

Failed Industries in Nigeria: A Game Theoretic Analysis

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ABSTRACT

Failed industries are a big problem in Nigeria and other parts of the world. A general feature is that these industrial organizations failed due to tyranny of small decisions by employers/management and employees; hence, failed industrial enterprises are analyzed in the context of a social dilemma, hence, game theoretic models based on the famous prisoner dilemma game are used to model failed industrial enterprises. The analysis revealed the mechanism and scientific basis for industrial failures. Finally, it is suggested that the undesirable equilibrium outcome of the social dilemma could be avoided by using mechanism design and structural changes to the social game to achieve the desired efficient outcome and by so doing increased productivity and resultant increased economic growth is achieved.

(Keywords: *game theory, social dilemma, sustainable industrialization, equilibrium mechanism design*)

INTRODUCTION

The industrial revolution has brought unprecedented economic growth and prosperity in many parts of the world. But in many parts of the world especially in developing countries, industrial development is very low, stalled, or unsustainable. This is very much the case in Nigeria, where though industrial development is poor, many existing ones have either failed or are loss making.

Several authors have written on why Nigeria has failed to take off industrially (Young, *et al.*, 2015; Agba and Odu, 2012; Yakubu, *et al.*, 2015). Poor electricity generation, globalization, corruption etc. have been identified by these authors. Of all these factors, electricity and corruption stood out as the most important factors hampering industrial

development in Nigeria. Although electricity has been an important factor in some failed industries, a vast majority of these industries that have failed or are loss making is due to the tyranny of small decisions by the owners/employers or employees. Even power plants are industries and the failure of power industries in Nigeria to develop is due to the tyranny of small decisions (embezzlement, fraud, and corruption) (Agba and Odu, 2012). Hence, industrial failures in Nigeria could be analyzed in the context of a social dilemma using game theory.

A celebrated case of industrial failure in Nigeria is the Ajaokuta Steel Industry which after massive investment in human resources and infrastructure has failed to successfully take more than 36 years after it was built. The steel complex was very well designed that it was supposed to generate its own power and send the excess to the national grid. But the power plant failed to function and the whole company failed due to corruption. Social dilemmas are situations in which private interests are at odds with collective or group interests. This is usually referred to as the tyranny of small decisions. Such situations arise because people very often attach more importance to their short-term selfish gains than to the long-term benefits of the group, organization, or society to which they belong. Many of the most challenging issues we face, from the interpersonal to the inter-group, are at their core social dilemmas.

Social dilemmas describe situations in which the rational behavior of an individual, which are defined in pure and simple economic terms, leads to sub-optimal outcomes from the collective standpoint (Dawes, 1980; Kollock, 1998). Researchers frequently use the experimental games method to study social dilemmas in the

laboratory to compare theoretical predictions with empirical evidence. Sometimes the experimental results may differ from theoretical predictions (Carmichael, 2005). In fact, in an experiment conducted on prisoner dilemma, players were found to cooperate half of the times (Camerer, 2003). Social dilemmas are in fact a “conflict in which most beneficial action for an individual will, if chosen by most people, have a harmful effect on everyone” (Oliver, 1980; Marwell, 1988; Elster, 1989).

There are three main types of social dilemma. They include tragedy of the commons, prisoner dilemma, and public goods dilemma. The concept of social dilemma has been used to explain many phenomena in various facets of life. In 1982, the estuarine ecologist, William Odum, published a paper where he extended the notion of the tyranny of small decisions to environmental issues. According to Odum, “much of the current confusion and distress surrounding environmental issues can be traced to decisions that were never consciously made, but simply resulted from a series of small decisions” (Odum, 1982). Other writers like Odum have applied the concept of social dilemma to problems in many spheres of life. This work is the first attempt to apply this concept to failed industrial enterprises in Nigeria and all over Africa.

Many industrial enterprises have failed due to the tyranny of small decisions by the employers, management, employees. Industrial organizations are set up for the benefit of all (employer, employee and the whole society). If industrial enterprises fail the whole society is the ultimate loser because people lose their jobs and means of livelihood. In addition to this, the economic growth of the nation is affected leading to more poverty and underdevelopment. This paper sampled some failed industrial enterprises in Nigeria, establishes the general reasons for their collapse, which is most often due to tyranny of small decisions, and modelled their failure in the context of a social dilemma using game theoretic analysis.

Theoretical Background

There are several theories used to analyze and understand the mechanisms and scientific basis of social dilemmas. Such theories are game theory, evolutionary theories, and psychological theories. The basic or fundamental theory used in studying social dilemma is the game theory. The

psychological and evolutionary theories are used as a complementary and reinforcement to game theory to give more insights into game theoretic outcomes. The psychological and evolutionary theories are used to explain why rational agents behave the way they do in social dilemma situations resulting in certain outcomes from the underlying game theoretic model.

Game theory is the study of interaction between rational players where the outcomes depend on the choice of strategy of each player given the opponent’s strategies. Game theory is interested in optimizing outcomes/payoffs for decision makers in strategic situations.

Game theory has witnessed tremendous progress since it was formalized by the outstanding works of John von Neumann and Oskar Morgenstern in 1947 (Nwobi-Okoye, 2011a, Nwobi-Okoye and Okiy, 2018).

John Nash popularized the theory with his famous papers between 1950 and 1953 (Nwobi-Okoye, 2011a). Since then, many types of games have been developed and applied in solving real life problems. Such games include Bayesian Games, introduced by John Harsanyi (Nwobi-Okoye, 2010a), Evolutionary Games, introduced by Maynard Smith (Nwobi-Okoye, 2010a), Virtual games (Nwobi-Okoye, 2009; Nwobi-Okoye, 2010a; Nwobi-Okoye, 2010b; Nwobi-Okoye, 2010c; Nwobi-Okoye, 2011a; Nwobi-Okoye, 2011b), Prisoner dilemma (Nwobi-Okoye, 2011a), etc.

The utility of game theory in modelling complex social interactions has been invaluable in the development of modern management science. Whether in social choice theory, mechanism design etc., game theory has been extremely useful. As a case study in social dilemma, Nwobi-Okoye (2011a) analyzed road traffic problems in Nigeria using game theory. Many solution concepts exist in game theory which guides the decision maker in arriving at an outcome that maximizes his/her utility. The most widely used solution concept in non-cooperative games is the Nash equilibrium (Nash, 1950). The Nash equilibrium solution concept will guide the prediction of players behavior in social dilemma game models developed in this work.

Several have theorized that studying the circumstances or conditions under which people cooperate or defect might lead to

recommendations and suggestions to solve social dilemmas in society (Carmichael, 2005; Nwobi-Okoye, 2011a; McCarter and Northcraft, 2007). According to Nwobi-Okoye (2011a), Kopelman, *et al.* (2002), the literature distinguishes between three broad classes of solutions to social dilemma. These solutions are motivational, strategic, and structural; and they vary in whether the solutions see players as motivated purely by selfish behavior and in whether they change the rules of the social dilemma game.

According to Nwobi-Okoye (2011a), the structural solutions involve changing the structure of the game model used to model the social dilemma. By doing this a new equilibrium point is obtained for the game, and the new equilibrium point will lead to a more efficient game outcome. In this work, the structural solution shall be used.

The Game Theoretic Models

Two models are used in the analysis done in this work. The first model is based on two-person social dilemma (prisoner dilemma) while the second is based on multi-person social dilemma (public goods/commons dilemma).

Model 1: Prisoner Dilemma: The game matrix in Figure 1 shows the prisoner dilemma model that is used to analyze industrial failures as a social dilemma. In this model it is assumed that the employer and employees are opposed to each other. As shown in the diagram, if the employer or employees want to maximize their gains, their preferred strategy would be to adopt defective behaviors. In the long term this would to losses and eventual failure of the enterprise.

Looking at the game matrix in fig. 1, from game theoretic predictions, the equilibrium point is at point D, D. Defective behavior is the dominant strategy for both players, hence, the game theoretic prediction is that both players would defect. This is a prisoner dilemma for both players as they could get better payoffs by cooperating. Hence, it is in the best interest of both players to cooperate. If both cooperate, the employer gets a payoff of 28, while the employee gets a payoff of 8. If both defect, the employer gets a payoff of 22, while the employee gets a payoff of 4. Of course, lower payoffs for both players means that the industrial enterprise is likely bound to fail. This model is characteristics of many failed private enterprises in Nigeria.

The game is symmetric because it is assumed that the employer gets the same payoff as the combined payoff of the employees. If the game is symmetric the generalized payoff structure is shown in Figure 2.

If the game is asymmetric, it is assumed that the employer gets the higher payoff than the combined payoff of the employees. If the game is asymmetric the generalized payoff structure is shown in Figure 3.

The defective behavior by the employer or employee constitutes a trigger strategy and the grim outcome of such a strategy is for the cooperating party to defect forever. The theoretical prediction is supported by my observation of what happens in practice. In many failed industrial enterprises, I found out that once the employer engages in defective behaviors, the employees most of the time respond by starting their own defective behavior. This is akin to tit for tat behavior in prisoner dilemma.

		Employee	
		D	C
Employer	D	22, 4	30, 2
	C	20, 10	28, 8

Figure 1: Sustainable Industrialization as Prisoner Dilemma.

$c > a > d > b$

	D	C
D	d, d	c, b
C	b, c	a, a

Figure 2: Prisoner Dilemma with Symmetric Payoff Structure.

$c1 > a1 > d1 > b1$
 $c2 > a2 > d2 > b2$
 $c1 > c2$
 $a1 > a2$
 $d1 > d2$
 $b1 > b2$

	D	C
D	d1, d2	c1, b2
C	b1, c2	a1, a2

Figure 3: Prisoner Dilemma with Asymmetric Payoff Structure.

If either or both players (employer or employees) engage in cooperative behaviors and the game repeated indefinitely, capturing the situation mathematically as a repeated prisoner dilemma repeated indefinitely we have:

$$EPO_{coop} = a + aP + aP^2 + aP^3 + \dots + aP^n + \dots = \sum_{n=0}^{n=\infty} aP^n = \frac{a}{(1-P)} \quad (1)$$

Here:

P is the probability that the game continues.

EPO_{coop} is the expected payoff from cooperation.

If the employees engage cooperative behavior and the employer engages in defective behaviors, the employees might retaliate by defecting. This tit for tat behavior results to the collapse of the enterprise. Capturing the situation mathematically

as a repeated prisoner dilemma repeated indefinitely, we have:

$$EPO_{defect} = c + dP + dP^2 + dP^3 + \dots + dP^n + \dots = c + \sum_{n=0}^{n=\infty} dP^n = c + \frac{dp}{(1-P)} \quad (2)$$

Here:

EPO_{defect} is the expected payoff from defection.

Since a reasonable decision rule for the players would be to cooperate if $EPO_{coop} > EPO_{defect}$

or:

$$\frac{a}{(1-P)} = c + \frac{dp}{(1-P)} \quad (3)$$

Rearranging (3) leads to:

$$\frac{a-c}{d-c} < P \quad (4)$$

$$\frac{a1-c1}{d1-c1} = P_1^* \quad (7)$$

$$\frac{a2-c2}{d2-c2} = P_2^* \quad (8)$$

$$\text{But } P_1^* > P_2^* \quad (9)$$

The derivation above is a proof of the Friedman's theorem which states that "for any prisoner dilemma where the equilibrium payoff is d where $d < a$, if the discount factor is sufficiently high or close to 1 there exists a sub game perfect equilibrium where the payoff is equal to a" (Gibbons, 1992).

In the asymmetric version of the game we have:

$$\frac{a1-c1}{d1-c1} < P_1 \quad (5)$$

$$\frac{a2-c2}{d2-c2} < P_2 \quad (6)$$

From Equation 9, it could be seen that it is easier for the employer to continue defecting. This explains the scenario witnessed in many private industrial enterprises in Nigeria where the payoff of the employer far exceeds the total payoff of the employees, in this situation, the employer finds it more favorable to continue defecting. As a matter of fact in such organizations, the employee is at the mercy of the employer, and the employer almost takes the employees as slaves.

Model 2: Public Goods/Commons Dilemma:

At critical values of the probability denoted by P_1^* and P_2^* we have:

The game matrix in Figure 4 shows the common goods dilemma model that is used to analyze industrial failures as a social dilemma.

		Employer/Management/Employee	
		D	C
Employer/ Management /Employee	D	30, 30	150, 25
	C	25, 150	100, 100

Figure 4: Sustainable Industrialization as Commons/Public Goods Dilemma.

Here it is assumed that employer, employee, and management are not necessarily opposed to each other. All the actors/parties (Employer/ Management/ Employee) could either cooperate for the common good of the firm or defect by engaging in activities that is beneficial to them, but it is not in the best interest of the firm and makes the firm worse off in the long run, while making themselves temporarily better off. This model is suitable for modeling situation that led to the failure of many public corporations in Nigeria.

Looking at the game matrix in Figure 2, from game theoretic predictions, the equilibrium point is at point D, D. Defective behavior is the dominant strategy for both players, hence, the game theoretic prediction is that both players would defect. This is a commons dilemma for both parties as they could get better payoffs by cooperating. Hence, it is in the best interest of both parties to cooperate. If both cooperate, the management gets a payoff of 100, while the employees get a payoff of 100. If both defect, the management gets a payoff of 30, while the employee gets a payoff of 30.

Non excludability implies that if there is defective behavior, defection continues as long as the organization is a going concern. Defection of one or both parties means that productivity reduces, operating costs increases and profit for the firm lowers.

If both parties want to maximize their payoffs, their dominant strategy is to engage in defective behaviors. In the long term this often leads to low productivity, high operating costs, decreasing profits and eventual collapse and failure of the enterprise. This model is characteristic of many failed public enterprises in Nigeria.

Defective Behaviors in Industrial Organizations in Nigeria

Three major types of defective behaviors could be identified in industrial organizations in Nigeria. These are similar to that identified in supply chains and in other social dilemmas and include: hold up defection, leakage problem and free rider problem (McCarter and Northcraft, 2007).

Hold up Defection: This occurs when the any of the alliance partners tries to claim an unfair share of the value that was created. This occurs in

several industrial organizations in Nigeria where the owners/employers take unfair share of the profits and uses them for profligacy, while the employers live in penury and virtual slavery. For example, some of the entrepreneurs use the unfair share of the profits for:

- a) Reckless taking of chieftaincy titles.
- b) Reckless expenditure on political campaigns.
- c) Reckless purchase of choice properties overseas.
- d) Reckless purchase of expensive and exotic cars.
- e) Donations at public events to attract attention, etc.

Hold-up defections is common with employers/ entrepreneurs due partly to asymmetric nature of the prisoner dilemma game on which their strategic interactions are based as discussed previously. Several Nigerian industrial organizations failed due to this type of defective behavior include but not limited to:

- a) The failure of J. Nwankwu Group of Companies, Abagana, Anambra State, Nigeria.
- b) Adamark Oil Servicing Company, Port Harcourt, Nigeria.
- c) Ferdinand Group of Companies.

This could be avoided by using game theory solutions such as Shapley value, Nash bargaining solution, game theory-based manpower policy development etc. (Carmichael, 2004; Nwobi-Okoye and Igboanugo, 2014).

Leakage Problem: Leakage problem occurs in an industrial organization when either the employer or employee takes the resources of the alliance to set up another business for his own benefit or engages in fraudulent acts that reduces the profitability of the industrial enterprise. This sometimes happens when employees of an organization steal money, tools or equipment to start their own businesses or engage in other fraudulent acts. Some of the defective behavior include but not limited to:

- a) Fraudulent sale of company properties.
- b) Fraudulent conversion of bank loans meant for industrial development for personal use.
- c) Deliberate low productivity to punish management.
- d) Vandalization of company properties.
- e) Fraudulent turn around maintenance (TAM) contracts.
- f) Inflated procurement contract prizes, over invoicing.
- g) Lack of competitive bidding in supply contract award.
- h) Procurement of low-quality spares etc.

In Nigeria several industries have failed due to massive leakages. Most of these industries are public corporations. Some of include:

- a) The failure of Ajaokuta Steel Complex.
- b) The failure of National Fertilizer Company of Nigeria (NAFCON), Onne.
- c) Nigerian Telecommunications Company.
- d) AVOP Vegetable Oil Company, Nachi, Enugu State, Nigeria.

Free Rider Problem: The free rider problem occurs when a party enjoys the benefits and successes of the alliance without contributing to its creation. Several failed industries in Nigeria suffered from the free rider problem. Nigeria is replete with case studies of industries established by visionaries which became prosperous, and the prosperity brought in free riders as directors and workers only for the industry to fail because of the failure of the new entrants to uphold the visions of the founding fathers of the enterprise.

A common free rider problem that bedeviled and contributed to the failure of many industries is the employment and placement of personnel to positions where they are not qualified to hold due non possession of requisite skill and/or experience. Such personnel end up consuming

the resources of the enterprise without contributing anything to its growth and sustainability. Many industries that have failed due to the free rider problem were founded by the colonial masters or independence leaders but with the exit of the founding fathers the new stake holders failed to manage and grow the industries. Examples of such industries include but not limited to:

- a) Nigeria Cement Company Limited, Nkalagu.
- b) Nigeria Coal Corporation, Enugu.
- c) General Cotton Mill, Onitsha.
- d) Warri, Port Harcourt, and Kaduna Refineries.
- e) Ajaokuta Steel Complex.

As a matter of fact, the free rider problem is a common problem in Nigeria where individuals labor to establish a thriving business only to be sidelined later and the business got liquidated subsequently.

Characteristics of Industrial Organizations for Sustainability

Here several key features of industrial organizations and its implications for sustainability are examined. These features are: Asymmetry, extension, repetition, agreement time horizon, rewards and sanctions, communication and Constellational interdependence.

Asymmetry

As discussed in section three, game models used in social dilemma analysis can be symmetric or asymmetric.

Proposition 1: Defective and opportunistic behaviors by employers or employees in an industrial enterprise increases as the asymmetry among the alliance partners increases.

Extension

Industrial enterprises vary in size. Three categories of industries can be identified. They are small, medium and large-scale industries. According to McCarter and Northcraft (2007), many studies have demonstrated that the greater the group's size in public good dilemmas the smaller the probability of effective cooperation.

Proposition 2: The bigger the industrial enterprise, the more likely the tendency for opportunistic or defective behaviors by the employer or employee.

For example, in Nigeria the three giant refineries failed to such an extent that country have to import fuels to meet demands for domestic consumption of fuels. But in recent times the government taking a cue from the success of illegal modular refineries used to refine petroleum products in the Niger Delta Region have legalized the use of modular refineries, and quite recently started issuing licenses for modular refineries to help satisfy domestic demand for fuel consumption.

Repetition

Employer-Employee social dilemma is often a repeated game. The repetition could be finite or infinite as stated above.

Proposition 3: Repetition of defective behaviors by either employer or employee leads to the parties defecting forever, hence more tendencies for industrial failure.

Agreement Time Horizon

Bargaining is an integral component of industrial relations. An important principle in bargaining is that the bargaining parties continue to lose as long as they fail to reach an agreement (Carmichael, 2005). As long as employers don't wait for industrial actions to set in to settle worker disputes, the firm continues to function effectively.

Proposition 4: The time horizon available for the employer and employee to reach agreement on

wages and working conditions determines the chance for success of the enterprise.

Rewards and Sanctions

There should be mechanisms to reward good behavior and punish or sanction defective behaviors by employers and employees. Government and regulators can play a very crucial role in this area. For example, governments can offer firms subsidies or tax rebates for cooperative behavior, while not extending such generosity to defecting employers. Rewards and punishments acts as strong deterrents to tempting short-term benefits of defective behaviors (Dawes, 1980; Kollock, 1998).

Proposition 5: The probability of success of an industrial enterprise increases if there are sanctions or punishment for defective behavior by the employer or employee and rewards for cooperative behaviors.

Communication

Employers and employees need to constantly communicate with each other to help resolve all grey areas in industrial relations. Breakdown in communication often leads to strikes and industrial actions which often cripple productivity. As noted by Hansen and Wernerfelt (1989), effective communications where participatory decision-making technique is adopted is a mark of good management.

Employees who feel that they are properly rewarded with good wages and recognition, and who have leaders/managers who train, help, listen and are experts in their tasks, are more productive (Hansen and Wernerfelt, 1989). Katz et al. (1983) advocated what they called communication-motivation-commitment cycle where the workers who effectively communicate with their employers and participate in decision making processes have increasing commitment to the job and the firm. Also, effective communication has been found to increase the financial performance of firms (Addison and Belfield, 2001). According to McCarter and Northcraft (2007), many studies in social dilemma have shown that increased communication

among individuals increases the frequency of cooperation.

Proposition 6: The probability of an industrial enterprise succeeding depends on the level and frequency of communication between the employers and employees.

Constellational Interdependence

According to McCarter and Northcraft (2007), there is tendency for participants in a social dilemma to belong to more than one group at the same time. For example, an entrepreneur may own more than one industry. This is usually the case with some business moguls who have controlling interest in several industrial enterprises. Similarly, workers, usually contract worker, sometimes have more than one employment contracts with more than one industrial enterprise.

Proposition 7: The probability of an employer or employee defecting increases if the employer has another industrial enterprise or the employee works in more than one organization.

RESULTS AND DISCUSSION

It is been shown that a lot of industrial failures in Nigeria and indeed some parts of the world could

be modelled and analyzed in the context of social dilemma. Small decisions taken by the employer/management and employees which though rational do not consider the overall interest of the enterprise. Consequently, over time the enterprise sinks and goes under with the attendant loss of jobs for the workers and the managers.

One big question therefore arises. How can this disastrous outcome be avoided? As this paper has mentioned earlier, one method of solving the problem of social dilemma is through structural change to the underlying game. A very good structural solution approach which could be used to solve social dilemma problems is the adoption of mechanism design. Mechanism design is increasingly being used by social choice planners to obtain desirable outcomes that would improve social welfare. In this context using mechanism design, the principal (government regulator), would design a mechanism which would make it in the best interest of the players to cooperate and hence a most efficient outcome is obtained.

One method of changing the structure of this social dilemma game is by rewarding cooperative behaviors and punishing defective behaviors which motivates both the employees, management, employers to cooperate. A regulator such as government could be used to achieve this. This scenario changes the game structure to a non-commons/prisoner dilemma as shown in Figure 5.

	D	C
D	10, 10	75, 40
C	40, 75	120, 120

Figure 5: Sustainable Industrialization as Non-Commons/Public Goods Dilemma.

As shown in Figure 5, the dominant strategy equilibrium point is (C, C). Hence, it is favorable to both parties to cooperate.

One way of achieving cooperation is through the enactment of strong labor laws. At the moment the labor laws in Nigeria are too weak to protect the workers. Even where the laws are good, their implementation is very work. For example, in the oil industry in Nigeria, the regulator (NNPC) has good labor regulations designed to protect oil workers from exploitation, but bribery and corruption has made it impossible to implement them in the oil industry in Nigeria.

CONCLUSIONS

The decisions we make today determines our future wellbeing. A deep understanding of the science of decision making and human judgment, if harnessed properly, will enable us to make better decisions for the collective good of the society. Industries are invaluable for economic growth and societal wellbeing. If industrial enterprises fail economic growth is hampered and poverty increases. It is therefore in the best interest of individuals and government that our industrial organizations continue to thrive and prosper indefinitely. The game theoretic analysis done in this work has given us an insight into why some industrial organizations fail.

Armed with the analytical tools used in this work industrial failures could be controlled by employing appropriate control mechanisms and problem solutions recommended in this work. The analysis done in this work will be very useful to game theorists, systems engineers, economists, psychologists and sociologists who are actively involved in the science of decision making and its consequences on the society

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