In the case of the enterprise under study, it can be seen that conditions or characteristics of employees radically change in the period of analysis without a reward or salary raise. Considering a salary raise authorization, it can increase employees' compromise, not only with supervisor but higher-level decision makers, managers. With the salary raise proposed, enterprise would save 30% compared with payment in January 2019 and without considering 9.85% mandatory raise from 2019 to 2020 stated by Minimal Salary's National Commission.

Comparing January 2019 payroll with Minimal Salary's National Commission mandatory raise from 2019 to 2020 and proposed raise, enterprise is saving 39.85%. Comparing January 2019 payroll with Minimal Salary's National Commission mandatory raise from 2017 to 2020 and proposed raise, enterprise is saving 48.95%.

**REFERENCES**

- Billard, L. (2017). Study of salary differentials by gender and discipline. *Statistics and Public Policy*, 4(1), 1-14.10.1080/2330443X.2017.1317223
- Da.Cunha Silva, G., Korzenowski, AL, Dall'Agnol, M., Simões, WL, & Santo Júnior, JVDE (2018). Prioritization of production engineer skills demanded by the market in northern Brazil: an analysis of the university and the labor market. *Brazilian Journal of Development*, 4 (1), 196-220.
- Dai, H., Cheng, W., & Guo, P. (2018). An improved Tabu search for multi-skill resource-constrained project scheduling problems under step-deterioration. *Arabian Journal for Science and Engineering*, 43, 3279-3290.4.
- Jokinen, J., & Pehkonen, J. (2017). Promotions and earnings—gender or merit? Evidence from longitudinal personnel data. *Journal of Labor Research*, 38, 306-334.
- Khan, H., Abbas, J., Kumari, K., & Najam, H. (2022). Corporate level politics from managers and employees perspective and its impact on employees' job stress and job performance. *Journal of Economic and Administrative Sciences*,
- Lehner, O. M., Nicholls, A., & Kapplmüller, S. B. (2022). Arenas of contestation: A senian social justice perspective on the nature of materiality in impact measurement. *Journal of Business Ethics*, 179(4), 971-989.
- Litvaj, I., Ponisciakova, O., Stancekova, D., Svobodova, J., & Mrazik, J. (2022). Decision-making procedures and their relation to knowledge management and quality management. *Sustainability*, 14(1), 572.
- Moon, S. (2018). Skill development, bargaining power, and a theory of job design. *Journal of Economics & Management Strategy*, 27(2), 270-296.
- Rodríguez-Espíndola, O., Chowdhury, S., Dey, P. K., Albores, P., & Emrouznejad, A. (2022). Analysis of the adoption of emergent technologies for risk management in the era of digital manufacturing. *Technological Forecasting and Social Change*, 178, 121562.
- Said, M., Majbouri, M., & Barsoum, G. (2022). Sticky Floors and Glass Ceilings: Gender Wage Gap in Egypt. *Feminist Economics*, 28(4), 137-165.
- Sat (2018). Salarios mínimos 2018, Servicio de Administración Tributaria,

**Received:** 31-Mar-2023, Manuscript No. IJE-23-13518; **Editor assigned:** 03-Apr-2023, Pre QC No. IJE-23-13518 (PQ); **Reviewed:** 17-Apr-2023, QC No. IJE-23-13518; **Revised:** 22-Apr-2023, Manuscript No. IJE-23-13518(R); **Published:** 29-Apr-2023