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# COHERENCE

VOLUME 3 | SEPTEMBER 2021

*(A collection of Articles by the Teachers and Students)*

**SCIENCE SECTION**



**THE BHAWANIPUR**

THE BHAWANIPUR EDUCATION SOCIETY COLLEGE

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# From the Desk of the Editor

We would like to present with great pleasure “COHERENCE”, our Scientific Journal encompassing all the Departments of Science like Physics, Chemistry, Mathematics, Computer Science, Electronics, Economics, Statistics and Environmental Science. This issue (Volume 3, September 2021) comprises of Scientific articles contributed by the Departments of Physics, Chemistry, Computer Science and Economics.

The main objective of publishing this Journal is to encourage the undergraduate students to express their thoughts, views and ideas also in different fields of Science. All the articles are written by the Teachers and Students focussed and highlighted new and emerging trends in Science. All the articles are beautifully photographed and illustrated. Most of the articles are well illustrated with explanatory pictures and diagrams. Articles are thoroughly checked and presented under direct supervision of concerned Science Faculty members.

Readers interested in advancement in Science and Technology would enjoy reading our Journal. We convey our sincere thanks to Teacher in-Charge and Management of our college for their encouragement and financial support.

**Samir Kanti Datta**

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# Message



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### Message

It is my great pleasure to know that the teachers and students of the Science Section of our college have taken the initiative to publish the departmental journal "COHERENCE" through their collective effort to focus the contemporary scientific views and thoughts. This journal will be of interest to promote the ideas and values in the day to day scientific development in the modern era of innovative research in every aspects of life.

I convey my sincere thanks to all the Teachers and Students of the Science Section and wish to broadcast their ideas in future.

*S. Gangopadhyay*  
**Dr Subhabrata Ganguly**  
Teacher in Charge  
The Bhawanipur Education Society College

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# Meatalloinfluence in medicine

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## Abstract

Metals are essential cellular components selected by nature to function in several indispensable biochemical processes for living organisms. Metals are endowed with unique characteristics that include redox activity, variable coordination modes, and reactivity towards organic substrates. Due to their reactivity, metals are tightly regulated under normal conditions and aberrant metal ion concentrations are associated with various pathological disorders, including cancer. For these reasons, metal complexes, either as drugs or prodrugs, become very attractive probes. Finally, based on the interface between molecular biology and bioinorganic chemistry the design of metal complexes in medicinal field is evaluated and design strategies and mechanisms of action are discussed.

**Key words:** Metals; Medicine.

## Introduction

Metals play crucial roles in life processes. It is increasingly recognized that metals are involved in cellular and subcellular functions. With the application of new and sophisticated machines to study biological and biochemical systems the true role of inorganic salts in living systems can be revealed. Today, it is known that metals are important ingredients in life, just as the organic molecules. For instance, the divalent magnesium and calcium ions play important regulatory roles in cells. Metallothionins are proteins rich in metal ions found in living systems. For example, the divalent cations  $Zn^{2+}$ ,  $Ca^{2+}$  and  $Mg^{2+}$  prevent cytotoxicity and in vivo antagonize Cd-induced carcinogenesis. Lack of body iron is common in cancer patients and it is associated with complications in surgery and in animal experiments. The transport of iron and other metal ions by the blood plasma is achieved through the formation of protein complexes. Copper is recognized as an essential metalloelement and is primarily associated with copper-dependent cellular enzymes. Metals are also used as inorganic drugs for many diseases. This field in medicine may usefully be divided into two main categories-

1. Drugs, which target metal ions in some form, whether free or protein-bound.
2. Metal-based drugs where the central metal ion is usually the key feature of the mechanism of action.

Finally, we will report on the developments of models for the metal ion sites found in metal complexes of single metal ions with organic ligands having as donor atoms, oxygen, nitrogen, sulfur or phosphorous donor atoms. Molecular models were originally developed for the conformational analysis of organic compounds.

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Any consideration of the uses of inorganic chemistry in medicine must bridge at least two areas: -

### **Bioinorganic chemistry and medicinal chemistry**

Bioinorganic chemistry is best considered as understanding all aspects of the role of metal ions in biology and has been traditionally heavily involved in understanding their processing, incorporation into protein and the nature and function of metalloproteins.

In a 'steady- state' environment all essential are incorporated in the right place at right time and the organism functions normally. Alternatively, genetic factor may lead to failure to incorporate and subsequent metabolic disorders may be caused by free metal ions<sup>1</sup>.

Medicinal chemistry requires intimate knowledge of the metabolism and stability, as well as target interactions of the drugs. Most mechanistic work is performed in tissue culture or with isolated proteins, DNA and/or RNA. In tissue culture assays to measure the efficacy of a potential drug in inhibiting cell growth, the drug is usually in direct contact with medium throughout the experiment. There is not always a direct extrapolation to the clinically relevant in vivo situation when biodistribution and pharmacokinetics play an increasing important role in determining drug efficacy.

Many compounds with exciting in vitro results have failed to display the same promise in vivo. Nevertheless, the mechanistic information of tissue culture experiments is very useful and aside from target interactions may also inform on approaches to in vivo efficacy.

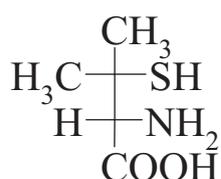
Finally, medicinal chemistry distinguishes between drug acting by a pharmacodynamic mechanism and chemotherapeutic drugs<sup>2,3</sup>.

In the former case, the drug action must be rapid and essentially reversible. A patient who submits to an anaesthetic does not expect to be deprived of feeling of forever. Further, a graded response is required to balance effects-a drug to reverse a stroke must be aware of the severity of the stroke and concentrations adjusted accordingly. Chemotherapeutic agents on the other hand involve cell killing, an irreversible process.

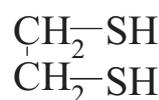
### **Metal ions in diseases**

It is well understood that many metals are essential for the human organism and endogenous concentrations of these metal ions are very important. However, a corollary of this situation is that uncontrolled mobilization may lead to presence of excess free metal ions, with subsequent health problems. The classic examples are those of iron and copper overload. Wilson's disease is an autosomal disorder of copper accumulation. If untreated, it becomes inevitable fatal and destroys life.

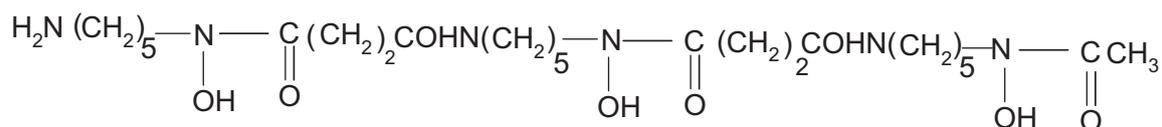
The treatments of copper and iron overload by clinically used chelating agents are well documented by typical examples are shown in bellow-



D - Penicillamine



Cysteamine



Desferrioxamine B

### Metalloproteins as drug targets

A more recent and relates question to the specificity of chelating agent is that of metalloprotein targets. It is well known that many metalloproteins and metalloenzymes play vital metabolic roles as well as being critical in genetic information transfer. Drug design and discovery relies more and more on the elucidation of the three-dimensional structure of a target by X-ray crystallography or NMR methods, followed by modeling and synthesis of potential inhibitors of the protein or enzyme active sites. Metalloproteins are being increasingly recognized as drug targets.

Ribonucleotide reductase, the diironenzyme essential for de novo synthesis of deoxyribonucleotides for DNA synthesis has long been recognized as a drug target. The pharmaceutical and chemical properties of chelating thiosemicarbazones and their potential interference with the active site iron moieties has been extensively studied.

A current and very relevant example is zinc. Zinc is the second most prominent trace metal in the human body after iron. While deficiency of zinc may cause growth effects, few noxious effects of excess zinc have been observed and zinc per Se is probably one of the least toxic metals.

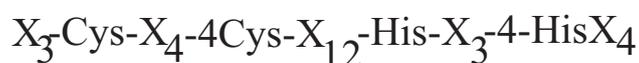
Zinc is involved in a large number of enzymatic functions, fulfilling both structural and catalytic roles. These functions include DNA transcription and regulation, as well as oxidation and hydrolysis, cleavage of peptide bonds as well as formation of phosphodiester bonds. Because Zn is not redox active its catalytic functions derive from its properties as a Lewis acid. More recently, zinc proteins have been recognized as attractive targets for chemotherapy.

Especially, there are two principal areas of interest in pharmaceutical laboratories – inhibition of matrix metalloproteinase enzymes such as collagenase as an approach to treatment of metastatic cancer and inhibition of zinc finger activity as a novel chemotherapeutic attack against HIV infectivity. These apparently diverse goals are united by the common feature that the active site Zn in both cases the target of attack.

### Zinc and human immunodeficiency virus

#### Zinc finger as medicinal target

The role of the zinc in transfer of genetic information is believed to be structural, deriving from the specific conformations protein adapt upon complexation by the metal. Many transcription factors (required for RNA transcription) contain zinc. The existence of metal-binding domains in regulatory proteins was first postulated because researchers noted that the systematic repeats of Cysteine and Histidine residues in



suggested a role for metal binding. Model building suggested that zinc binding to His and Cys folded the

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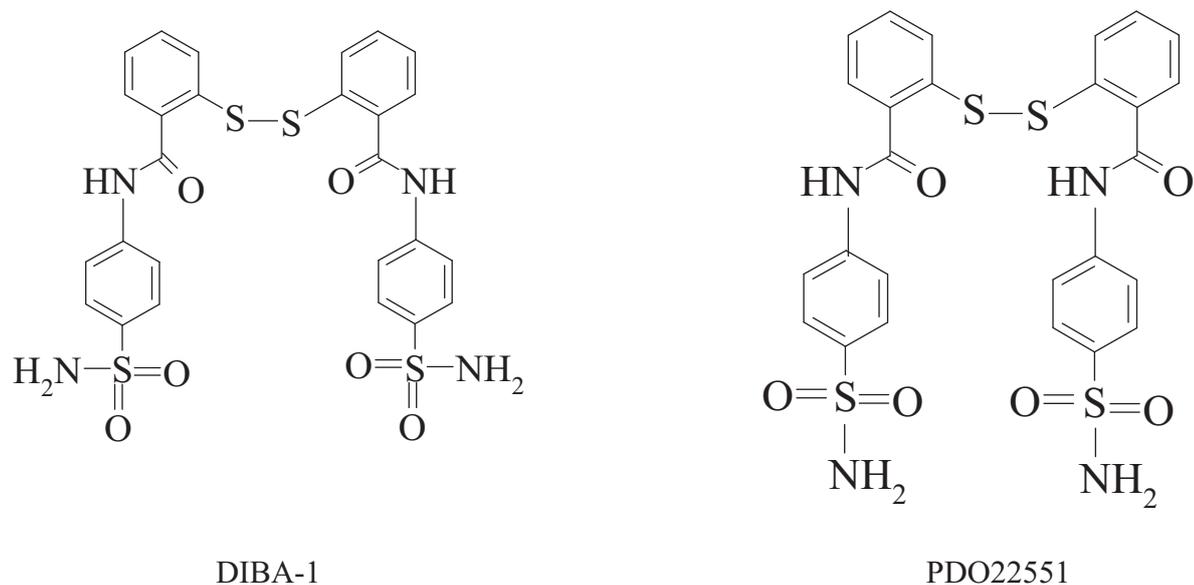
protein into a conformation, which repeated like “FINGERS”.

X-ray crystallographic evidence has now been obtained for such structures.

The human immunodeficiency virus type 1 (HIV-1) is the etiologic agent of acquired immune deficiency syndrome (AIDS). Effective therapies of AIDS are still urgently required, despite the intense effort and screening of nearly 220,000 natural and synthetic agents during the last 15 years. Currently, combination therapy using especially Purine and Pyrimidine analogs such as ddC, ddI and AZT in conjunction with protease inhibitors is a promising approach to achieve permanent therapeutic effect. Part of the rationale behind combination therapy has been to use drugs which act on different parts of viral cycle, thus limiting development of resistance once. However, new effective therapies producing long lasting permanent effects against HIV infectivity are still urgently needed.

As such, new targets within the viral cycle need to be identified and understood on a molecular basis to allow development of drug design strategies.

A relatively recent target for drug design has been the zinc fingers of the nucleocapsid protein. A principal approach is to design chelating agents such as dithiobenzamides (DIBAs, see below) which chemically modify the zinc finger cysteine residues resulting in Zinc ejection from the fingers with resultant inhibition of HIV replication<sup>4</sup>. These results serve as a basis for further rational target-based drug design.



### Metal based chemotherapeutic drugs

Chemotherapy is the use of drugs to injure and invading organism without injury to the host. The definition therefore covers the anti-bacterial, anti-viral and anti-cancer agents. In the first two the invading organism is clearly distinct from the host.

In the case of cancer, a family of diseases characterized by uncontrolled cellular proliferation, the organism is strictly not different but the treatment has a common aim, that of elimination of unwanted

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cells. Thus chemotherapeutic drugs, in contrast to pharmacodynamic drugs, must induce an irreversible cytotoxic effect.

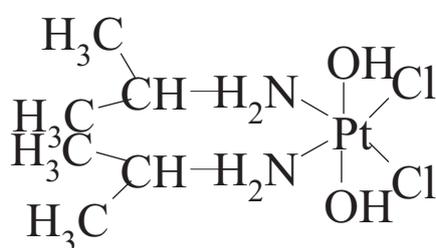
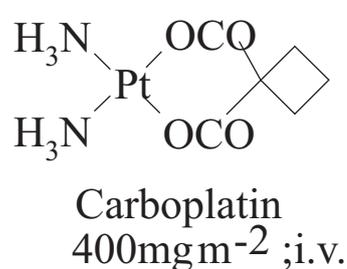
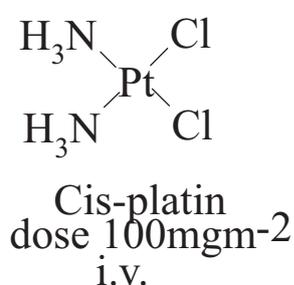
By far the greatest success of inorganic chemotherapy is the advent of cis-platin and carbo-platin into the clinic.

### Anti-cancer drugs based on platinum

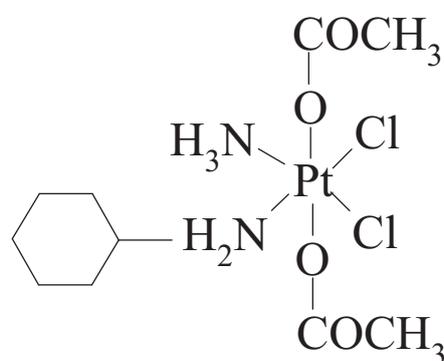
*cis*-platin [CDDP, *cis*-diamminedichloroplatinum(II)] and its analogue *carbo*-platin [CBDCA, *cis*-diammine(1,1 cyclobutanedicarboxylato) platinum(II)] are among those most frequently used today.

The discovery of *anti*-tumour properties of CDDP was accidental by Barnett Rosenberg while investigating the effects of electric field on bacteria.

*cis*-platin was introduced into clinical practice in 1971 (five years after the initial discovery of its cell killing properties) and less toxic analogue Carbo-platin, in 1981. To date, Carbo-platin is the only platinum analogue to have received worldwide registration.



Iproplatin



JM 216

The dramatic impact of the cis-platin has been observed in men presenting with testicular cancer. Before 1975 the cure of such patient was rare. Following the introduction of CDDP into a regimen also containing vinblastina and bleomycin (PVB regime) around 85% of these patients now are cure of disease.

Initial studies at the Royal Marsden Hospital (UK) by Wiltshaw and colleagues established that cis-platin also conferred promising activity against ovarian cancer.

Combination regimens including cis-platin (typically with cyclophosphamide) produce clinical complete remission in approximately 50% of patients with advanced disease. Numerous clinical trials have demonstrated that carboplatin is substantially less toxic (especially in terms of nephrotoxicity and gastrointestinal effects) than is CDDP. Urinary Pt excretion 16-35% compared to 65%.

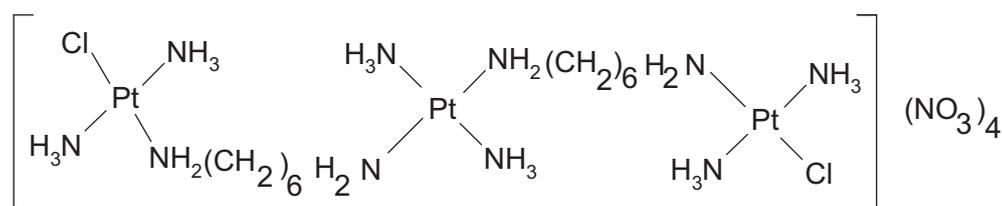
Despite the synthesis of many hundreds of CDDP analogues over the past 20 years. There have been few leads to the discovery of novel Pt drugs capable of circumventing tumor resistance to cis-platin/carboplatin.

JM216 has now undergone phase I clinical evaluation according to both single dose and daily X 5 schedules. [JM216, bis(acetato) (amine) (dichloro)-cyclohexylaminePt(IV)]. In agreement with the rodent data, myelosuppression has been the dose limiting toxicity, with no observation of nephro- or neurotoxicity. Worldwide phase II/III clinical trials are now going on. The compound is orally active.

### Mechanism of action

The cell killing effects of *cis*-platin and Carboplatin appear to be due to the formation of various stable bifunctional adducts on DNA which then block replication or inhibit transcription. Supporting evidence for DNA as the critical target for the anti-tumor activity of *cis*-platin is provided by observations that cells from patients with diseases where DNA repair processes are deficient (e.g. Xeroderma pigmentosum) are hypersensitive to *cis*-platin.

In early 1998 a novel trinuclear Pt compound BBR 3464, entered phase I clinical trials, the first genuinely new Pt-agent not based on the 'classical' *cis*-platin structure to do so.



BBR 3464

There are now more than 40 drugs approved for treatment of human cancer in USA. Among them are two drugs that require a metal ion as part of their structures. One is the simple metal complex CDDP and other, bleomycin, is a natural product that must form an iron complex to display cytotoxicity. In addition to anthracycline natural products, doxorubicin or adriamycin and daunomycin may also function as iron complexes or utilize cellular iron in an indirect way in the mechanism of action.

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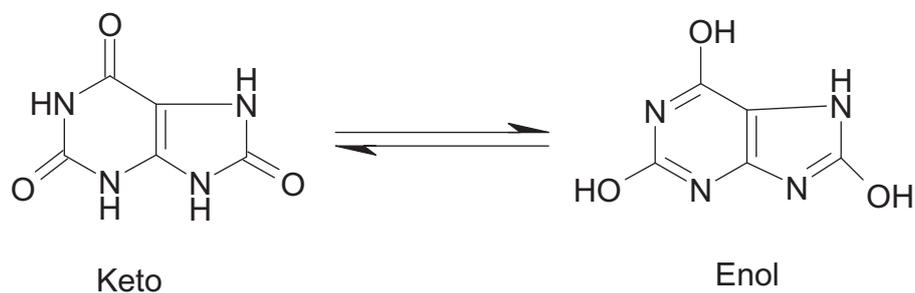
Bleomycin is a natural product regularly used in combination chemotherapy. The left side of the structure contains a versatile metal binding domain probably composed of five-labeled nitrogen. The right includes a bithiazole moiety and a positively charged variable R group, which can bind to DNA. The role of the disaccharide unit has yet to be established.

### Biomedical uses of lithium

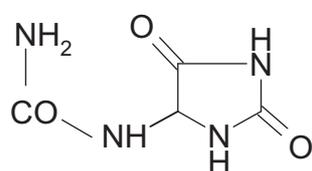
Lithium occurs naturally in biological tissues and hence is incorporated into foodstuffs. It occurs widely in drinking water usually in low concentrations. Natural water that contains higher concentrations of this and other metals frequently are designated “mineral water” with supposed medicinal properties. Li was first used for the treatment of gout. Garrod (1859) first described its medical use in detail and particularly mention the use in “brain gout” a depressive disorder. Lithium ureate is the most soluble salt of uric acid and hence was expected to increase uric acid excretion to relieve gout symptoms. Lithium’s clinical value in psychiatry was discovered in 1949 by Cade, an Australian psychiatrist. It has been established that about 500000 patients receive it worldwide.

Lithium carbonate used specially for prophylaxis or prevention of recurrent mood changes in patients suffering from manic depressive psychoses.

Lithium is a very safe drug in experienced hands. The ability of Lithium to reduce or abolish recurrent mood swings has undoubtedly improved immensely the quality of life of many patients and their families and saved the lives of many who would otherwise have been led to suicide.



### URIC ACID



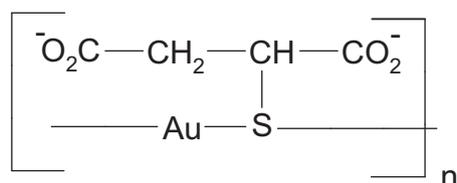
### Allantoin

The miscible pool of ureate in the body is about 7.2 mmol (1200mg) of which there is a turnover of about half daily, i.e. 600mg is formed daily and about the same amount lost of which about 70% to 75% is excreted in urine about 20% destroyed by bacteria in colon. Urate is also formed from purine containing

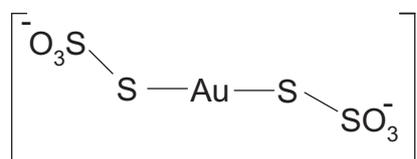
compounds present in food. Richest are the organ meats liver, heart and kidney, then muscle meat. Recently, the anti-viral drug zidovudine (AZT) has been used extensively in the treatment of AIDS, but its effectiveness is limited by the myelo suppression and bone marrow toxicity that it induces. Lithium when joined with AZT significantly reduces the myelosuppression and marrow toxicity of AZT. Animal receiving AZT alone showed anemia, thrombocytopenia and neutropenia, which were dose, related which were prevented by combination with Lithium.

### Gold complexes

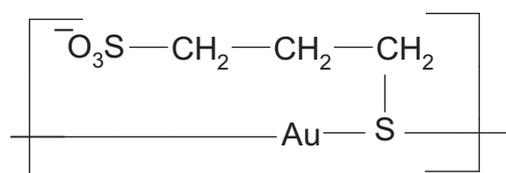
In current medical practice, chrysotherapy, the treatment of rheumatoid arthritis with gold-based drugs is well established. It derives its name from chryses, a golden haired heroine of Greek Mythology. Five Gold(I) complexes are widely used throughout the world in these treatments. Thiomalato gold(I), Thioglucose gold(I) and Thiopropanolsulfonate gold(I) are oligomeric complexes that contain linear gold(I) ions connected by bridging thiolate ligands. Bis(thiosulphate)gold(I) contains gold bound to the terminal sulphur donor atoms of  $S_2O_3^{2-}$ . The newest drug, auranofin contains coordinated triethyl phosphine 2,3,4,6-tetra-o-acetyl- $\beta$ -1-D-thioglucose ligands.



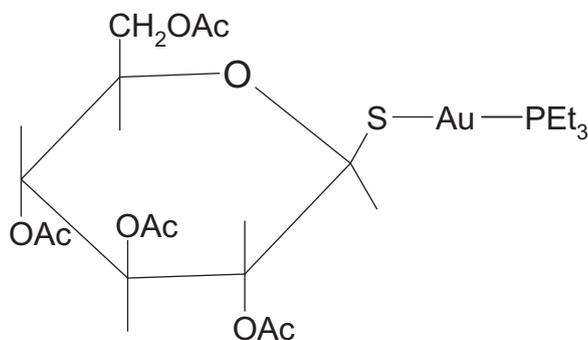
AuSTm= Gold(I) Sodium  
Thiomalate(myochrysin)



$\text{Au}(\text{S}_2\text{O}_3)^{-3}$   
Sodium bis(thiosulphato)gold(I)  
(Sanochrysin)



AuTpS= goldthiopropanolsulphonate  
(allochrysin)

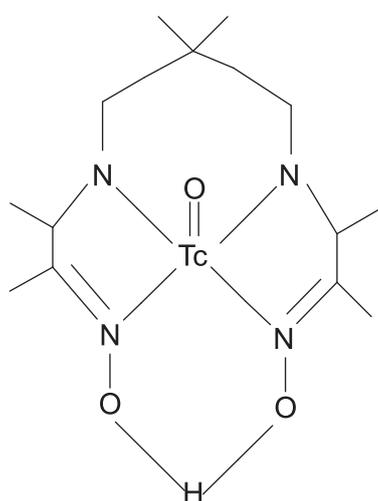


Auranofin

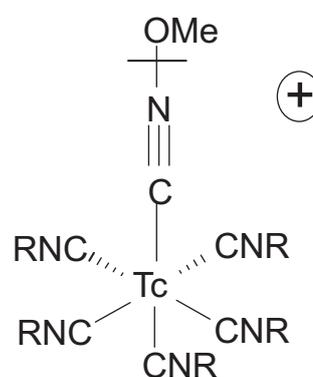
Rheumatoid arthritis is an inflammatory condition that leads to progressive erosion of the articular cartilage lining the interfaces of bones in joints. If the disease is not checked, the bones will eventually fuse after complete loss of the cartilage. In 30% patients mild side effects are observed (e.g. skin rashes).

### Metal complexes as diagnostic agents

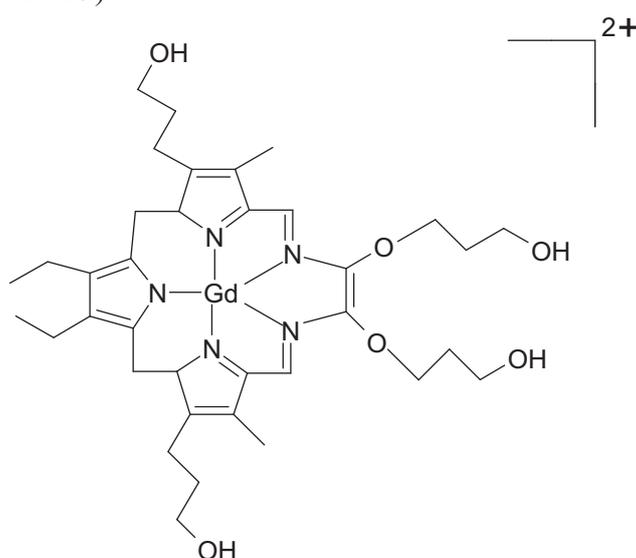
A further subset of inorganic drugs in medicine is comprised of diagnostic agents. In this application, no pharmacodynamic or Chemotherapeutic end is desired. Rather imaging of tissue is achieved. The principal sets are Technetium based imaging agents and paramagnetic MRI contrast agents. Gadolinium(III) containing MRI contrast agents are the most commonly used for enhancement of vessels in MR angiography or for brain tumor enhancement associated with the degradation of the blood-brain barrier. To consider for clinical development of imaging and contrast agents similar studies to those for drugs are required. The stability and water solubility are of paramount importance. Clearly, the agents must be relatively unreactive and not be rapidly metabolized or degraded. Finally, clearance of the agents must also be relatively rapid.



Tc- (HMPAO)



Tc-(MIBI)



Gd based MRI contrast agents

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## Conclusion

The field of medicinal inorganic chemistry is rapidly advancing. In particular metal ions have much potential as therapeutic and diagnostic agents. The establishment of structure–activity relationships and elucidation of the speciation of metal complexes under conditions relevant to drug testing and formulation are crucial for the further development of promising medicinal applications. In this paper, we have highlighted numerous cases where metals have made a positive impact on the field of medicinal inorganic chemistry. As our understanding of biological processes and disease physiology improves, opportunities for the design of new metal-based and metal-binding agents will arise.

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# Chemical Explosives

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## Abstract

Explosive devices may be chemical, mechanical or atomic. Among the vast majority of explosives, most are chemical explosives. Explosives mostly have fewer amounts of potential energy than fuels, but their high rate of energy release produces a very high blast pressure. Chemical explosives may be either liquid, gas or gel based. Mainly they are compounds of C (carbon), H (hydrogen), N (nitrogen) and O (oxygen). Trinitrotoluene [ TNT ( $C_7H_5N_3O_6$ )], pentaerythritol tetranitrate [ PENT ( $C_5H_8N_4O_{12}$ )], RDX ( $C_3H_6N_6O_6$ ) etc are commonly used chemical explosives. These explosive chemicals are used in making bombs, gun powders, dynamites and other detonation devices. Apart from chemical explosives, there is another source of explosion, nuclear explosion, which is more vigorous than chemical explosives. Explosive chemistry has its own boon and curse in human lives.

**Key words:** Explosives, history, different chemical explosives, applications

## Introduction

An explosion is a rapid increase in volume and sudden release of energy in an extreme manner, usually with the generation of high temperatures and the release of gases. Explosions are made by the use of different chemicals called explosives. An explosive (or explosive material) is a reactive substance that contains a great amount of potential energy that can result in an explosion, usually accompanied by the production of light, heat, sound and pressure.

An explosive charge is a measured quantity of explosive material, which may be composed of a single ingredient or a combination of two or more. The potential energy stored in an explosive material may, for example, be i) chemical energy, such as nitro-glycerine or grain dust. ii) pressurized gas, such as a gas cylinder or aerosol can and iii) nuclear energy, such as in the fissile isotopes uranium-235 and plutonium-239.

## Theory of Explosives

In general explosive has three basic characteristics as mentioned below:

- i) It is a chemical compound or mixture ignited by heat, shock, impact, friction, or a combination of these conditions.
- ii) Upon ignition, it decomposes rapidly in a detonation.
- iii) There is a rapid release of heat and large quantities of high pressurised gases which expand rapidly with sufficient force to overcome confining forces.

A general theory of explosives is that the detonation of the explosives charge causes a high velocity shock wave and a tremendous release of gas.

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In an explosion, the released energy is generally measured in a unit of energy, like joules. Instead, sometimes, the size of the explosion is also measured based on how many tons of TNT it would take to produce a similarly-sized explosion. One gram of TNT, or trinitrotoluene, has an explosive energy of somewhere between 2000-6000 joules, depending on the composition and density. To make it more useful as a quasi-scientific unit, that energy level was fixed at 4686 joules per gram.

### **History**

At its root, the history of chemical explosives lies in the history of black powder also known as gunpowder. During the Tang Dynasty in the 1044, Taoist Chinese alchemists accidentally made an explosive gunpowder which was made from coal, saltpetre (commonly known as Potassium nitrate,  $\text{KNO}_3$ ) and sulphur in 1044 and started to use it in warfare by 1161. The blackpowder was first used in civil engineering during 1548-1572 for dredging of river in Northern Europe. Then it was also used for blasting of copper mines in Germany. One of its shortcomings was that it was sensitive to water and produced copious amount of dark smoke.

Liquid Nitroglycerin, another important chemical explosive, which was stronger than gunpowder was developed in 1846 by an Italian professor Ascanio Sobrero. In 1888, Swedish chemist, Alfred Bernhard Nobel developed Ballistite (a mixture of nitrocellulose, nitroglycerine, benzene and camphor), the first smokeless powder. From this Ballistite, Alfred Nobel discovered dynamite, more powerful explosive on addition of ammonium nitrate in it.

François Eugène Turpin, a French chemist showed that picric acid (trinitrophenol) can also be used as explosive. Later picric acid was accepted all over the world as the basic explosive for military uses. Joseph Wilbrand first prepared TNT (trinitrotoluene), another important explosive in Germany. In 1902, TNT was adopted for use by the German Army replacing picric acid. In 1912 the US Army also started to use TNT. By 1914, TNT became the standard explosive for all armies during World War I.

Major research programs were initiated to find out new and more powerful explosive materials after World War-I. From these programs cyclotrimethylenetrinitramine [(RDX)( $\text{C}_3\text{H}_6\text{N}_6\text{O}_6$ )] also called Cyclonite or Hexogen, and pentaerythritol tetranitrate [(PETN) ( $\text{C}_5\text{H}_8\text{N}_4\text{O}_{12}$ )] were developed. Baronal (mixture of Barium nitrate, TNT and aluminium), H-6 (45% RDX, 30% TNT, 20% aluminium and 5% wax), Pentolites (50% PETN and 50% TNT), Tetrytols (70% Tetryl and 30% TNT) PVA-4 (90% RDX, 8% PVA and 2% dibutyl phthalate) etc were mostly used explosives in World War-II. Two nuclear explosives containing mixtures of Uranium and Plutonium were respectively used at the bombings of Hiroshima & Nagasaki.

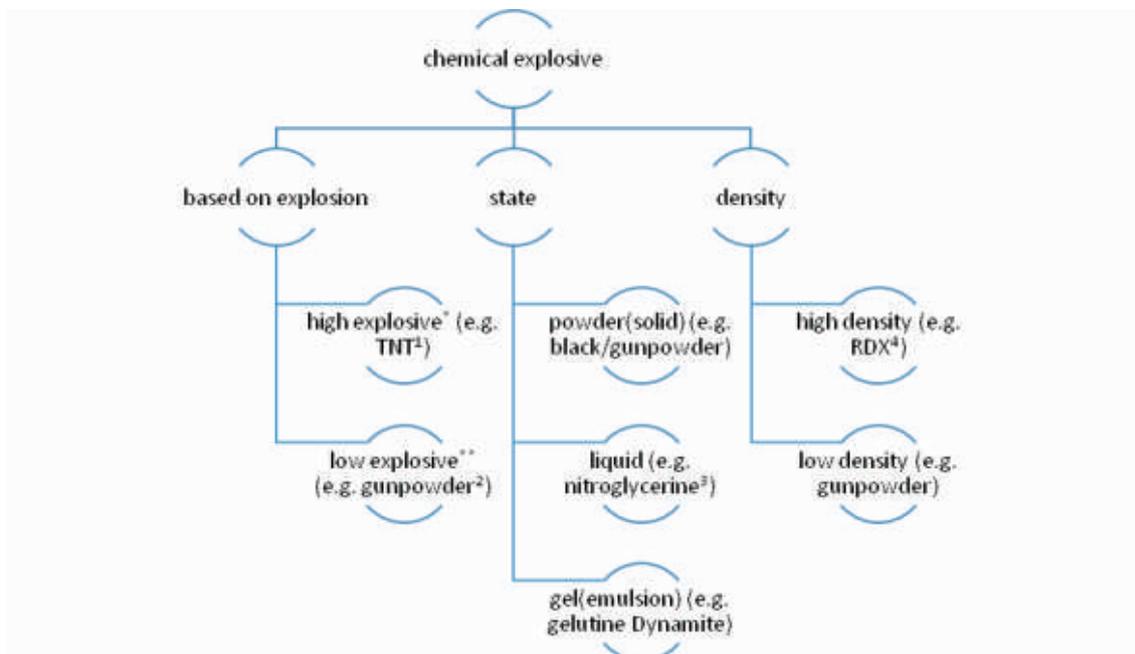
Polymer bonded explosives (PBXs) were developed to reduce the sensitivity of the newly synthesized explosive embedding the explosive crystals in a rubber-like polymeric matrix. The first PBX composition was developed at the Los Alamos Scientific Laboratories in USA in 1952 where RDX crystals were embedded in plasticized polystyrene. HMX (Acetyl-formyl-2,2-dinitropropanol (DNPAF) in polyurethane), PETN (Butyl rubber with acetyl tributylcitrate), RDX (Polyisobutylene/Teflon, polytetrafluoroethylene) etc are different types of synthesized PBX.

### **Classification**

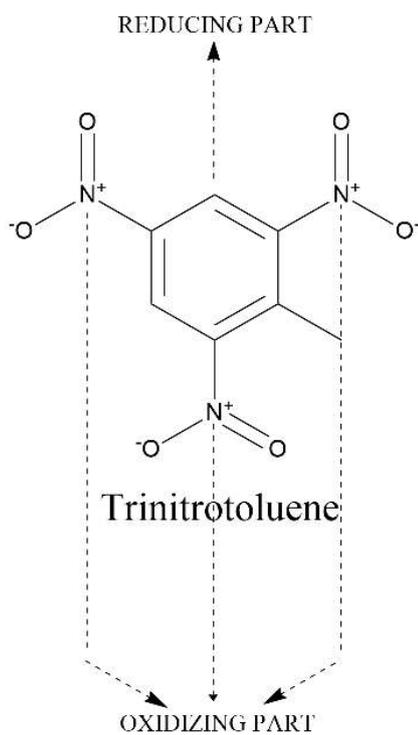
Chemical explosives can be classified into different categories based on three broad areas like i) based on

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explosion, ii) state of explosives & iii) density of explosives as mentioned in the diagram below.



**Diagram-1:** Different types of explosives



**Diagram-2**

**\*\*Low Explosives:** Low explosives deflagrate rather than detonate. Their reaction velocities are 2000 to less than 3000 feet per second. They release a large amount of energy, but due to the relatively slow rate of reaction the energy is more useful as a propellant where the expansion of the gases is used to move projectiles will not shoot at all.

**\*High Explosives:** A high explosive is any chemical mixture that detonates with a reaction velocity over 5000 feet per second. By contrast, a 'high explosive' like trinitrotoluene (TNT), has oxygen as part of the single, explosive molecule. TNT explodes by a fast monomolecular reaction, and its speed of ignition is several kilometres a second. They are used solely for their destructive power.

**Chemistry behind explosion**

A chemical explosive can be decomposed by heat, by shock or by the hit of wave. The explosion reaction is entropically highly favourable as explosive compounds are mainly composed of C (carbon), H (hydrogen), N (nitrogen) & O (oxygen).

Explosion leads to the formation of C, H<sub>2</sub>O, CO, CO<sub>2</sub>, N<sub>2</sub>, O<sub>2</sub>.

For example, the following reaction is taking place during explosion of TNT.



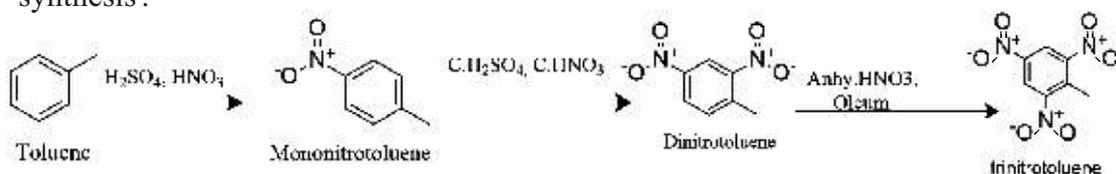
The reaction is highly exothermic ( $\Delta H = -ve$ ). So it produces high amount of energy.

There are few explosives which are involved with a limited set of simple reactions. They mainly involve oxidation-reduction reactions. In most of the explosives the molecules have co-existence of a reducing part (the poly ring system) and an oxidizing part (nitro group) as shown in the Diagram 2.

### Some explosives and their applications

#### i) TNT (trinitrotoluene)

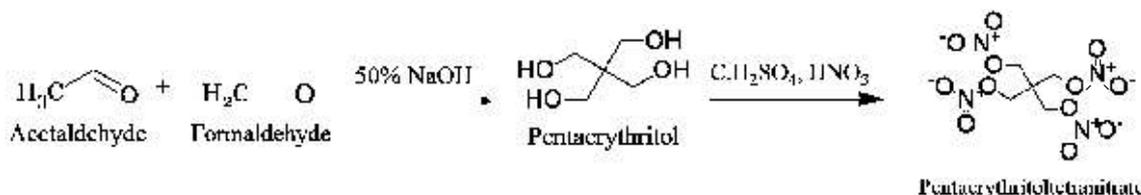
- mw-227
- Def-(-54.39)kj/mol
- synthesis:



- Used mainly as booster i.e. intermediate high explosive. TNT is used for explosion in military, industrial and mining applications.

#### ii) PETN (pentaerythritol tetranitrate)

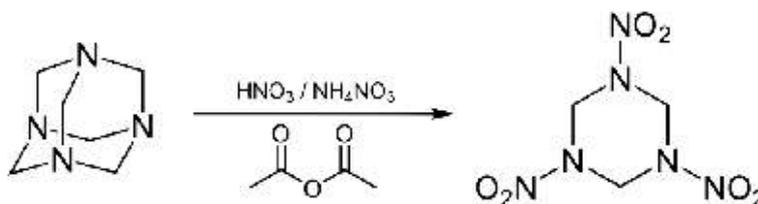
- mw-316
- Def-(-514.63)kj/mol
- synthesis:



- Used as booster i.e. intermediate high explosive. It also used in several explosives mixture. It is used in exploding – bridge wire detonator for the atomic bomb.
- It has also have some medical use. It is used as vasodilator in treatment of heart.

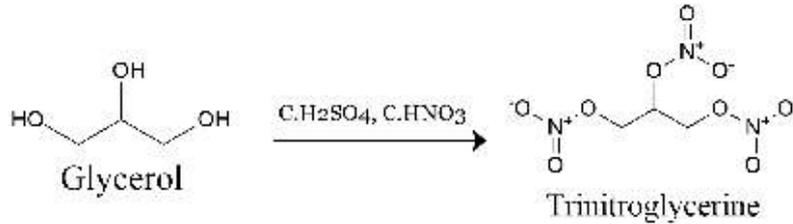
#### iii) RDX (research department explosive)

- chemical name:-1,3,5-trinitro-1,3,5 triazine
- mw :- 222
- Def:- 83.82 kj/mol
- synthesis



- RDX is used as secondary high explosive i.e. main charge. There are too many explosive mixtures where this compound is highly used.

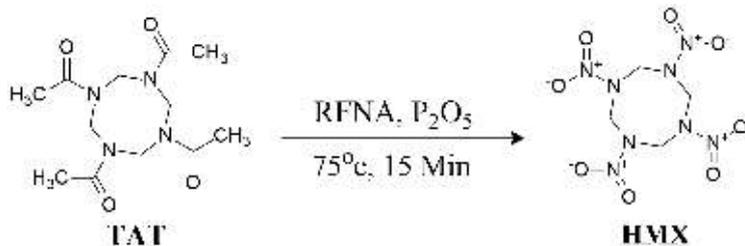
iv) **Nitroglycerine**



- used as booster i.e. intermediate high explosive. It is mainly used in various explosive mixture and bombs also.
- It has also medical value. Nitroglycerine is used for angina pectoris, a painful symptom of heart disease caused by inadequate flow of blood and oxygen to the heart.

v) **HMX (His majesty's explosive)**

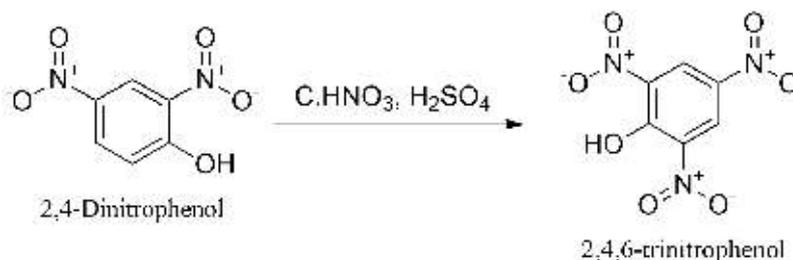
- chemical name :- octogen
- mw :- 296
- Def:- 104.71 kj/mol
- synthesis:



- use as booster i.e. intermediate high explosive. It has a huge use in military and civil.

vi) **Picric acid**

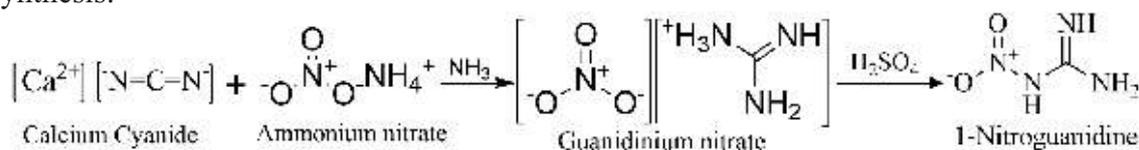
- Chemical name:- 2,4,6-trinitrophenol
- Molecular weight:- 229.1
- Def:- 873.8 kj/mol
- synthesis:



- Uses:- Bouin solution is a common picric-acid-containing fixative solution used for histology specimens. It improves the staining of acid dyes, but it can also lead to hydrolysis of any DNA in the sample. Clinical chemistry lab testing utilizes picric acid for the Jaffe reaction to test for creatinine. It forms a colored complex that can be measured using spectroscopy.

#### vii) Nitroguanidine

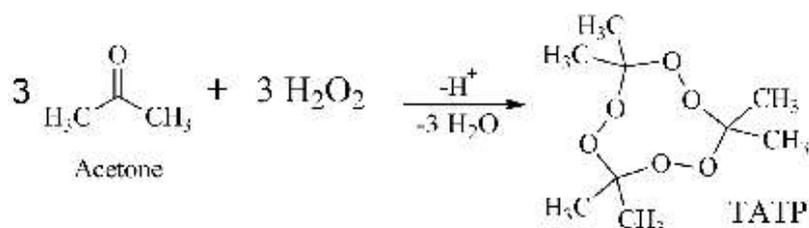
- Chemical Name:- 1-Nitroguanidine
- Molecular Weight:- 104.1
- Def:- 773.4 kJ/mol
- Synthesis:



- Uses: Nitroguanidine is used as an explosive propellant, notably in triple-base smokeless powder. The nitroguanidine reduces the propellant's flash and flame temperature without sacrificing chamber pressure. These are typically used in large bore guns where barrel erosion and flash are particularly important to avoid.

#### viii) TATP (triacetone triperoxide)

- Chemical Name:- 3,3,6,6,9,9-Hexamethyl-1,2,4,5,7,8-hexaoxacyclononane
- Molecular Weight:- 222.4
- Def:-
- Synthesis:



- Uses: TATP has been used in bomb and suicide attacks and in improvised explosive devices. TATP is attractive to terrorists because it is easily prepared from readily available retail ingredients, such as hair bleach and nail polish remover. It is also able to evade detection because it is one of the few high explosives that do not contain nitrogen, and can therefore pass undetected through traditional explosive detection scanners designed to detect nitrogenous explosives

### Laboratory Explosives

- **Pyrophorics:** These are substances that readily ignite and burn in air spontaneously. They should be handled only by chemists with the knowledge and skills to work with them safely.

**Examples:** white phosphorus, alkali metals and their compounds

- **Peroxides:** These are a group of chemicals that have an oxygen-to-oxygen bond (R-O-O-R). Care must be taken when handling inorganic or organic peroxides, since they tend to be unstable and can decompose violently.

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- Hydrogen peroxide,  $H_2O_2$  ; Peroxide-forming substances to avoid—ethers, alkenes, secondary alcohols, ketones, alkali metals.
  - Flammables:** These are most commonly used in the laboratory as solvents. We should never use any type of open flame or any source of ignition around flammable chemicals. Examples: acetone, ethanol, ethyl acetate, hexane, methanol.
  - Nitrogen Halides:** Nitrogen Halides like  $NX_3$  (X= F, Cl, Br, I) are highly unstable and thus are highly explosive in nature. They produce explosives through the following reaction:  $X_2$  or  $M'XO + NH_3$  or Ammonium salts.
  - Sodium** and **potassium** metals are kept in kerosene or in dry mineral oil. In summary, these metals are stored in kerosene because kerosene contains no water and protects these metals from being exposed to any moisture in the air that would cause these metals to react, potentially violently.

### Few Mixtures of explosives

Name	Composition	High/low explosive
Gunpowder	75% $KNO_3$ +15% charcoal+10% sulphur	Low
AMATOL	80% ammonium nitrate + 20% TNT	High
ANFO	94% ammonium nitrate + 6% # 2 diesel oil	High
Comp B-3	64% RDX + 36% TNT	High
Comp C-4	91%RDX + 5.3% di( 2-ethylhexyl)sebacate + 2.1% polyisobutylene + 1.6% motor oil	High
Dynamite	75% RDX + 15% TNT + 10% Plasticizer	High

### Nuclear Explosive

A nuclear explosive (weapon) is an explosive device that derives its destructive force from nuclear reactions, either fission (fission bomb) or from a combination of fission and fusion reactions (thermonuclear bomb) both bomb types released large quantity of energy from relatively small amount of substance.

In fusion reaction mainly used radioactive elements like uranium, radium, thorium etc. The reaction is an example of chain reaction that will never stop until the reactant fully decomposed and the reaction initiated by a neutron.

### Laboratory precautions

- When a reaction is attempted first time small quantities of reactants should be used to minimize hazards
  - Operations are carried out under non-ambient conditions. Fume hood, isolator, or glove box if necessary to keep material stable should be utilized.
  - Designate areas where explosives are stored or manipulated.
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- Person shall work alone when working with explosives chemicals and the minimum amount of explosives necessary for the operation should be used.

### **Explosive: Boon & Curse**

Like any other natural or manmade things explosives come with its boon and curse (advantages and shortcomings). Since its invention explosives has been used by humans for protection, war, scientific discoveries, excavation of natural resources (coal, diamond, steel, etc). Curious nature of humans made them realise that explosives like gunpowder can also be used for artistic as well for protection. Dynamite on the other hand was first invented mainly for the use of excavation of natural resources, but then people started using them in wars. Nowadays explosives like nuclear explosives (weapons) pose a global threat to nations. On one hand explosives have been used by humans for progress of mankind in many ways on the other hand, they are being exploited in different destructive purposes, where humans are responsible for misusing them. So explosives if handled carefully can be beneficial or else destructive. Thus it finally depends on us whether we use for progress or dragging the earth to Stone Age.

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# Some Metal-Stabilized Aminyl and Arylamino Radicals

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## Abstract

Stabilization of aminyl radical ( $R^1R^2N^\bullet$ ) and arylamino radical ( $R^1HN^\bullet$ ) in a free form or upon coordination to a transition metal ion is a big challenge in the coordination chemistry of organic radical due to their high reactivity with very short lifetimes (where  $R^1$  and  $R^2$  are aryl or alkyl group). These highly reactive short-lived radicals are generated thermally or photolytically by homolytic bond cleavage or by the oxidation of amide analogue. The radical cation,  $R^1R^2N^\bullet H^+$ , combines by way of C-C or C-N coupling whereas the neutral analogue,  $R^1R^2N^\bullet$ , undergoes C-N and N-N couplings. To terminate these types of coupling and thereby to increase the lifetime of the radicals, the aryl group must be protected by bulky substituents to the ortho and para positions or by increasing the bulkiness of the alkyl group. Porter *et al.* confirmed the presence of 2,4,6-tri-*tert*-butylanilino radical in solution by electron paramagnetic resonance (EPR) spectroscopy in the past but received much less attention.<sup>1</sup>

**Key Words:** aminyl radical, density functional theory (DFT), EPR spectroscopy, spin density

## Introduction

The chemistry of aminyl and arylamino radicals are important to disclose the parallel chemistry of the phenoxyl ( $ArO^\bullet$ )<sup>2</sup>, thiyl ( $RS^\bullet$ )<sup>3</sup> and alkyl ( $R_3C^\bullet$ )<sup>4</sup> radicals which perform several essential biological and chemical processes.<sup>5</sup> Some metallo-enzymes like cytochrome-c peroxidase and photosystem-II of photosynthesis contain nitrogen centered amino acid radical intermediates, perform different electron transfer organic reactions which are well documented in recent literatures.<sup>6</sup>

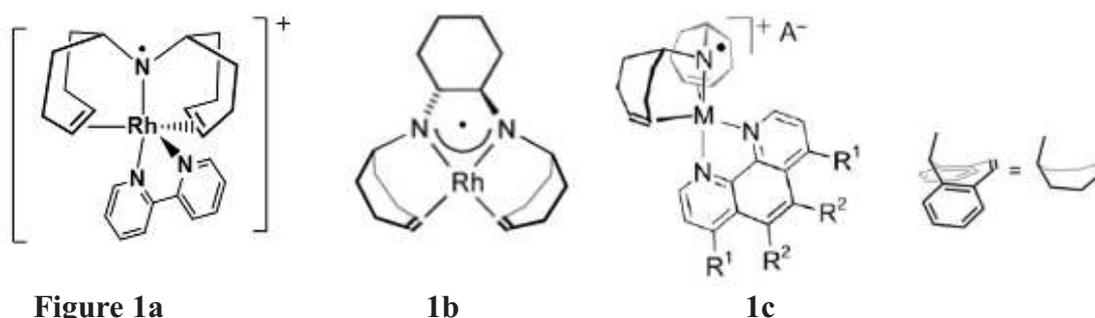
Partial aminyl and arylamino radical states are obtained when the spin density is delocalized in a conjugated  $\pi$ -system and/or an adjacent donor group with a lone pair in a  $\pi$ -type orbital is bonded to the formally electron deficient nitrogen atom. Isolation of these radicals only be possible when sufficiently bulky substituents are introduced. Electron-rich transition metal ions [ $M^{n+}$ ] should be likewise efficient as stabilizing groups because the  $M^{n+}$  serves as an electron donor *via* one of the filled  $d_{xy}$ ,  $d_{xz}$ , or  $d_{yz}$ -type orbitals. The electronic ground state of an aminyl or arylamino radical complex is a hybrid of two extreme resonance forms, [ $M^{n+}$ ]- $N^\bullet R_2$   $\leftrightarrow$  [ $M^{(n+1)+}$ ]- $N R_2$ . Most of the cases, the metal amide form [ $M^{(n+1)+}$ ]- $N R_2$  is the better description, *i.e.*, the unpaired electron is mainly localized at the metal center.

Complexes with the spin density predominantly localized at the nitrogen center,  $[M^{n+}]N^{\bullet}R_2$  are rare.

Many scientists have confirmed the existence of aminyl radical complexes only in solution. In this vast coordination chemistry, only a few of aminyl radical complexes have been isolated and characterised by single-crystal X-ray crystallography.

## Results and Discussion

The first stable aminyl ( $R^1R^2N^{\bullet}$ ) radical stabilized by rhodium(I),  $[Rh(trop_2N^{\bullet})(bipy)]^+OTf^-$  (Figure 1a) was reported by Grützmacher *et al.* (where trop is 5-H-dibenzo[*a,d*]cycloheptene-5-yl, bipy is 2,2'-bipyridyl and OTf is trifluoro-sulfonate).<sup>7</sup> They characterized the radical complex by single-crystal X-ray diffraction study and high-resolution EPR spectroscopy. Density functional theory (DFT) calculations support that the electron spin density localization on the N-atom is  $57 \pm 4\%$  and only 30% on the Rh center. This pioneer work was published in *Science* **2005**, 307, 235.



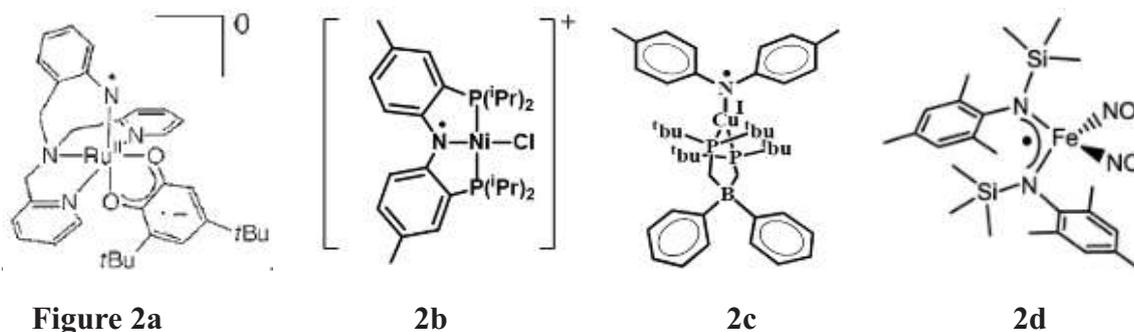
They reported another aminyl radical complex of tetracoordinated rhodium,  $[Rh(trop_2dach-2H)]$  [ $trop_2dach = (R,R)-N,N'$ -bis(5H-dibenzo[*a,d*]cyclohepten-5-yl)-1,2-diaminocyclohexane] (Figure 1b) where  $\sim 50\%$  spin density is localized on the aminyl nitrogen and this assumption is fully supported by CW, pulse EPR spectroscopy and DFT calculations.<sup>8</sup>

A series of cationic amino complexes  $[M(trop_2NH)(R,R-phen)]^+$  were isolated by the same group [ $M = Rh, Ir$ ;  $trop_2NH =$  bis(benzo[*a,d*]cycloheptenyl)amine;  $R = H, Me, Ph$  substituents in the 4,7- or 5,6-positions of the phenanthrene (phen) ligand;  $A^- = CF_3SO_3^-, PF_6^-$ ]. These complexes are sufficiently acidic to be quantitatively deprotonated by one equivalent of  $tBuOK$  to give neutral amido complexes  $[M(trop_2N^{\bullet})(R,R-phen)]$ , which can be easily oxidized to give aminyl radical complexes  $[M(trop_2N^{\bullet})(R,R-phen)]^+A^-$  (Figure 1c). Rhodium complex of aminyl radical was isolated as green crystals but the corresponding iridium analogue is unstable. The EPR results in combination with DFT calculations confirmed that significant spin population (about 30%) is located at the metal center and 60% resides on the nitrogen, which justifies the formation of aminyl radical complex.<sup>9</sup>

K. Wieghardt *et al.* have confirmed the existence of anilino radical complexes of cobalt(III) and manganese(IV) in solution. They electrochemically generated  $[Co^{III}(L^1)(Bu_2acac)]^{2+}$  species by one electron oxidation of  $[Co^{III}(L^1)(Bu_2acac)]^+ClO_4^-$  and  $[Mn^{IV}(L^2)]^+ClO_4^-$  complex upon successive three ligand-centered one-electron-transfer oxidation produces  $[Mn^{IV}(L^{2*})]^{2+}$ ,  $[Mn^{IV}(L^{2**})]^{3+}$  and  $[Mn^{IV}(L^{2***})]^{4+}$  containing one, two and three coordinated anilino radicals (Where,  $HL^1 = 1$ -(2-amino-3,5-di-*tert*-butylbenzyl)-4,7-dimethyl-1,4,7-triazacyclononane,  $H_3L^2 = 1,4,7$ -tris(2-amino-3,5-di-*tert*-

butylbenzyl)-1,4,7-triazacyclononane and  $\text{Bu}_2\text{acac} = \text{di-tert-butylacetylacetonate}$ ).<sup>10</sup> These anilino radical complexes have been characterized by UV-vis, X-band EPR, and resonance Raman spectroscopy and their characteristic spectroscopic features have been interpreted.

Tanaka *et al.* reported a  $\text{Ru}^{\text{III}}$ -semiquinone-anilido complex,  $[\text{Ru}^{\text{III}}(\text{NPhbpa})(t\text{Bu}_2\text{sq})]^+ \text{ClO}_4^-$  which undergoes deprotonation with  $t\text{BuOK}$  in dimethoxyethane (DME) to afford  $\text{Ru}^{\text{II}}$ -semiquinone-anilino-radical complex,  $[\text{Ru}^{\text{II}}(\cdot\text{NPhbpa})(t\text{Bu}_2\text{sq})]\cdot 2\text{H}_2\text{O}$  rather than  $[\text{Ru}^{\text{III}}(\text{NPhbpa})(t\text{Bu}_2\text{sq})]\cdot 2\text{H}_2\text{O}$ . The  $\text{Ru}^{\text{II}}$ -catechol-anilino radical complex  $[\text{Ru}^{\text{II}}(\cdot\text{NPhbpa})(t\text{Bu}_2\text{cat})]^-$  was obtained by the electrochemical reduction of  $\text{Ru}^{\text{II}}$ -semiquinone-anilino-radical complex in DME at -1.5 V (Figure 2a). All complexes contain the 2-(bis(2-pyridylmethyl)aminomethyl)anilido ligand ( $\text{NPhbpa}^{2-}$ ) and 3,5-di-*tert*-butylsemiquinonate ( $t\text{Bu}_2\text{sq}$ ) as co-ligand. The anilino-radical character was proved by EPR spectroscopy, resonance Raman spectroscopy and DFT calculations. The two unpaired spins of  $\text{Ru}^{\text{II}}$ -semiquinone-anilino-radical complex are spread mainly over the anilido nitrogen (43%), the Ru center and the dioxolene moiety. The amount of spin density on N and Ru was found to be 64% and 31%, respectively in  $\text{Ru}^{\text{II}}$ -catechol-anilino radical complex.<sup>11</sup>



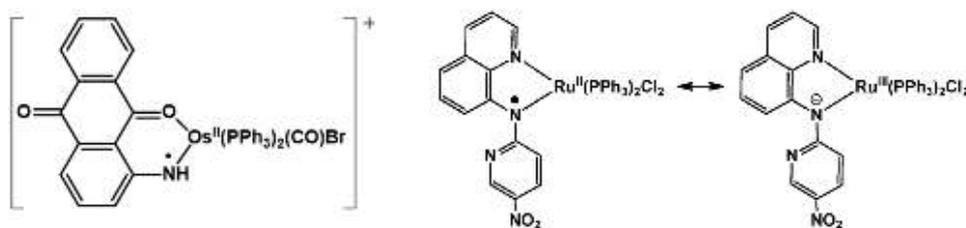
Using different characterization methods such as XRD, EPR, UV-vis, and multiedge XAS in combination with DFT analysis of the orbitals and spin densities, Mindiola *et al.* have characterized a square-planar  $\text{Ni}(\text{II})$  radical cation complex of type  $[(\text{PNP})\text{NiCl}]^+ \text{OTf}^-$  (Figure 2b), where the electron hole resides mostly at the nitrogen and aryl carbon atoms (ortho and para positions) of the pincer type PNP ligand ( $\text{PNP}^- = \text{N}[2\text{-P}(\text{CHMe}_2)_2\text{-4-methylphenyl}]_2$ ). This complex confirms the presence of aminyl radical stabilised by  $\text{Ni}^{2+}$  ion.<sup>12</sup>

A paramagnetic  $\text{Cu}(\text{I})$  aminyl radical complex,  $[\text{Ph}_2\text{BP}^{\text{tBu}}_2]\text{Cu}(\cdot\text{NTol}_2)$  [ $\text{Ph}_2\text{BP}^{\text{tBu}}_2 = \text{Ph}_2\text{B}(\text{CH}_2\text{P}^{\text{tBu}}_2)_2$ ,  $\text{Tol} = p\text{-tolyl}$ ] was synthesized and characterised by J. C. Peters *et al.* using single-crystal X-ray crystallography, PK-edge XAS data and S, X and Q bands EPR spectroscopy (Figure 2c). Here N atom is populated by 49% spin density.<sup>13</sup>

Two  $\text{Ni}^{\text{II}}$ -anilidosalen and a mixed  $\text{Ni}^{\text{II}}$ -phenol-anilidosalen complexes where ligands involving sterically hindered anilines moieties were synthesized by F. Thomas *et al.* Their one-electron oxidized species generate extremely stable aniliny radical complexes those were isolated as single crystals and further confirmed by different spectroscopy methods.<sup>14a</sup> Another anilinosalen complex of cobalt(II) was prepared by the same group and subsequent oxidation by one electron of the complex comprises a square planar low spin  $\text{Co}(\text{II})$  complex ion which anti-ferromagnetically coupled to an aniliny radical.<sup>14b</sup>

Hsu and Liaw described a delocalized aminyl radical  $[(N(\text{Mes})(\text{TMS}))_2]_2^{\bullet-}$  (Mes = mesityl, TMS = trimethylsilane) stabilized by the electron-deficient  $\{\text{Fe}^{\text{III}}(\text{NO})_2\}^9$  motif, *i.e.*, substantial spin is delocalized onto the  $[(N(\text{Mes})(\text{TMS}))_2]_2^{\bullet-}$  such that the highly covalent dinitrosyl iron core is preserved (Figure 2d). IR, EPR, single-crystal X-ray structure, Fe K-edge pre-edge energy calculation and the  $^{15}\text{N}$  NMR spectrum of  $[\text{Fe}(\text{NO})_2]$  confirmed this existence.<sup>15</sup>

1-Amido-9,10-anthraquinone (AqNH) complex of the type *trans*- $[\text{Os}^{\text{II}}(\text{AqNH})(\text{PPh}_3)_2(\text{CO})\text{Br}]$  was isolated by Ghosh *et al.* AqNH is redox active and upon oxidation with  $\text{I}_2$  in  $\text{CH}_2\text{Cl}_2$  afforded a crystalline 1-amino-9,10-anthraquinone radical (AqNH $^{\bullet}$ ) complex of the type *trans*- $[\text{Os}^{\text{II}}(\text{AqNH}^{\bullet})(\text{PPh}_3)_2(\text{CO})\text{Br}]^+\text{I}_5^-\cdot\frac{1}{2}\text{I}_2$  (Figure 3a). The electronic structure of the complex was authenticated by single crystal X-ray structure, EPR spectroscopy and DFT calculations. AqNH $^{\bullet}$  instigates a  $2c-3e$   $p_{\pi}-d_{\pi}$  interaction and the  $\text{Os}^{\text{II}}-\text{NH}_{\text{Aq}}^{\bullet}$  length is relatively shorter than  $\text{Os}^{\text{II}}-\text{NH}_{\text{Aq}}^-$  length, while the Aq-NH $^{\bullet}$  bond, is longer than Aq-NH bond. DFT calculations predicted that the atomic spin is delocalized over the ligand backbone (56%) particularly in one of the p-orbitals of the nitrogen and the metal ion.<sup>16</sup>

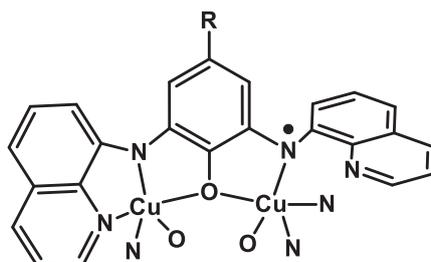


**Figure 3a**

**3b**

Ghosh *et al.* have been successfully isolated a paramagnetic complex *trans*- $[(L^{\bullet})\text{Ru}(\text{PPh}_3)_2\text{Cl}_2]\text{CH}_2\text{Cl}_2$  (Figure 3b), which is delocalized and is a hybrid of two extreme resonance forms,  $[(L^-)\text{Ru}^{\text{III}} \quad (L^{\bullet})\text{Ru}^{\text{II}}]$  (HL = *N*-(5-nitropyridin-2-yl)-quinolin-8-amine). The molecular and electronic structures of the complex were established by single crystal X-ray crystallography, EPR spectroscopy, UV-vis-NIR absorption spectra and DFT calculations. The spin scatters over ruthenium (54%), one of the chlorine (6%) atoms, and the ligand backbone (40%).<sup>17</sup>

Recently, Lemaire *et al.* have reported polynuclear  $\text{Cu}_4\text{L}_4$  copper(II) aminyl radical complexes with 2,6-bis(8-quinolylamino)-4-**R**-phenol (HL) ligand, where **R** = <sup>t</sup>Bu or Me (Figure 4). These are the first polynuclear metal aminyl radical complexes and X-ray data and DFT calculations support the aminyl-type radical character in these complexes.<sup>18</sup>



**Figure 4.** View of the molecular structure of one of the  $\text{Cu}_2\text{L}$  units.

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## Conclusions

From this study, it can be concluded that the coordination chemistry of the aminyl and arylamino radicals are very limited in scope. The molecular geometry and electronic structure of metal-stabilized aminyl and arylamino radical complexes are significant in chemical science. These radical complexes can be used as catalyst to carry out different organic synthesis and such radicals are likely to be discovered in a biological context in future. Reactive aminyl and arylamino radical complexes play an important role in carcinogenesis on human body. They alter the structure of lipids and proteins, induced DNA damage and trigger a number of diseases.

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# Name in Organic Chemistry: What a Mystery!

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## Abstract

In chemistry systematic nomenclature of molecules is done by the parent body IUPAC; however there are always associated with them, a trivial name. The word “trivial” here does not mean “insignificant”, these are the names chemists use for their molecules in day to day conversations and discussions instead of the 'burdensome' IUPAC ones. In fact sometimes the trivial name itself is recognized by IUPAC as the official one. These trivial names have varied origins and in some cases these lead to interesting stories, which offer glimpses into the rich history of development of chemistry as well as makes the learning process much enjoyable. In this article a few organic molecules' trivial names and their origins will be discussed, almost all of these molecules are encountered in the undergraduate classrooms all over the world.

## Introduction

Chemistry is a molecular science; it primarily deals with molecules of various sizes and shapes. Chemists in general and organic chemists in particular, are in constant search of new molecules. These molecules are isolated from natural sources, or synthesized in the laboratory. Many of them are useful in day to day life, but some of are pure theoretical interests of chemists. Naturally, they call their coveted molecules by various names. For communication and collaboration with other scientists the name of the molecule is all important. There is a parent body of renowned chemists called IUPAC (International Union of Pure and Applied Chemistry) which decides systematic names for all the molecules that there are. But, the IUPAC names are often very complicated to use e.g. carbohydrates which is the most essential element for our daily life, are very familiar to use with its trivial names as glucose, sucrose, lactose etc. whereas the IUPAC name of Glucose is (2*R*,3*S*,4*R*,5*R*)-2,3,4,5,6-pentahydroxyhexanal. Similarly, for the well known alkaloid strychnine, the IUPAC name is (1*R*,11*R*,18*S*,20*S*,21*S*,22*S*)-12-oxa-8.17-diazaheptacyclo-[15.5.0<sup>1,8</sup>.0<sup>2,7</sup>.0<sup>15,20</sup>]-tetracos-2,4,6,14-tetraene-9-one. In most of the cases the trivial name is plain easier (and much wiser) one to use. Almost always most of the molecule chemists deal with, is associated with some trivial name (in some cases several ones). Sometimes its because the trivial name chronologically precedes the IUPAC ones and therefore are more popular (eg. acetic acid).

Tracing the origin of the trivial name is tricky. Some names are derived legitimately from the molecular

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structure, or from the location where the molecules were first discovered / synthesized. Many come from the name (Greek / Latin) for the plant or animal species from which the molecules were isolated, or *even* from the name of chemist who has discovered / synthesized these molecules. Some molecules are given intentionally trivial names based on their structure, or simply as a result of the whimsy of chemists. Irrespective of how they are derived, on many occasions these trivial names have interesting history behind their origins. Unearthing these historical anecdotes can be rewarding, not only because they faithfully reflect the passion behind the chemists' eternal quest of new molecular targets but also they tell stories that are profoundly rich in human experience<sup>1,2,3</sup>.

## SOME INTERESTING TRIVIAL NAMES

### Buckminsterfullerene

Buckminsterfullerene (C<sub>60</sub>), was serendipitously made in 1985 by Robert Curl, Harold Kroto and Richard Smalley, who won the Nobel prize in Chemistry (1996) for their discovery of this unique carbon allotrope. The name was homage to Richard Buckminster Fuller, whose geodesic domes the molecule resembles.

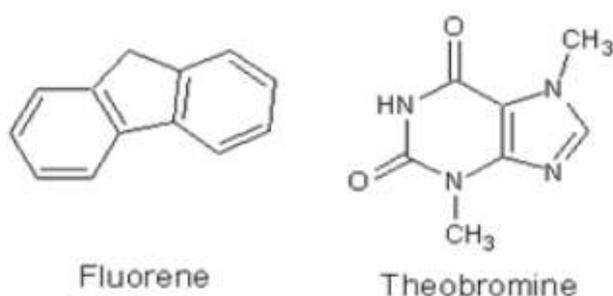


**Figure 1 . Geodesic Dome and Allotrope of carbon – C<sub>60</sub>**

The name is a bit of a mouthful and it is often referred to just as a *Bucky Ball*. Because it's a soccerball shaped molecule it's also known as 'Footballene' by some researchers. In fact, there is now a whole family of fullerene molecules, the members of which are affectionately called by Kroto "beasties in the fullerene zoo", Some of them has very very odd names, mainly based on their appearance. Here are some "beasties": *Buckybabies* (C<sub>32</sub>, C<sub>44</sub>, C<sub>50</sub>, C<sub>58</sub>), *Rugby Ball* (C<sub>70</sub>), *Giant Fullerenes* (C<sub>240</sub>, C<sub>540</sub>, C<sub>960</sub>), *Russian Egg* or *Bucky Onions* (balls within balls, just like the Russian Dolls), *Fuzzyball* (C<sub>60</sub>H<sub>60</sub>), *Bunnyball* (C<sub>60</sub>(OsO<sub>4</sub>)(4-t-Butylpyridine)<sub>2</sub>), *Platinum-Burr Ball* ({[(C<sub>2</sub>H<sub>5</sub>)<sub>3</sub>P]<sub>2</sub>Pt}<sub>6</sub>C<sub>60</sub>) and *Hetero-fullerenes* (in which some Cs are replaced by other atoms). IUPAC name for Buckminsterfullerene is (C<sub>60</sub>-I<sub>h</sub>)[5,6]fullerene.

### Fluorene & Theobromine

Sometimes trivial names can be guileful as well. Contrary to its name the molecule of Fluorene doesn't contain the element fluorine. In fact it is a polycyclic aromatic hydrocarbon.

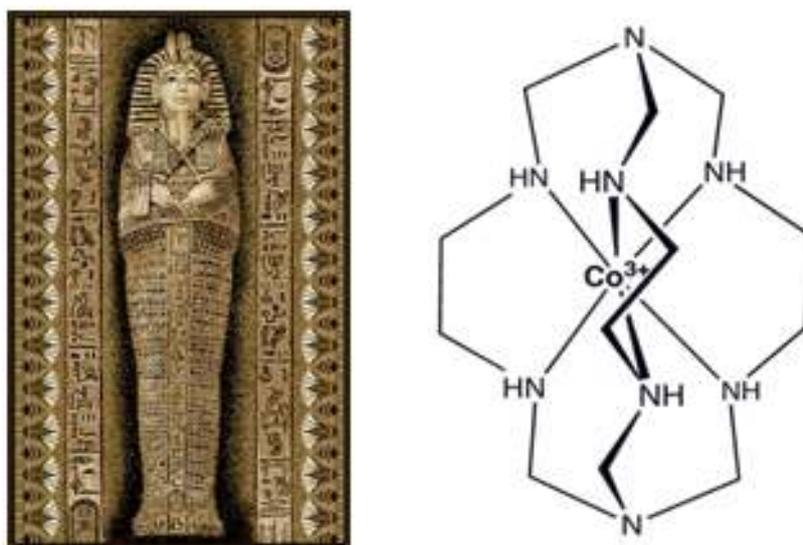


**Figure 2. Aromatic hydrocarbon and Ingredient of *Theobroma Cacao* fruit**

It's named after its violet fluorescences when exposed to UV light. Similarly, there is no bromine in theobromine. It's derived from cocoa trees (*Theobroma*), and is the bitter taste in dark chocolate. *Theos* actually means 'god' in Greek, and *brosi* means 'food'. So, chocolate really is the food of the gods!

### Sepulchrates & Sarcophagene

These funeral names trace back their origin to terms sepulcher (a type of tomb or burial chamber) and sarcophagus (funeral receptacle for a corpse).



**Figure 3. Cobalt (III) sepulchrates “in deathly embrace”**

These molecules are clathrochelates with structures which wrap around and “bury” metal ions, such as cobalt, in a coffin-like cage (their chemistry is much like that of their more famous oxygen “cousins” – the crown ethers; in picture:  $\text{Co}(\text{sepulchrates})^{3+}$ ). They belong to the general class “Cryptand” which implies that this ligand binds substrates in a crypt, interring the guest as in a burial (Greek *kryptos* meaning hidden).

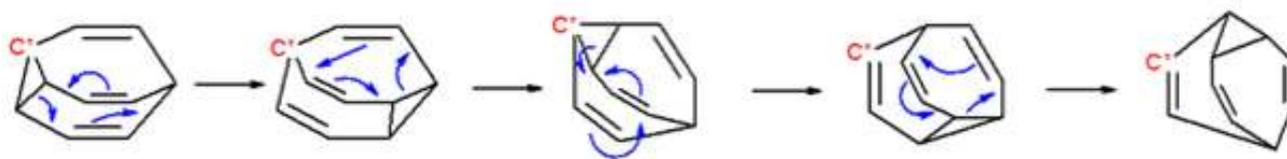
### Bullvalene

This hydrocarbon is truly one exceptional molecule. It has a fluxional (constantly changing) structure. The rapid movement of double bonds around the structure ensures that all 10 hydrogen atoms of the

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molecule are equivalent (and so are the all 10 carbon atoms), with the result that the high-temperature proton NMR spectrum of bullvalene consists of a single line.

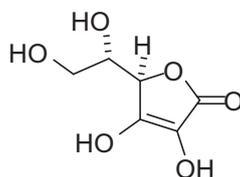


**Figure 4. A Fluxional molecule**

The molecule has more than 1.2 million possible structures! The origin of the name is equally interesting. The structure and fluxional properties of the molecule was first predicted by Professor William von Doering in early 1961. The molecule was actually synthesized in the lab by Schröder in the later half of the same year, whereupon Doering's "controversial" predictions about the structure were verified. The name has come either from Doering's nickname, 'Bull', or from his seminars which were popularly known as Doering's 'bull sessions', since it was at one of these that the structure was first discussed. Other reports, however, suggest that a skeptical graduate student didn't believe that such a structure could exist, and simply dismissed it as 'Bull-valene'.

#### **Godnose / L-ascorbic Acid / Vitamin C**

Godnose is actually not an official molecular name, but it has an interesting story. Albert Szent-Gyorgyi (Hungarian physiologist, Nobel prize winner in Physiology & Medicine, 1937) first isolated ascorbic acid from adrenal gland tissue. Since he was convinced that the substance isolated was related to carbohydrates (like glucose and fructose) but was ignorant of the molecular structure, he tried to publish his findings using the name "ignose" ("ignosco" meaning "don't know", "ose" meaning sugar).



**Figure 5 . Vitamin C**

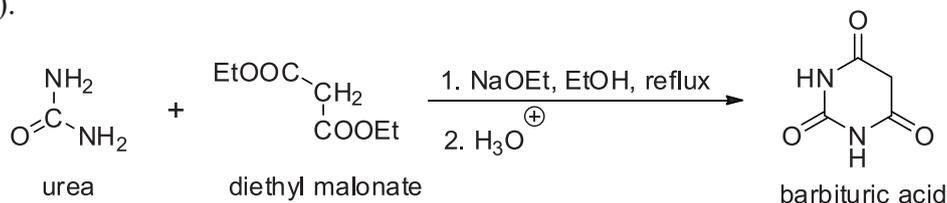
Then the *Biochemical Journal* Editor Sir Arthur Harden refused to accept ignose as a *sensible* name. Szent-Gyorgyi came up with 'Godnose' (pun intended, of course)! Unfortunately that also failed to make the cut. The structure of the carbohydrate was elucidated in collaboration with W. N. Haworth at Birmingham and the results were finally published under the name "hexuronic acid" (the name was suggested by Harden himself). Later it was established that hexuronic acid and Vitamin C (isolated from lemon juice) were identical. Thus hexauronic acid was re-baptized as ascorbic acid.

Incidentally, the name ascorbic acid derives from 'a-' (against) and the Latin scorbutus, meaning the disease scurvy, since eating it prevents scurvy, as the old English sailors discovered. This word 'scurvy' was itself derived from Old Norse (skyr = old curdled milk) and bjugr (edema) – referring to the ancient Viking belief that scurvy was caused by the sailors' diet of old curdled milk .

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## Barbituric Acid

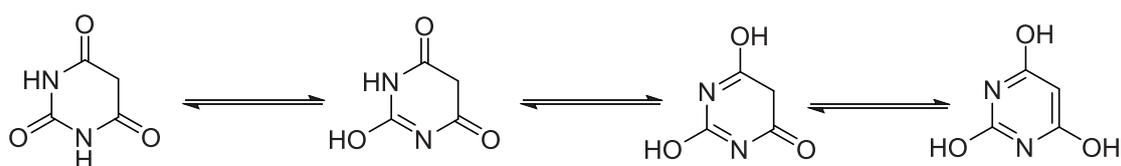
Barbituric acid was first synthesized November 27, 1864, by German chemist Adolf von Baeyer. This was done by condensing urea (an animal waste product) with diethyl malonate (an ester derived from the acid of apples).



**Figure 6. Synthetic Method of Barbituric acid**

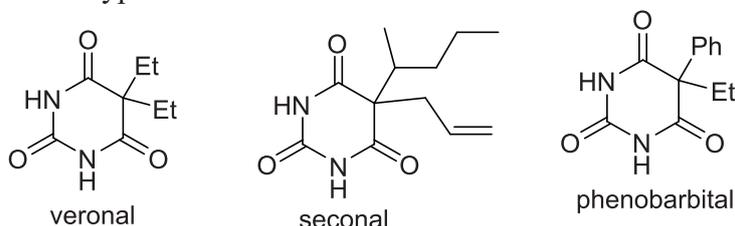
There are several stories about how the substance got its name. The most likely story is that Baeyer and his colleagues went to celebrate their discovery in a tavern where the town's artillery garrison was also celebrating the feast of Saint Barbara—the patron saint of artillerymen. An artillery officer is said to have christened the new substance by amalgamating *Barbara* with *urea*. Another story holds that Baeyer synthesized the substance from the collected urine of a Munich waitress named Barbara.

Barbituric acid is a pyrimidine derivative and it can exist in several tautomeric forms as shown:



**Figure 7. Tautomeric forms of Barbituric Acid**

No substance of medical value was discovered, however, until 1903 when two German scientists working at Bayer, Emil Fischer and Joseph von Mering, discovered that barbital, a substituted barbituric acid, was very effective in putting dogs to sleep. Barbital was then marketed by Baeyer under the trade name Veronal. It is said that Mering proposed this name because the most peaceful place he knew was the Italian city of Verona. Afterwards several substituted barbituric acids often called barbiturates were discovered which are used as hypnotics:



**Figure 8. Trade name of Barbital as Veronal and othe Barbiturates as drugs**

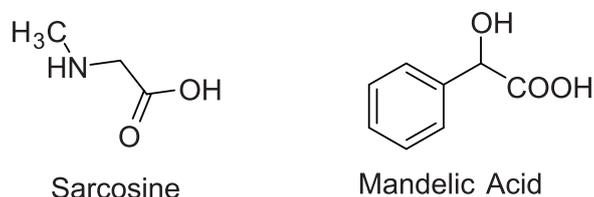
Barbiturates are prepared by condensing urea with substituted malonic esters. Although barbiturates are very effective hypnotics their use is also hazardous. An overdose often proves to be fatal, as it did in case of Hollywood actress Marilyn Monroe and legendary guitarist Jimi Hendrix.

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## Sarcosine & Mandelic Acid

Sarcosine is basically an amino acid. The water soluble amino acid gets the name from Greek *sarx* means *Flesh*, its typical source. It was first isolated by Justus von Leibig.



**Figure 9. Amino acid and  $\alpha$ -hydroxy acid**

Mandelic acid is an aromatic  $\alpha$ -hydroxy acid lately gaining popularity as an appropriate treatment for a wide variety of skin concerns particularly acne and wrinkles. It is said that this helps in retaining the youthful look of the skin. It gets its name from the German word “*mandel*” meaning almond, which is its source.

## Draculin

Draculin is an anticoagulant glycoprotein found in the saliva of vampire bats *Desmodus rotundus*. When the bat bites its victims, draculin inhibits certain blood coagulation factors, thus keeping the blood of the bitten victim from clotting while the bat feeds.

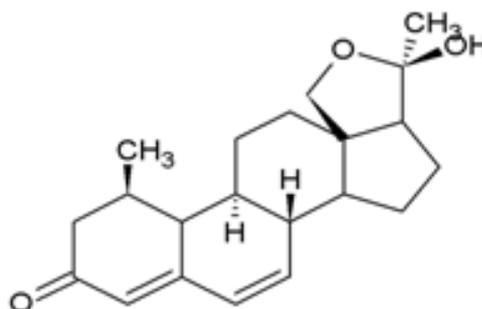


**Figure 10.D. *Rotundus*, in full flight**

Being such an effective anticoagulant draculin is prescribed for heart attack and stroke patients. The name originates from a certain infamous Transylvanian Count who made his first public appearance in Bram Stoker's Gothic-horror classic “*Dracula*”.

## Mirasorvone

This steroid molecule is a part of the defense mechanism of the sunburst diving beetle *Thermonectus marmoratus*. When disturbed the beetle ejects a milky fluid from the prothoracic gland, which has this volatile steroid. It was isolated and characterized by *J. Meinwald's* group at Ithaca, Cornell (1998).

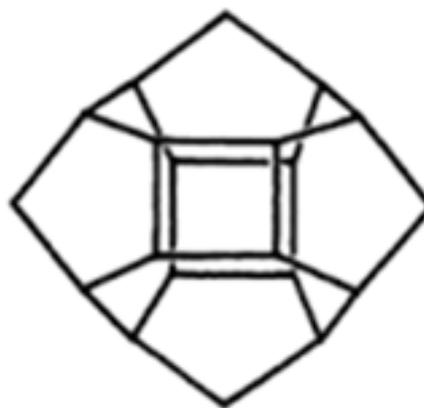


**Figure 11. *Thermonectus marmoratus***

This compound is named after Hollywood actress *Mira Sorvino* for her role as an entomologist-biochemist in sci-fi horror film “Mimic” (1997) .

### **Golcondane**

In 19<sup>th</sup> century, the assembly of  $C_{20}$ -polyhedranes in particular received a great deal of attention from organic chemists and culminated in many notable achievements. This interesting cage hydrocarbon ( $C_{20}H_{24}$ ) has been synthesized by Goverdhan Mehta and S. Hari Krishna Reddy in 1993 in the University of Hyderabad in India<sup>4</sup>. Padma Shri awardee Prof. Mehta is one of the leading organic chemist of India. In a 1993 paper, his group describes a short synthesis of this nonacyclic  $C_{20}H_{24}$ -hydrocarbon which was a new member to the esoteric  $C_{20}$ -family.



**Figure 12.  $C_{20}$ -family Hydrocarbon**

Prof. Mehta kept the name of the compound in honour of the 400<sup>th</sup> anniversary of the founding of the Indian city of Hyderabad, whose ancient name was “Golconda” .

### **Conclusion**

A small number of interesting trivial names of chemical compounds are enlisted here, there are hundreds of others. But you might ask “What’s in a name?” The name of a molecule is all-important when one is trying to communicate with fellow chemists (& others). In this connection a very pertinent joke made by

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famous Sci-Fi writer Isaac Asimov (incidentally, he was also a chemist) may be quoted, which underlines the importance of use of correct terminology for proper communication between professionals: if you want to find a chemist, ask him or her to discuss the following words: 1) mole and 2) unionized. If he or she starts talking about 1) furry animals and 2) organized labor, keep walking.<sup>5</sup>

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# Gravitational Waves

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## Abstract

This dissertation describes the discovery of gravitational waves. It recounts the journey of predicting and finding those waves, since its beginning in the early twentieth century, their prediction by Einstein in 1916, theoretical and experimental blunders, efforts towards their detection and finally the subsequent successful discovery. Gravitational waves can penetrate regions of space that electromagnetic waves cannot. It also discusses the other various properties, behavior and applications of gravitational waves.

**Keywords:** Gravitational waves, General Relativity, LIGO, Einstein, strong-field gravity, binary black holes.



## Introduction

Gravitational waves are 'ripples' in the fabric of space-time caused by some of the most violent and energetic processes in the Universe. Albert Einstein predicted the existence of gravitational waves in 1916 in his general theory of relativity. Einstein's mathematics showed that massive accelerating objects (such as neutron stars or black holes orbiting each other) would disrupt space-time in such a way that 'waves' of distorted space would radiate from the source (like the movement of waves away from a stone thrown into a pond). Furthermore, these ripples would travel at the speed of light through the Universe, carrying with them information about their cataclysmic origins, as well as invaluable clues to the nature of gravity itself. Though gravitational waves were predicted to exist in 1916, actual proof of their existence wouldn't arrive until 1974, 20 years after Einstein's death. All of this changed on September 14, 2015, when LIGO physically sensed the distortions in spacetime caused by passing gravitational waves generated by two colliding black holes nearly 1.3 billion light years away! LIGO's discovery will go down in history as one of humanity's greatest scientific achievements.[1]

## Where Do Gravitational Waves Come From?

Gravitational waves are produced by masses moving through space-time in a special way. The simplest

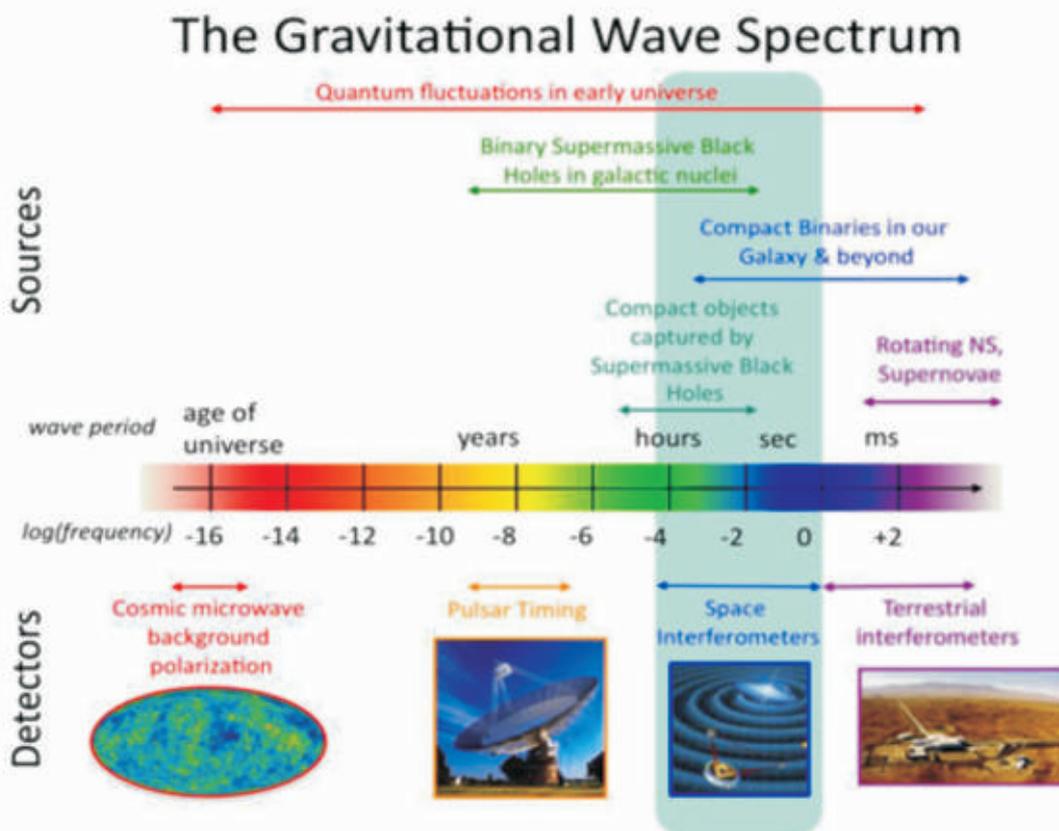
system that produces gravitational waves is two masses orbiting their common center of mass.

One of the most common such system is a binary star system – two stars orbiting each other's common center of mass. It turns out that about half of the stars you see in the sky are members of a binary system. And those stars can be at any stage of their life cycle, which means you can have any combination of a normal star, giant star, white dwarf, neutron star, or black hole. Another place you might find large masses orbiting each other is the center of a galaxy - if two galaxies merged, their central supermassive black holes would orbit for a long time before they also merged.

### How Can We Detect Gravitational Waves?

The detection of gravitational waves requires measurements that detect changes in distance less than the size of an atomic nucleus. To do this, scientists use interferometry, which consists of two parts: test masses separated by a distance and lasers to measure that distance. Test masses are set at a large distance from each other – the large distance helps make any change in their distance be large enough to measure. The masses are then shielded from all disturbances except gravity, which we cannot shield against. Then lasers make continuous measurements of the distance between each of the test masses. The masses are free to move in response to gravity so that when a gravitational wave passes, space-time stretches and the time it takes light to travel between the masses changes.

Gravitational waves were first detected by the ground-based LIGO detectors in 2015 using ground-based facilities in Washington and Louisiana. The Virgo detector in Italy spied its first gravitational wave in 2017. A space-based observatory called LISA is scheduled to launch in the early 2030s as part of the European Space Agency's Cosmic Visions Program.



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## Properties and Behaviour

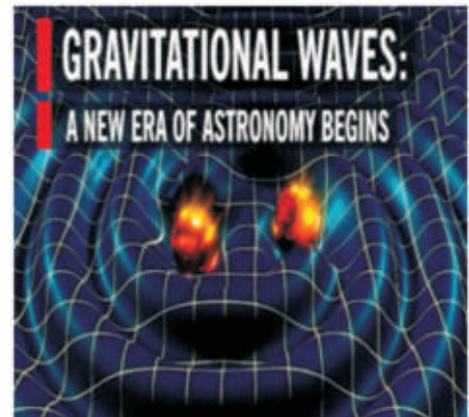
**Energy, momentum and angular momentum:** Water waves, sound waves, and electromagnetic waves are able to carry energy, momentum, and angular momentum and by doing so they carry those away from the source. Gravitational waves perform the same function. Thus, for example, a binary system loses angular momentum as the two orbiting objects spiral towards each other—the angular momentum is radiated away by gravitational waves. The waves can also carry off linear momentum, a possibility that has some interesting implications for astrophysics.[2]

**Redshifting:** Like electromagnetic waves, gravitational waves should exhibit shifting of wavelength due to the relative velocities of the source and observer, but also due to distortions of space-time, such as cosmic expansion. [3] This is the case even though gravity itself is a cause of distortions of space-time. Redshifting of gravitational waves is different from redshifting due to gravity.

**Significance for study of the early universe:** Due to the weakness of the coupling of gravity to matter, gravitational waves experience very little absorption or scattering, even as they travel over astronomical distances. In particular, gravitational waves are expected to be unaffected by the opacity of the very early universe. In these early phases, space had not yet become "transparent," so observations based upon light, radio waves, and other electromagnetic radiation that far back into time are limited or unavailable. Therefore, gravitational waves are expected in principle to have the potential to provide a wealth of observational data about the very early universe.

## Conclusion

Gravitational waves promise a glimpse into regions of our cosmos that are inaccessible to regular astronomical observation. In the past, whenever astronomers have opened a new window to the universe (for example, at the beginning of radio astronomy or X-ray astronomy), this has brought about new, and often unexpected, results for astrophysics. With gravitational waves, researchers hope for a similar leap forward.



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# “Neutrino”

## The Mysterious Particle

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### Abstract

This article explain the various properties and related discoveries associated with the neutrino particles. The discovery of mass of the neutrino particles by scientists Takaaki Kajita and Arthur McDonald put new light on the physics of the particle. Giant underground experiments revealed that the elusive particles transform from one variety into another. These crucial findings demonstrated that neutrinos have mass but goes by the standard model that predicts the properties of nature's particles and forces

### 1. Introduction

**Composition:** Elementary particle

**Classification:** Fermions

**Interactions:** Gravity, Weak interaction

**Symbol:**  $\nu_e, \nu_\tau, \nu_\mu, \bar{\nu}_e, \bar{\nu}_\tau, \bar{\nu}_\mu$

**Discoverers:** Frederick Reines, Clyde Cowan, Leon M. Lederman, Jack Steinberger, Melvin Schwartz

**Mass:**  $0.320 \pm 0.081 \text{ eV}/c^2$  (sum of 3 flavours)

**Electric charge:** Neutral

A neutrino is a subatomic particle has no electrical charge and a very small mass, which might even be zero. Neutrinos are one of the most abundant particles in the universe. They are incredibly difficult to detect, because they have very little interaction with matter. They belong to the class of “**FERMIONS**”; which are elementary particles with half integer spin. The neutrino is so named for it is electrically neutral and because its rest mass is so small that it was long thought to be zero. Nuclear forces treat electrons and neutrinos identically; neither participate in the strong nuclear force, but both participate equally in the weak nuclear force. Particles with this property are termed leptons<sup>[9]</sup>. In addition to the electron (and its anti-particle, the positron), the charged leptons include the “muon” (with a mass 200 times greater than that of the electron), the “tau” (with mass 3,500 times greater than that of the electron) and their anti-particles.

Weak interactions create neutrinos in one of three leptonic flavours: electron neutrinos ( $\nu_e$ ), muon neutrinos ( $\nu_\mu$ ), or tau neutrinos ( $\nu_\tau$ ), in association with the corresponding charged lepton. Although

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neutrinos were long believed to be massless, it is now known that there are three discrete neutrino masses with different tiny values, but they do not correspond uniquely to the three flavours

A neutrino created with a specific flavour is in an associated specific quantum superposition<sup>[10]</sup> of all three mass states. As a result, neutrinos oscillate between different flavours in flight. For example, an electron neutrino produced in a beta decay reaction may interact in a distant detector as a “muon” or “tau” neutrino.

For each neutrino, there also exists a corresponding antiparticle, called an “antineutrino”, which also has half-integer spin and no electric charge. They are distinguished from the neutrinos by having opposite signs of lepton number and chirality. To conserve total lepton number, in nuclear beta decay, electron neutrinos appear together with only positrons (anti-electrons) or electron-antineutrinos, and electron antineutrinos with electrons or electron neutrinos.

## 2. Detection and Discovery

Neutrinos are created by various radioactive decays, like the beta decay of atomic nuclei or hadrons, nuclear reactions like those that take place in the core of a star or artificially in nuclear reactors, nuclear bombs or particle accelerators, during a supernova, in the spin-down of a neutron star, or when accelerated particle beams or cosmic rays strike atoms. The majority of neutrinos in the vicinity of the Earth are from nuclear reactions in the Sun. In the vicinity of the Earth, about 65 billion ( $6.5 \times 10^{10}$ ) solar neutrinos per second pass through every square centimetre perpendicular to the direction of the Sun. For study, neutrinos can be created artificially with nuclear reactors and particle accelerators.

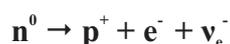
## 3. Pauli's Proposal

The neutrino was postulated first by Wolfgang Pauli in 1930 to explain how beta decay could conserve energy, momentum, and angular momentum (spin). In contrast to Niels Bohr, who proposed a statistical version of the conservation laws to explain the observed continuous energy spectra in beta decay, Pauli hypothesized an undetected particle that he called a "neutron", using the same *-on* ending employed for naming both the proton and the electron. He considered that the new particle was emitted from the nucleus together with the electron or beta particle in the process of beta decay.

James Chadwick discovered a much more massive neutral nuclear particle in 1932 and named it a neutron also, leaving two kinds of particles with the same name. Earlier (in 1930) Pauli had used the term "neutron" for both the neutral particle that conserved energy in beta decay, and a presumed neutral particle in the nucleus; initially he did not consider these two neutral particles as distinct from each other.

Finally the name Neutrino was given by Enrico Fermi who used it during a conference in Paris in July 1932 and at the Solvay Conference in October 1933, where Pauli also employed it.

In Fermi's theory of beta decay, Chadwick's large neutral particle could decay to a proton, electron, and the smaller neutral particle (now called an electron antineutrino):



Neutrinos were first detected in 1956 by Fred Reines of the University of California at Irvine and the late George Cowan. They showed that a nucleus undergoing beta decay emits a neutrino with the electron, a discovery that was recognized with the 1995 Nobel Prize for Physics.

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#### 4. Neutrino Oscillation and Solar Neutrino Problem

**Neutrino oscillation** is a quantum mechanical phenomenon whereby a neutrino created with a specific lepton family number ("lepton flavours": electron, muon, or tau) can later be measured to have a different lepton family number.

The **Solar neutrino problem** deals with the large difference between the fluxes of solar neutrinos as measured by the total energy emitted per unit time by the sun and measured directly. The solar neutrino fluxes are very hard to detect, because they interact very weakly with matter, traversing the whole Earth. Out of the three types of flavours of neutrinos, the Sun produces only **electron neutrinos**. When neutrino detectors became sensitive enough to measure the flow of electron neutrinos from the Sun, the number detected was much lower than predicted. In various experiments, the number difference was between one half and two thirds.

##### Importance

The **discovery** of the **neutrino oscillations** thus helped to solve **the Solar Neutrino Problem** and also proved the presence of neutrino mass, by **the Super-Kamiokande Observatory** and the **Sudbury Neutrino Observatories** thereby recognizing it with the Nobel Prize in Physics in 2015. The existence of a neutrino mass allows the possibility of existence of a tiny neutrino magnetic moment, for which neutrinos can interact electromagnetically as well. Neutrino oscillations proved thereby that neutrinos can transform from a specific lepton family member to another lepton family member; a phenomenon that is only possible when neutrinos have mass.

##### Conclusion and Applications

Recent discoveries have led to the invention of masses of the neutrino particles earning Takaaki Kajita of the University of Tokyo and Arthur McDonald of Queen's University in Kingston, Canada, the 2015 Nobel Prize in physics. The subatomic particles which were once considered massless were recently found to transform from one variety into other; a phenomenon that can occur only if neutrinos have masses. Results from the Super Kamiokande experiment in Japan suggest that neutrinos have a mass of 0.1 eV or greater, compared with about 0.5 MeV for the electron. Today physicists around the world are working to identify the particles' exact masses and understand neutrinos' importance throughout the history of the universe.

Neutrinos are produced from radiation, so it might be possible for the International Atomic Energy Agency to use neutrino detectors to monitor which countries are following the treaty on the Non-Proliferation of Nuclear Weapons. They have the potential to do amazing things like speed up global communication, detect the presence of nuclear weapons, and even confirm the presence of elusive dark matter.

Recently, a breakthrough in the study of "**ghostly particles**" called high-energy neutrinos that traverse space, through planets and whole galaxies, is giving scientists a new way to expand our understanding of the "**cosmos**". Researchers have for the first time located a deep-space source for these subatomic particles. They detected high-energy neutrinos in pristine ice deep below Antarctica's surface, then traced their source back to a giant elliptical galaxy with a massive, rapidly spinning black hole at its core, called a **blazar**, located 3.7 billion light years from Earth in the "**Orion constellation**". The key

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observations were made at the **IceCube Neutrino Observatory** at a U.S. scientific research station at the South Pole and then confirmed by land-based and orbiting telescopes. The ability to use particles like high-energy neutrinos in astronomy enables a more strong examination, much as the confirmation of ripples in the fabric of space-time called “**gravitational waves**”, announced in 2016.

Various project firms on Neutrinos have been coming up in recent times in India, like the INDIA-BASED NEUTRINO OBSERVATORY (INO). It is a particle physics research project under construction to primarily study atmospheric neutrinos in a 1,300 meters (4,300 ft) deep cave under Ino Peak near Theni , Tamil Nadu , India. This project is notable in that it is anticipated to provide a precise measurement of neutrino mixing parameters. The project is a multi-institute collaboration and one of the biggest experimental particle physics projects undertaken in India

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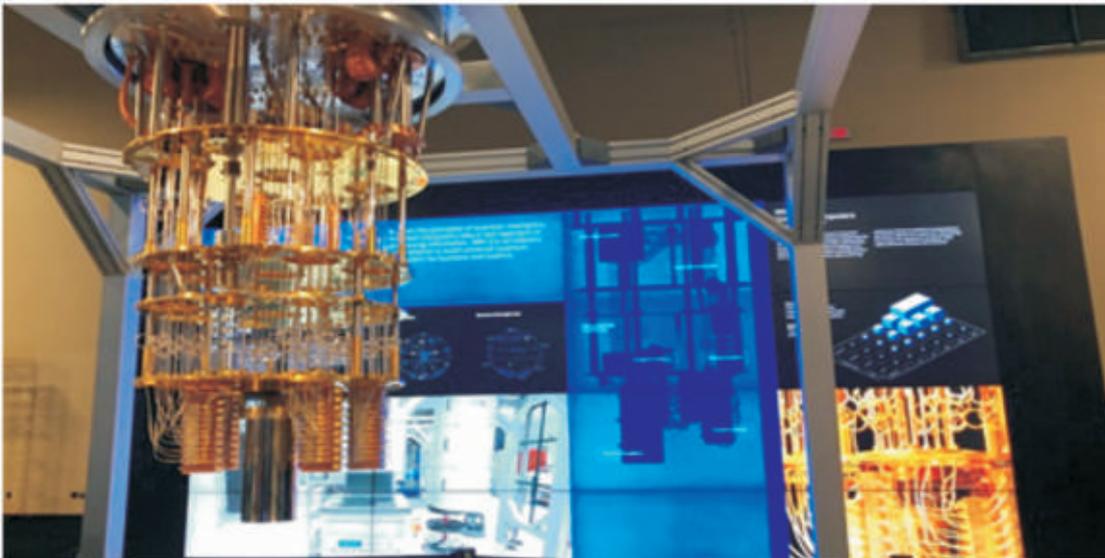
# Quantum Computation

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## Abstract

Quantum Computing is a new and exciting field at the intersection of mathematics, computer science and physics. It focuses on the utilization of quantum mechanics to improve the efficiency of computation. Here the paper presents an introduction to some of the basic ideas in quantum computation. The paper begins by giving brief introduction on the central ideas of quantum mechanics and quantum computation. Central notions of quantum architecture (qubits and quantum gates) are defined. A brief comparison between classical and quantum computer has also been done. The paper ends with application and future scope of quantum computation. My presentation demands neither advanced mathematics nor advanced physics.

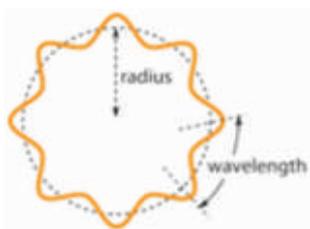


## Introduction

Quantum computing is the field of study which focuses on developing computer technology based on the principles of quantum theory, which explains the nature and behaviour of energy and matter on the quantum (atomic and subatomic) level. Development of a **quantum computer**<sup>(1)</sup>, if practical, would mark a leap forward in computing capability far greater than that of the abacus to a modern day supercomputer, with performance gains in the billion-fold realm and beyond. The quantum computer, following the laws of quantum physics, would gain enormous processing power through the ability to be in multiple states, and to perform tasks using all possible permutations simultaneously.

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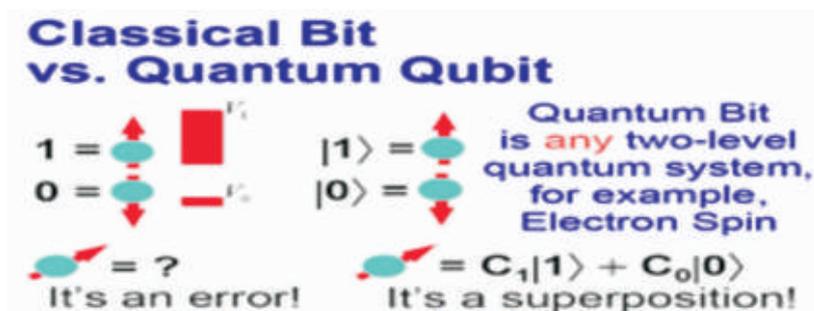
Before we begin with understanding of Quantum computer, let's have a brief idea about quantum theory. Quantum theory's establishment began in 1900 with a presentation by Max Planck to the German Physical Society, in which he introduced the idea that energy exists in individual units (which he called "quanta"), as does matter. Further developments by a number of scientists over the following thirty years led to the modern understanding of quantum theory.



### The Essential Elements of Quantum Theory:

- Energy, like matter, consists of discrete units, rather than a continuous wave.
- Elementary particles of both energy and matter, depending on the conditions, may behave like either particles or waves.
- The movement of elementary particles is inherently random, and thus, unpredictable.
- The simultaneous measurement of two complementary values, such as the position and momentum of an elementary particle, is almost next to impossible; the more precisely one value is measured, the more flawed will be the measurement of the other value.

### A Comparison between Classical and Quantum Computing

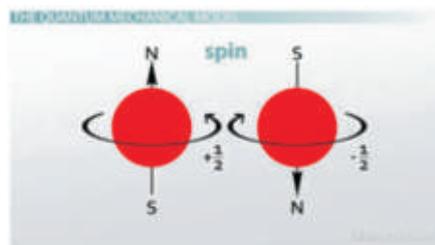


Classical computing relies, at its ultimate level, on principles expressed by Boolean algebra, operating with a (usually) 7mode logic gate principle. Data must be processed in an exclusive binary state at any point in time - that is, either 0 (off / false) or 1 (on / true). These values are binary digits, or bits. The millions of transistors and capacitors at the heart of computers can only be in one state at any point. While the time that each transistor or capacitor need be either in 0 or 1 before switching states is now measurable in billionths of a second, there is still a limit as to how quickly these devices can be made to switch state. As we progress to smaller and faster circuits, we begin to reach the physical limits of materials and the threshold for classical laws of physics to apply. Beyond this, the quantum world takes over, which opens a potential as great as the challenges that are presented. The Quantum computer, by contrast, can work with a two-mode logic gate: XOR and a mode we'll call QO1 (the ability to change 0 into a superposition of 0 and 1, a logic gate which cannot exist in classical computing). In a quantum

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computer, a number of elemental particles such as electrons or photons can be used (in practice, success has also been achieved with ions), with either their charge or polarization acting as a representation of 0 and/or 1. Each of these particles is known as a quantum bit, or qubit, the nature and behaviour of these particles form the basis of quantum computing. The two most relevant aspects of quantum physics are the principles of superposition and entanglement.

**Superposition** Think of a qubit as an electron in a magnetic field. The electron's spin may be either in alignment with the field, which is known as a spin-up state, or opposite to the field, which is known as a spin-down state.



Changing the electron's spin from one state to another is achieved by using a pulse of energy, such as from a laser - let's say that we use 1 unit of laser energy. But what if we only use half a unit of laser energy and completely isolate the particle from all external influences? According to quantum law, the particle then enters a superposition of states, in which it behaves as if it were in both states simultaneously. Each qubit utilized could take a superposition of both 0 and 1. Thus, the number of computations that a quantum computer could undertake is  $2^n$ , where  $n$  is the number of qubits used. A quantum computer comprised of 500 qubits would have a potential to do  $2^{500}$  calculations in a single step. The number  $2^{500}$  is infinitely more atoms than there are in the known universe.

**Entanglement:** Particles (such as photons, electrons, or qubits) that have interacted at some point retain a type of connection and can be entangled with each other in pairs, in a process known as correlation. Knowing the spin state of one entangled particle - up or down - allows one to know that the spin of its mate is in the opposite direction. Even more amazing is the knowledge that, due to the phenomenon of superposition, the measured particle has no single spin direction before being measured, but is simultaneously in both a spin-up and spin-down state. The spin state of the particle being measured is decided at the time of measurement and communicated to the correlated particle, which simultaneously assumes the opposite spin direction to that of the measured particle. This is a real phenomenon (Einstein called it "spooky action at a distance"), the mechanism of which cannot, as yet, be explained by any theory - it simply must be taken as given. Taken together, quantum superposition and entanglement create an enormously enhanced computing power. Where a 2-bit register in an ordinary computer can store only one of four binary configurations (00, 01, 10, or 11) at any given time, a 2-qubit register in a quantum computer can store all four numbers simultaneously, because each qubit represents two values. If more qubits are added, the increased capacity is expanded exponentially.

## Some applications of Quantum Computing<sup>(2)</sup>

### 1. Machine Learning

Machine learning is a hot area right now because we are now seeing significant deployments at the

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consumer level of many different platforms. We are now seeing aspects of every day in voice, image and handwriting recognition, to name just a few examples. But it is also a difficult and computationally expensive task, particularly if you want to achieve good accuracy. Because of the potential payoff, there is a lot of research ongoing based upon sampling of Boltzmann distributions.

## **2. Computational Chemistry**

There are many problems in materials science that can achieve a huge payoff if we just find the right catalyst or process to develop a new material, or an existing material more efficiently. There is already a significant effort in using classical computers to simulate chemical interactions, but in many cases the problems become intractable for solving classically. So the original idea presented by Richard Feynman is why not use a quantum computer to simulate the quantum mechanical processes that occur. Here are just a few examples of significant problems that could see large payoffs if we can solve them.

- Replace the Haber process to produce ammonia for use in fertilizers.
- Find new materials that can achieve a room temperature superconductor.
- Find a catalyst that can improve the efficiency of carbon sequestration.
- Develop a new battery chemistry that can significantly improve the performance over today's lithium-ion batteries.

## **4. Logistics and Scheduling**

Many common optimizations used in industry can be classified under logistics and scheduling. Think of the airline logistics manager who needs to figure out how to stage his airplanes for the best service at the lowest cost. Or the factory manager who has an ever changing mix of machines, inventory, production orders, and people and needs to minimize cost, throughput times and maximize output. Or the pricing manager at an automobile company who needs to figure out the optimum prices of all the dozens car options to maximize customer satisfaction and profit. Although, classical computing is used heavily to do these tasks, some of them may be too complicated for a classical computing solution whereas a quantum approach may be able to do it.

## **5. Drug Design**

Although drug design is really a problem in computational chemistry. Many of the drugs being developed still do so through the trial and error method. This is very expensive and if more effective ways of simulating how a drug will react would save a ton of money and time.

## **6. Cyber Security**

Various techniques to combat cyber security threats can be developed using some of the quantum machine learning approaches mentioned above to recognize the threats earlier and mitigate the damage that they may do.

## **8. Circuit, Software, and System Fault Simulation**

When one develops large software programs with millions of lines of code or large ASIC chips that have billions of transistors, it can get awfully difficult and expensive to verify them for correctness. There can be billions or trillions of different states and it is impossible for a classical computer to check every single one in simulation. Not only does one want to understand what will happen when the system is operating

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normally, but one also wants to understand what happens if there is a hardware or other error. The cost of an error can be very high because some of these systems can be used where lives or millions of dollars might be dependent on their being error-free. By using quantum computing to help in these simulations, one can potentially provide a much better coverage in their simulations with a greatly improved time to do so.

### **Conclusion**

Quantum computing will give rise to a wave of technological applications, creating new business opportunities and helping solve some of today's most pressing global challenges. Previously untapped effects of quantum theory can now be used as a resource in technologies with far-reaching applications: secure communication networks, ultra-precise sensors, study of chemical reactions for pharmacology, novel materials and fundamentally new paradigms of computation.<sup>(3)</sup>

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# Spatial Inequality and Development in Eastern and Western Countries of the World

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## **Abstract**

An important feature of many developing countries is spatial inequality which seems to increase with economic growth and development. The theory of Kuznets (1955) and Williamson (1965) suggests that spatial inequality first increases in the process of development, and then decreases. The presence of spatial inequality has minimal effect on the rate of growth of Eastern and Western countries across the world. This paper examines the theoretical and empirical literature on spatial inequality to learn what we know and do not know about the causes of spatial inequality. This paper discusses the level of development and spatial inequality across the Eastern and Western Countries of the World in 2015. This paper studies the standard of living of both the regions and it is also evident that spatial inequalities increase at very high levels of economic development.

**Keywords:** Spatial inequality, economic development, empirical literature.

## **Introduction**

“I believe that virtually all the problems in the world come from inequality of one kind or another.”

-Amartya Sen

Spatial inequality is defined as inequality in economic and social indicators of well being across geographical units within a country.

The earlier group of thinkers tended to argue that inequality did not really matter, but more recent thinkers and literature, show that inequality does matter for growth, broader human development and well-being from instrumental and intrinsic viewpoints. Human capabilities are in any case independent of income growth, nevertheless countries differ in terms of human development although having similar level of per capita income. There is an inverted U-shaped relationship between spatial inequality and development. Spatial inequality is studied in order to understand the distribution of world income, and also to understand the concentrations of the very poor. It is important to have regional income estimates so that one can compare it within and between countries.

Spatial inequality may be beneficial or harmful, from the standpoint of economic efficiency. Empirical

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studies rarely have a decisive impact on policy or theory. Thus empirical literature became somewhat contradictory in proving this hypothesis. Some economists have stated that the inequality-growth relationship depends on the level of economic development (Barro,1999) or that any change in inequality reduces future growth (Banerjee and Duflo,2000) or the debate on the relationship between economic growth and inequality. We are still far from generalizing the channels through which inequality affects economic growth. Spatial inequality may be socially destabilizing if the regional divergence in economic welfare and political interests contributes to general social instability.

The empirical literature on human development identifies several dimensions of capabilities that reveals strong association with higher growth, the casualties however run both ways. The primary factor that is used to distinguish between developed and developing countries is Gross Domestic Product (GDP) per capita. One limitation of GDP is that consumer prices for same items vary from country to country, and hence we use Purchasing Power Parity(PPP) to solve this problem.

The present paper examines both economic and human development as both are measures of a country's overall development. Human development is defined as the process of enlarging people's freedoms and opportunities and improving their well-being. Whereas, economic development can be defined as the adoption of new technologies, transition from agriculture-based to industry-based economy, and general improvement in living standards.

According to the current HDI Report, the Eastern countries are still developing, whereas most of the Western countries are considered developed nations. This distinction arises because the developed countries are, (i) highly industrialized, (ii) their birth and death rates are stable or in other words we can say that they have a higher life expectancy, (iii) there is minimum under-utilisation of resources, (iv) they have more women working than unemployed women in developed nations and, (v) they have lower levels of debt than the developing countries. Another measuring device of development is the Human Development Index (HDI), to assess the social and economic development levels of countries. It lies between 0 to 1, and the closer it is to 1, the more developed is the country. Usually developed countries have HDI's of 0.8 or higher.

However, there are a very few literatures that could be found that have examined the level of inequality among Eastern and Western countries of the world. This paper is a modest attempt to examine such spatial inequality.

The paper is organized as follows-**Section 1** presents research questions and the purpose of study and explains how regional differences affects growth and development in literature review. **Section 2** shows the data and methodology while **Section 3** represents the findings and analysis of the data that tests which region is more developed, and finally Section 4 concludes the paper.

## **Section 1:**

### **1.1 Research Questions**

Following are the research questions, which are addressed in the following study

- 1.** Are the Eastern Countries or the Western Countries more developedΔ
- 2.** Is there any kind of **Inequality** between the Eastern and Western CountriesΔ
- 3.** Does the Eastern or Western Countries have a better standard of livingΔ

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## **1.2 Purpose of Study**

The primary objective of this paper is to highlight inter-temporal provincial inequalities in various economic and social dimensions. The indicators that have been included in this research relate to measures of economic development and spatial inequality. The purpose of study is to test which region is more developed and why. The objective is to analyze the under-utilisation of resources if any, and also to examine spatial inequality in these two regions. It also tests to measure the level of standard of living of both Eastern and Western countries. In this paper 18 countries from the Eastern region and 22 countries from the Western regions of the world are chosen to study the level of development and disparity in these regions.

## **1.3 Literature Review**

According to Ravi Kanbur and Anthony J. Venables economic inequality is structured and experienced spatially. The main objective of the paper of Ravi Kanbur and Anthony J. Venables(2005) was to analyze an important theme that has been neglected for years, named spatial inequality. The author address to a few important questions such as “What is spatial inequality $\Delta$ ”, “What are its determinants $\Delta$ ”, “how has it been evolving $\Delta$ ”, “Why does it matter $\Delta$ ” and “What should be the policy responses to spatial inequality $\Delta$ ”. In their book they have analyzed evidence of 50 developing countries having spatial inequality. There is regional inequality also as a consequence of uneven impact of trade openness and globalization.

David R. Henderson, Robert M. McNab, and Tamas Rozsas has analyzed the transition of many countries from socialism to somewhat free economies. Their research states that in relatively free economies, a large part of the inequality is due to differences in productivity. High income motivates productivity and hence virtually benefiting the society.

According to Dason Acemoglu and Melissa Dell, in their journal(2010), spatial differences in income per capita motivates growth theory and development economics. Inequality across countries is higher than interregional income differences in (within countries) which leads to income differences extensively. The major economic differences in income and productivity, and the possible presence of important interlinkages between local and national determinants of productivity has led to comprehensive explanations that growth and development should strive to match.

Sukoo Kim(2008) in his paper has surveyed the recent developments in spatial inequality to understand the benefits and costs, and to draw inferences concerning appropriate policy responses for dealing with spatial inequality. His reaction on increasing spatial inequality is economic development allowing regions to take advantage of first and second natures of geography (resources endowments and geographic proximity to rivers and ports) as an increase in spatial inequality may be beneficial as productivity is increased. From a theoretical standpoint, the causes of a long-run inverted U-shaped pattern of spatial inequality, to the extent that it exists, are still not well understood. According to him, economic development and growth may have common factor but each nations possesses differing geographic institutional and political conditions which may solve problems associated with spatial inequality.

## Section 2: Data and Methodology

This study is based on HDI Reports and statistical inference. The data collected for the purpose of the study are secondary in nature and are shown in Table 1 and Table 2. Table 1 shows 22 Western Countries of the world and their Human Development Index (HDI), Gross Domestic Product, Life expectancy and Unemployment problem. The data collected is secondary in nature. The HDI values of the 22 different countries shows the level of literacy rate, life expectancies and the standard of living. The value of HDI equal or more than 0.8 signifies a developed country. Here Switzerland tops the list with a HDI value of 0.93 and hence considered the most developed among the other 21 Western countries. Total and GDP per capita is calculated to measure the standard of living and to analyze if the workforce is efficiently producing goods and services. Life Expectancy of both male and female population is calculated to study the survival rate of both the population. Lastly unemployment is calculated to measure inequality and also development.

**Table 1: DEVELOPMENT INDICATORS OF THE WESTERN COUNTRIES OF THE WORLD**

COUNTRIES	HUMAN DEVELOPMENT INDEX [2015]	LIFE EXPECTANCY [2015]		GROSS DOMESTIC PRODUCT (GDP) 2011 PPP \$ BILLION		UNEMPLOYMENT [2015]
		MALE	FEMALE	TOTAL [2015]	PER CAPITA [2015]	TOTAL (% OF LABOUR FORCE)
SWITZERLAND	0.939	81	85.1	456.7	55112	4.3
<b>GERMANY</b>	<b>0.926</b>	<b>78.7</b>	<b>83.4</b>	<b>3586.5</b>	<b>44053</b>	<b>4.6</b>
DENMARK	0.925	78.5	82.3	246.4	43415	6.3
<b>NETHERLANDS</b>	<b>0.924</b>	<b>79.9</b>	<b>83.5</b>	<b>785.4</b>	<b>46374</b>	<b>6.1</b>
IRELAND	0.923	79	83.1	240.8	51899	9.5
<b>NEW ZEALAND</b>	<b>0.915</b>	<b>80.3</b>	<b>83.7</b>	<b>159.8</b>	<b>34762</b>	<b>5.9</b>
FRANCE	0.897	79.4	85.2	2492.3	37306	10.6
<b>BELGIUM</b>	<b>0.896</b>	<b>78.5</b>	<b>83.4</b>	<b>464.3</b>	<b>41138</b>	<b>8.7</b>
AUSTRIA	0.893	79.1	84	378	43893	5.7
<b>ITALY</b>	<b>0.887</b>	<b>80.9</b>	<b>85.7</b>	<b>2042.2</b>	<b>33587</b>	<b>12.1</b>
SPAIN	0.884	80	85.4	1523.2	32814	22.4
<b>GREECE</b>	<b>0.866</b>	<b>78.2</b>	<b>84</b>	<b>266.4</b>	<b>24617</b>	<b>24.9</b>
ESTONIA	0.865	72.2	81.4	35.3	26930	5.9
<b>PORTUGAL</b>	<b>0.843</b>	<b>78.2</b>	<b>84</b>	<b>276.2</b>	<b>26690</b>	<b>12.1</b>
HUNGARY	0.836	71.6	78.8	240.9	24474	7
<b>CROATIA</b>	<b>0.827</b>	<b>74.2</b>	<b>80.8</b>	<b>86.3</b>	<b>20430</b>	<b>16.1</b>
URUGUAY	0.795	73.7	80.8	68.5	19952	7.3
<b>PANAMA</b>	<b>0.788</b>	<b>74.8</b>	<b>80.9</b>	<b>82.1</b>	<b>20885</b>	<b>5.2</b>
MEXICO	0.762	74.6	79.4	2096	16502	4.3
<b>BRAZIL</b>	<b>0.754</b>	<b>71</b>	<b>78.5</b>	<b>3004.4</b>	<b>14455</b>	<b>7.2</b>
PERU	0.74	72.2	77.5	366.2	11672	3.5
<b>PARAGUAY</b>	<b>0.693</b>	<b>70.9</b>	<b>75.2</b>	<b>57.4</b>	<b>8644</b>	<b>4.9</b>
<b>TOTAL</b>	<b>18.778</b>	<b>1686.9</b>	<b>1806.1</b>	<b>18955.3</b>	<b>679604</b>	<b>194.6</b>
<b>MEAN</b>	<b>0.8535</b>	<b>76.6772</b>	<b>82.0954</b>	<b>861.6045</b>	<b>30891.0909</b>	<b>8.8455</b>
<b>STANDARD DEVIATION</b>	<b>0.0705</b>	<b>3.5165</b>	<b>2.8254</b>	<b>1083.8651</b>	<b>13315.8316</b>	<b>5.7127</b>

[Source: HDI Report 2016]

<b>Table 2: DEVELOPMENT INDICATORS OF THE EASTERN COUNTRIES OF THE WORLD</b>						
COUNTRIES	HUMAN DEVELOPMENT INDEX[2015]	LIFE EXPECTANCY[2015]		GROSS DOMESTIC PRODUCT(GDP) [2011 PPP \$ billion]		UNEMPLOYMENT [2015]
		Male	Female	Total(2015)	PER CAPITA(2015)	TOTAL[% OF LABOUR FORCE]
<b>INDIA</b>	<b>0.624</b>	<b>66.9</b>	<b>69.9</b>	<b>7512.5</b>	<b>5730</b>	<b>9.5</b>
EGYPT	0.691	69.2	73.6	938	10250	12.1
<b>PAKISTAN</b>	<b>0.55</b>	<b>65.4</b>	<b>67.4</b>	<b>86.4</b>	<b>4745</b>	<b>5.4</b>
MALDIVES	0.701	76	78	4.9	11892	11.8
<b>NEPAL</b>	<b>0.558</b>	<b>68.6</b>	<b>71.5</b>	<b>66</b>	<b>2919</b>	<b>9.1</b>
QATAR	0.856	77.5	80.1	302.5	135222	0.2
<b>MONGOLIA</b>	<b>0.795</b>	<b>65.6</b>	<b>74.2</b>	<b>39.9</b>	<b>11471</b>	<b>7.1</b>
CHINA	0.738	74.5	77.5	18374.7	13400	4.6
<b>BANGLADESH</b>	<b>0.579</b>	<b>70.7</b>	<b>73.9</b>	<b>505</b>	<b>9197</b>	<b>4.4</b>
INDONESIA	0.689	67	71.2	2674.9	10385	5.8
<b>JAPAN</b>	<b>0.903</b>	<b>80.4</b>	<b>86.9</b>	<b>4545.7</b>	<b>25804</b>	<b>3.3</b>
MALAYSIA	0.789	72.6	77.3	767.6	25308	2.9
<b>SINGAPORE</b>	<b>0.925</b>	<b>80.1</b>	<b>86.2</b>	<b>449.9</b>	<b>80192</b>	<b>3.3</b>
SAUDI ARABIA	0.847	73.2	75.9	1586	50284	5.8
<b>VIETNAM</b>	<b>0.683</b>	<b>71.2</b>	<b>80.6</b>	<b>519.8</b>	<b>5668</b>	<b>2.1</b>
BHUTAN	0.607	69.6	70.1	5.9	7601	2.6
<b>ISRAEL</b>	<b>0.899</b>	<b>80.8</b>	<b>84.2</b>	<b>265.4</b>	<b>31671</b>	<b>5</b>
THAILAND	0.74	71.3	78	1042.9	15345	1.1
<b>TOTAL</b>	<b>13.114</b>	<b>1300.6</b>	<b>1375.9</b>	<b>40486</b>	<b>460418</b>	<b>84.1</b>
<b>MEAN</b>	<b>0.7286</b>	<b>72.2556</b>	<b>76.4389</b>	<b>2249.2222</b>	<b>25578.7777</b>	<b>4.6722</b>
<b>STANDARD DEVIATION</b>	<b>0.1208</b>	<b>5.03</b>	<b>5.6468</b>	<b>4456.2521</b>	<b>33822.42</b>	<b>3.1581</b>

[Source: HDI Report 2016]

Table 2 shows 18 Eastern Countries of the world and their Human Development Index (HDI), Gross Domestic Product, Life expectancy and Unemployment problem. The data is secondary in nature. Here Singapore tops the list with a HDI value of 0.92 and hence considered the most developed among the other 18 countries. Mean and standard deviation is also calculated.

Here equality of two means  $\mu_1$  and  $\mu_2$  are tested (where  $\sigma_1$  and  $\sigma_2$  unknown, but we assume same population variance, that is  $\sigma_1 = \sigma_2 = \sigma$ )

We are to test  $H_0: \mu_1 = \mu_2$  vs  $H_{11}: \mu_1 > \mu_2$

$$H_{12}: \mu_1 < \mu_2$$

$$H_{13}: \mu_1 \neq \mu_2$$

To test for equality of means,  $x_1$  and  $x_2$  are used as unbiased estimator of  $\mu_1$  and  $\mu_2$  respectively. Now the distribution of  $x_1$  and  $x_2$  involve  $\sigma_1$  and  $\sigma_2$  which are unknown but equal in this case. Hence combining two samples we are to use some unbiased estimators of  $\sigma$ .  $s_1^2$  and  $s_2^2$  are the sampling variance comparing to the first and second sample respectively and we know  $(n_i - 1)s_i^2 / \sigma_i^2 \sim \chi_{n_i - 1}^2$ ,  $i = 1, 2$ . Now since  $\sigma_1$  and  $\sigma_2$  are equal, combining these two statistic we can use,

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$S^2 = (n_1 - 1)s_1^2 + (n_2 - 1)s_2^2 \div (n_1 + n_2 - 2)$  as an unbiased estimator of  $\sigma^2$ .

Evidently,

$$(n_1 + n_2 - 2)S^2 \div \sigma^2 \sim \chi^2_{n_1 + n_2 - 2}$$

Moreover  $x_i \sim N(\mu_i, \sigma_i^2/n_i)$ ,  $i=1, 2$

$x_1 - x_2 \sim N(\mu_1 - \mu_2, \sigma^2/n_1 + \sigma^2/n_2)$  and it is independent of  $S^2$ .

Therefore,

$$t = (x_1 - x_2) - (\mu_1 - \mu_2) \div \sqrt{(\sigma^2/n_1 + \sigma^2/n_2) \div S^2/\sigma^2}$$

$$t = (x_1 - x_2) - (\mu_1 - \mu_2) \div S\sqrt{(1/n_1 + 1/n_2)} \sim t_{n_1 + n_2 - 2}$$

The above statistic is known as **fisher's t** statistic.

We reject  $H_0$  at  $\alpha$  level of significance if,

- 1) Observed  $t > t_{\alpha, n_1 + n_2 - 2}$  to test  $H_0$  vs  $H_{11}$
- 2) Observed  $t < t_{1-\alpha, n_1 + n_2 - 2}$  to test  $H_0$  vs  $H_{12}$
- 3) Observed  $t > t_{\alpha/2, n_1 + n_2 - 2}$  to test  $H_0$  vs  $H_{13}$ .

The Confidence Interval (C.I) is given by,

$$\{(x_1 - x_2) - t_{\alpha/2, n-1} \times S\sqrt{(1/n_1 + 1/n_2)}, (x_1 - x_2) + t_{\alpha/2, n-1} \times S\sqrt{(1/n_1 + 1/n_2)}\}$$

The Central Limit Theorem states that the sampling distribution of the sample means approaches a normal distribution as the sample size gets larger. This fact holds especially true for sample sizes over 30.

### **Section 3: Analysis and Findings**

#### **3.1 Income Inequality Between Eastern And Western Countries**

There is very significant spatial inequality among western and eastern countries of the world. Gini Index is used to measure income inequality between the Eastern and Western countries. The Gini Index is a statistical measure of distribution often used as a gauge of economic inequality. The index is based on the Gini coefficient, a statistical dispersion measurement that ranks income distribution on a scale between 0 (or 0%) and 1 (or 100%), with 0 representing perfect equality and 1 representing perfect inequality.

A country in which every resident has the same income would have an income Gini coefficient of 0, but this is not the case for the Eastern and Western countries. Moderately, the value of Gini coefficient is 0.37 for both the regions on the basis of the given data. Some Western countries like Paraguay, Panama, Uruguay, and Peru has higher income inequality compared to other countries in the given data, with a Gini coefficient of 0.49 (or 48.8%), 0.5 (or 49.9%), 0.42 (or 41.7%) and 0.44 (or 44.3%). Whereas, Netherlands has lower income inequality compared to other countries of the Western region, with the value of Gini Index being 0.28 (or 28.2%).

A country with perfect equality in income distribution, that is Gini coefficient of 0 (or 0%) does not exist. A high-income country and a low income country can have the same Gini coefficient, as long as incomes are distributed similarly within each: Germany and Croatia both had income Gini coefficients around 0.31-0.32 in 2015, though Croatia's GDP per person was less than half of Germany's.

Similarly, on an average, the Gini coefficient of the Eastern countries had been 0.37 (or 37.2%) during 2015, on the basis of the given data. Countries like Thailand and Singapore has higher income inequality

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with the value of Gini Index being 0.44(or 44.5%) and 0.46(or 45.9%) in 2015. Whereas countries like India, Indonesia, Nepal, Mongolia and Egypt has a Gini coefficient around 0.31-0.34 (Table 3).

**Table 3: GINI INDICES OF THE WESTERN COUNTRIES OF THE WORLD**

<b>COUNTRIES</b>	<b>YEAR</b>	<b>VALUE OF GINI INDEX</b>
AUSTRIA	2015	30.5
CROATIA	2015	31.1
GERMANY	2015	31.7
FRANCE	2015	32.7
ESTONIA	2015	32.7
GREECE	2015	36.0
NETHERLANDS	2015	28.2
PORTUGAL	2015	35.5
SPAIN	2015	36.2
PARAGUAY	2017	48.8
PANAMA	2017	49.9
URUGUAY	2015	41.7
SWITZERLAND	2015	32.3
ITALY	2015	35.4
MEXICO	2016	43.4
PERU	2015	44.3
BRAZIL	2015	51.3

*[Source: Gini Index(World Bank estimates)]*

**Table 4: GINI INDICES OF THE EASTERN COUNTRIES OF THE WORLD**

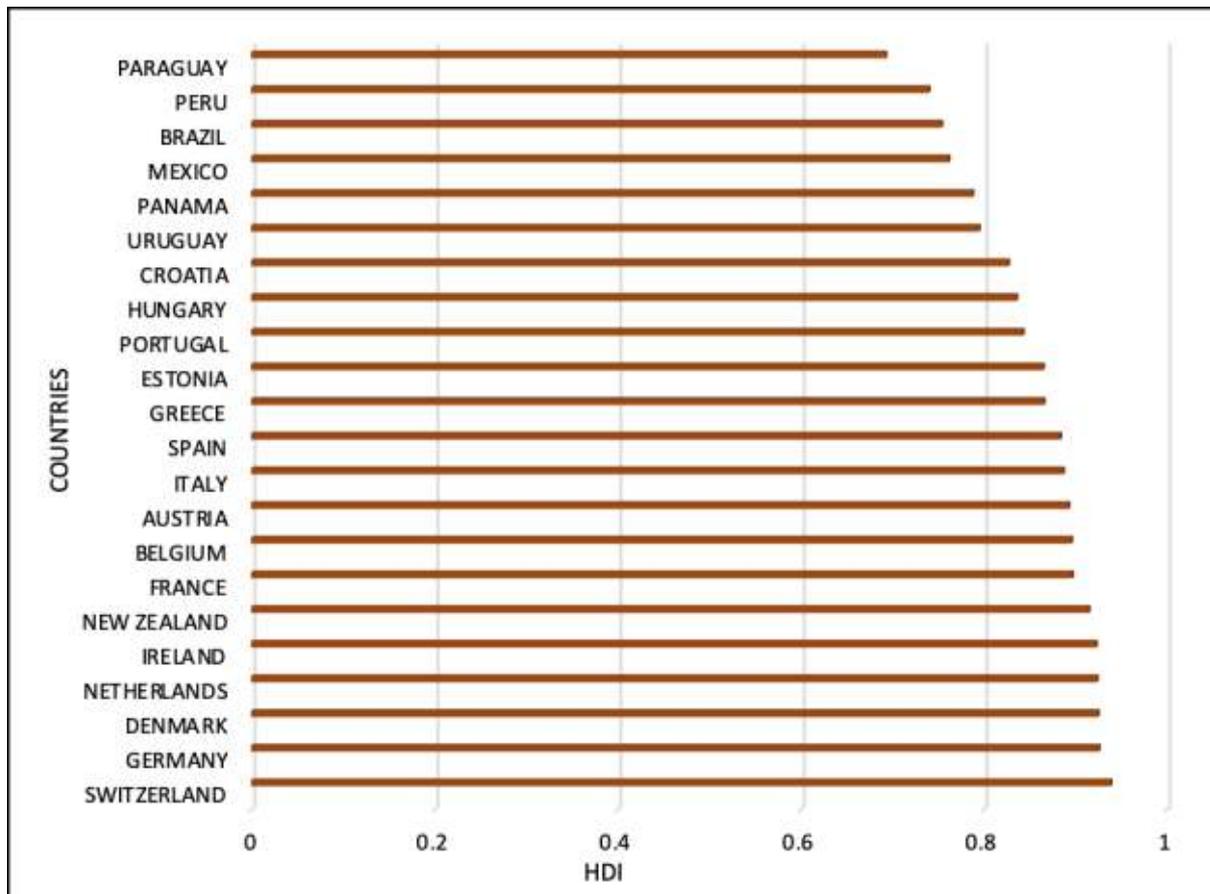
<b>COUNTRIES</b>	<b>YEAR</b>	<b>VALUE OF GINI INDEX</b>
INDIA	2011	35.7
BHUTAN	2017	37.4
CHINA	2015	38.6
INDONESIA	2017	38.1
NEPAL	2010	32.8
PAKISTAN	2015	33.5
VIETNAM	2016	35.5
THAILAND	2015	44.5
JAPAN	2011	37.8
ISRAEL	2016	38.9
MALDIVES	2009	38.4
MONGOLIA	2016	32.3
EGYPT	2015	31.8
SINGAPORE	2017	45.9

*[Source: Gini Index(World Bank estimates)]*

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The Western countries are more developed compared to the Eastern countries with respect to HDI measured by UNDP, GDP per capita and also unemployment.

**Figure 1: Human Development Index (HDI) of the Western Countries in 2015**



The above Figure 1 shows which Western countries are more developed and which are less developed based on the value of HDI. It assesses the social and economic development levels of the 22 countries. Switzerland has a HDI of 0.93 and hence considered the most developed on the basis of the given data. Countries having HDI value equal to or greater than 0.8 are considered developed. Here Paraguay has the lowest HDI value of 0.69 on the basis of the given data.

In contrast Figure 2 shows which Eastern countries are more developed and which are less developed based on the HDI value. Here Singapore has the highest HDI value of 0.92 on the basis of the given data. This shows Singapore is the most developed among the rest of the Eastern countries based on the given sample. Whereas Pakistan with a HDI value of 0.55 is the least developed among the other Eastern countries. GDP per capita shows the standard of living of the Eastern and Western Countries.

**Figure 2: Human Development Index (HDI) of the Eastern Countries in 2015**

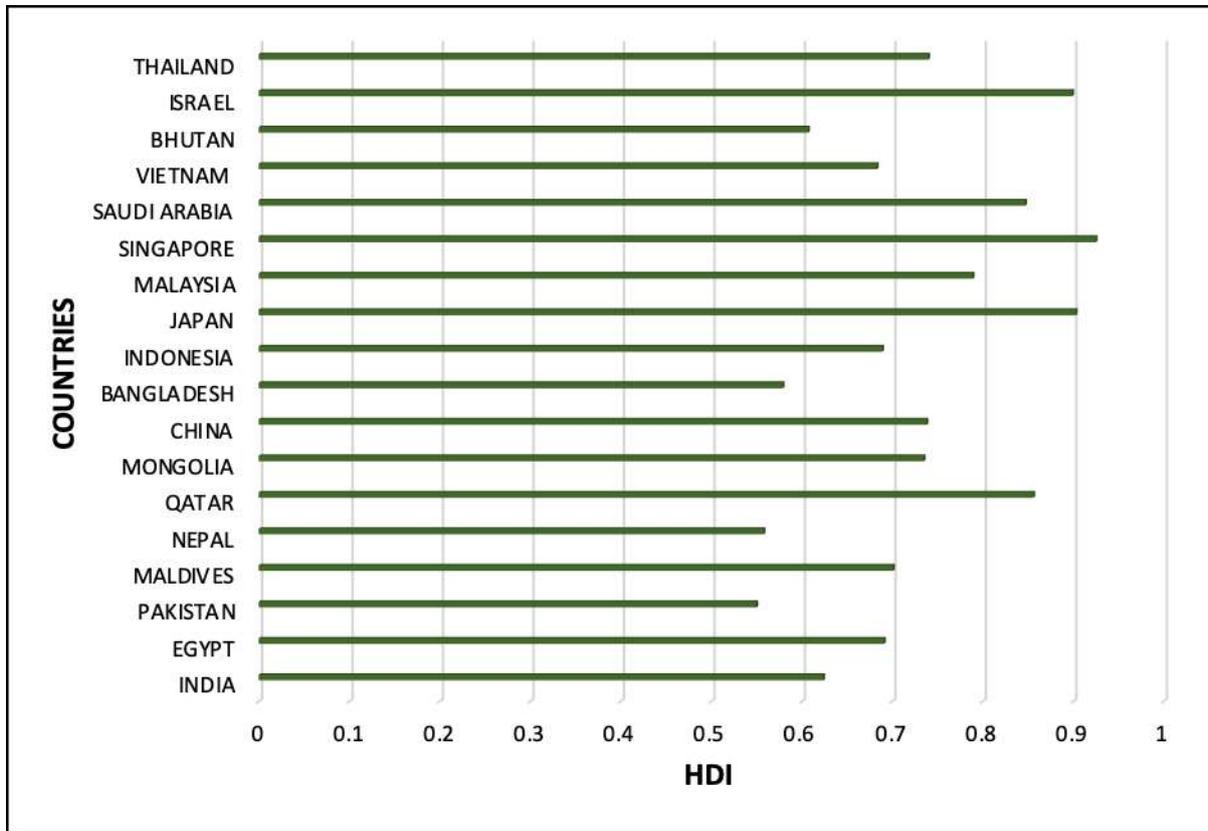


Figure 3 shows which Western Countries have a better standard of living. Switzerland has the highest GDP per capita of \$55112. This shows that Switzerland has a better standard of living than the other Western countries based on the given sample. While Peru has the lowest GDP per capita of \$11672 implying it has the lowest standard of living among the other 21 countries.

Figure 4 compares the standard of living between the 18 Eastern countries of the world. Qatar has the highest GDP per capita of \$135222 whereas Nepal has the lowest GDP per capita of \$2313. Qatar has a better standard of living than rest of the Eastern countries.

Unemployment is greater in Western Countries than in Eastern Countries as shown in Figure 5. This diagram shows the massive level of unemployment present in the 22 Western countries. This is due to the under-utilisation of labour resources and Greece tops the list with unemployment of 24.9 while Peru has the lowest level of unemployment. Western countries has higher level of regional inequality.

Figure 3: GDP per capita of the Western Countries in 2015

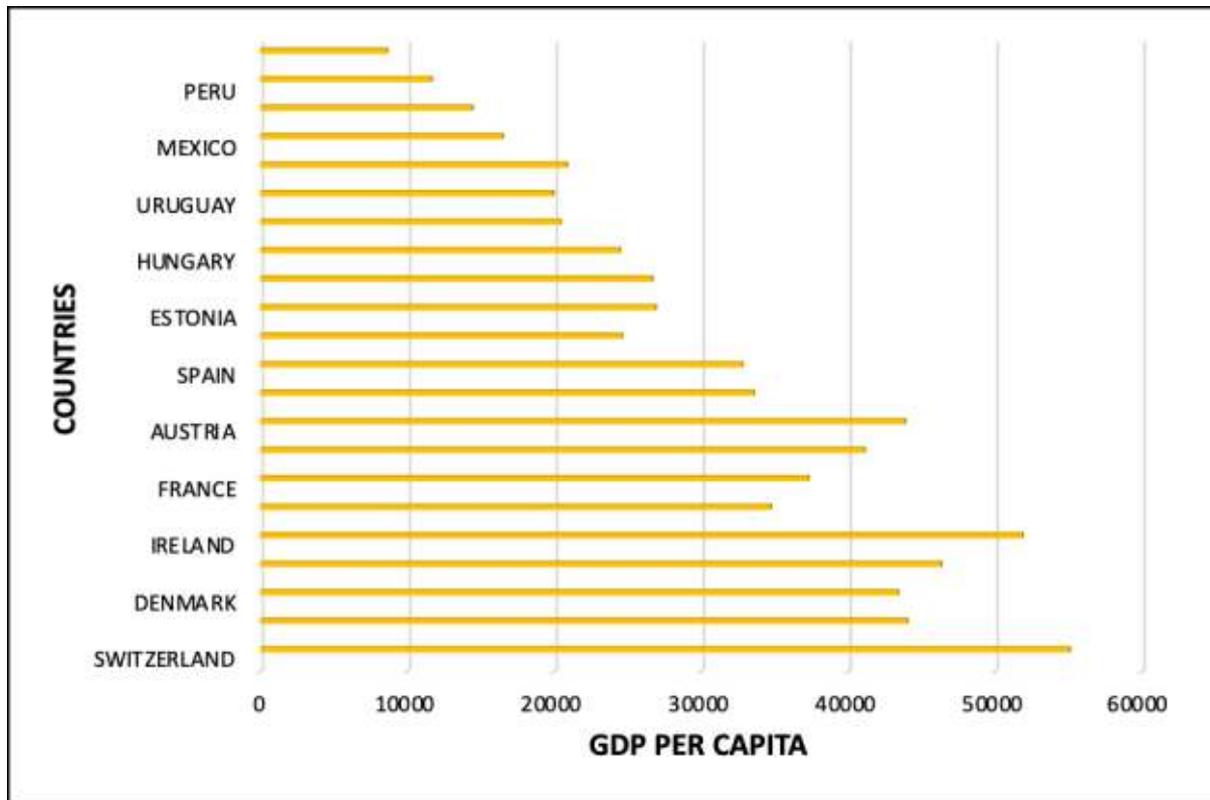


Figure 4: GDP per capita of the Eastern countries in 2015

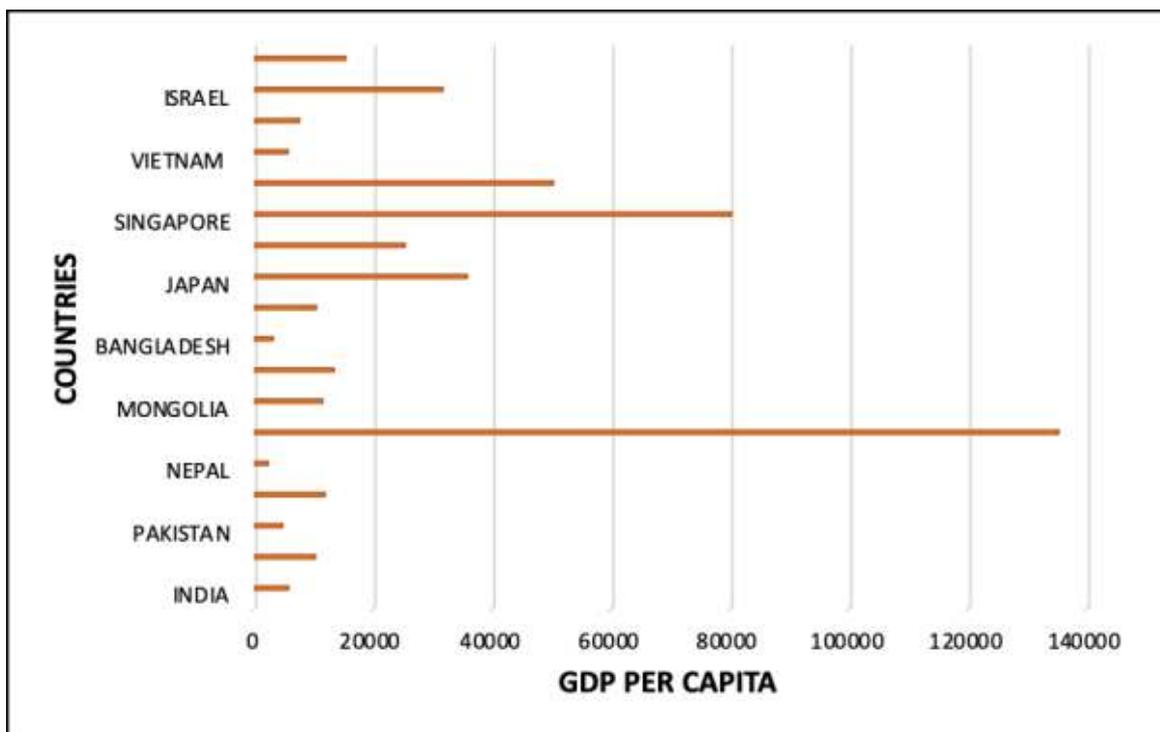


Figure 5: Unemployment in the Western Countries in 2015

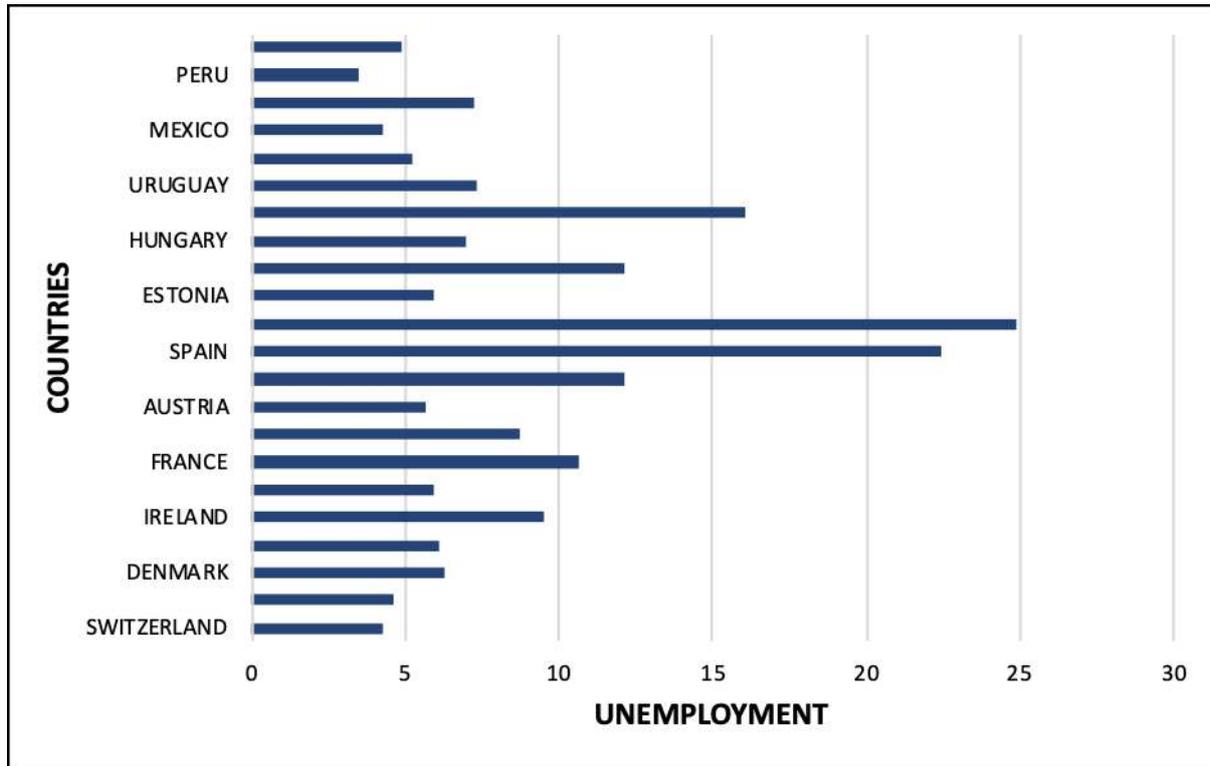
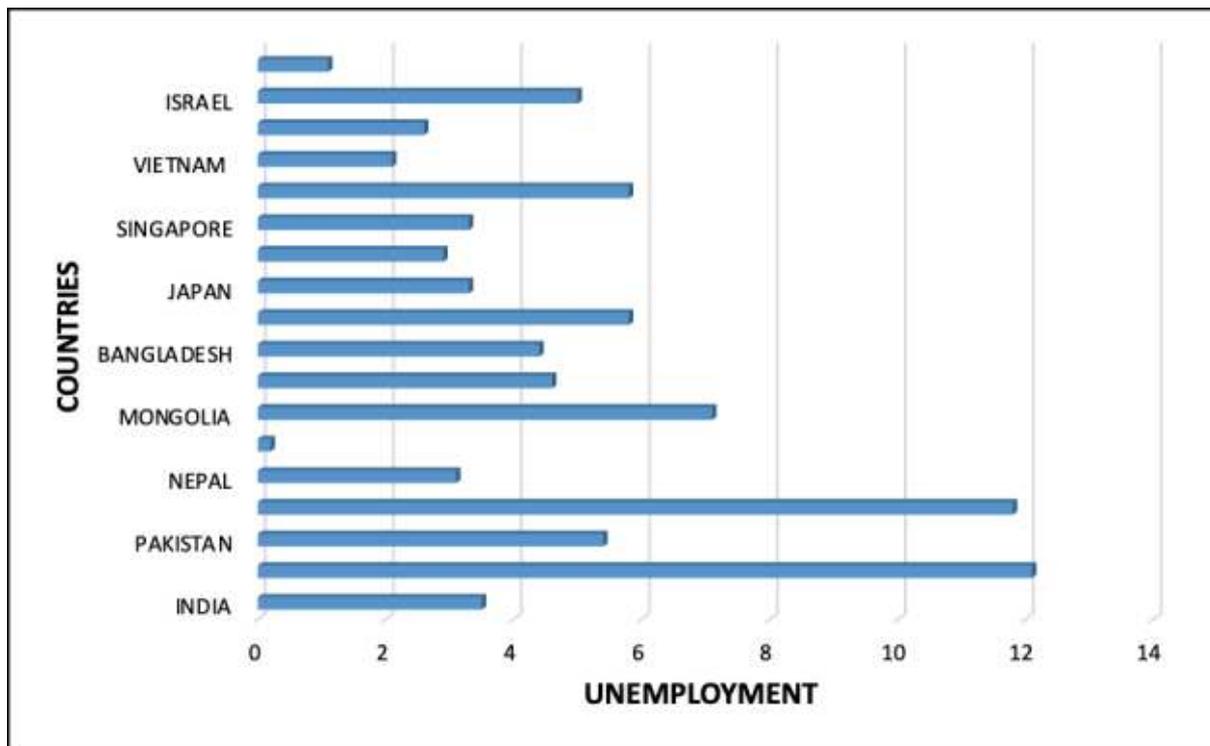


Figure 6: Unemployment in the Eastern Countries in 2015



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This figure shows the level of unemployment in the 18 Eastern countries. Egypt has the highest unemployment rate of 12.1. Eastern countries have less regional inequality (Figure 6). However, this paper also carries out some hypothesis testing of indicators for the countries in these two regions.

### 3.2 Comparison of HDI of Eastern and Western countries

Here Human Development Index of Eastern and Western Countries of the world are compared.

It is assumed  $x_i \sim N(\mu, \sigma^2)$

It is also assumed that  $\mu_1$  to be unknown population mean for Western Countries and  $\mu_2$  to be the unknown population mean for Eastern Countries. Here we test at 5% level of significance.

Here two hypothesis, null hypothesis and alternative hypothesis  $H_0: \mu_1 = \mu_2$  vs  $H_1: \mu_1 > \mu_2$  are tested.

Here,  $n_1$  = number of Western countries

$n_2$  = number of Eastern countries

$x_1$  = sample mean of the HDI of Western countries

$x_2$  = sample mean of the HDI of Eastern countries

$s_1$  = sample variance of the HDI of Western countries

$s_2$  = sample variance of the HDI of Eastern countries

$n_1 = 22, n_2 = 18, x_1 = 0.8535, x_2 = 0.7286, s_1 = 0.0705, s_2 = 0.1208$

Assuming same population variance (homoscedasticity)

Now since,  $\sigma_1$  and  $\sigma_2$  are equal, combining these two statistics we can use,

$S^2 = \frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2}$  as an unbiased estimator of  $\sigma^2$

$S^2 = \frac{(22 - 1) \times 0.00497025 + (18 - 1) \times 0.01459264}{22 + 18 - 2}$

$S^2 = 0.0093$

$S = 0.0963$

As the sample size is greater than 30, so we apply Central Limit Theorem which is normally distributed.

Here the test statistic is used:

$Z = \frac{(x_1 - x_2) - (\mu_2 - \mu_1)}{s \sqrt{1/n_1 + 1/n_2}} \sim N(0, 1)$  asymptotically

Observed  $Z = \frac{\{(0.8535 - 0.7286) - 0\}}{0.0963 \sqrt{(1/22 + 1/18)}}$

Observed  $Z = 4.0805$

Therefore  $H_0$  is rejected at 5% level of significance if,

Observed  $Z > Z_{\alpha}$

$Z_{0.05} = 1.64$

Therefore Observed  $Z > Z_{\alpha}$

So  $H_0$  is again rejected at 5% level of significance.

So HDI of Western Countries is more than the HDI of Eastern Countries implying Western Countries are more developed than the Eastern Countries.

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### 3.3 Comparison of GDP per capita of the Eastern and Western countries

Here comparison of the Gross Domestic Product (GDP) per capita among 18 Eastern and 22 Western countries of the world are compared.

Here  $x_i \sim N(\mu, \sigma^2)$

$\mu_1$  is the unknown population mean of the Western Countries and  $\mu_2$  is the unknown population mean of the Eastern Countries. Here we test at 5% level of significance.

Two hypotheses are tested  $H_0: \mu_1 = \mu_2$  vs  $H_1: \mu_1 > \mu_2$

Here,  $n_1$  = number of Western countries

$n_2$  = number of Eastern countries

$x_1$  = sample mean of the GDP per capita of Western countries

$x_2$  = sample mean of the GDP per capita of Eastern countries

$s_1$  = sample variance of the GDP per capita of Western countries

$s_2$  = sample variance of the GDP per capita Eastern countries

$n_1 = 22, n_2 = 18, x_1 = 30891.0909, x_2 = 25578.7777, s_1 = 13315.8316, s_2 = 33828.42$

Assuming same population variance (homoscedasticity) and since  $\sigma_1$  and  $\sigma_2$  are equal, combining these two,

$S^2 = (n_1 - 1)s_1^2 + (n_2 - 1)s_2^2 \div n_1 + n_2 - 2$  can be used as an unbiased estimator of  $\sigma^2$ .

$S^2 = (22 - 1) \times (13315.8316)^2 + (18 - 1) \times (33828.42)^2 \div (22 + 18 - 2)$

$S^2 = 609939283.9481$

$S = 24696.9489$

As the sample size is greater than 30, so we apply Central Limit Theorem which is normally distributed.

Here following test statistic is used,

$Z = (x_1 - x_2) - (\mu_1 - \mu_2) \div s \sqrt{(1/n_1 + 1/n_2)} \sim N(0, 1)$  asymptotically.

Observed  $Z = (30891.0909 - 25578.7777) - 0 \div 24696.9488 \sqrt{(1/22 + 1/18)}$

Observed  $Z = 0.6768$

$H_0$  is rejected at 5% level of significance if,

Observed  $Z > Z_\alpha$

However,  $Z_{0.05} = 1.64$

Therefore Observed  $Z < Z_\alpha$

So  $H_0$  is rejected at 5% level of significance.

On an average GDP per capita of Western Countries and Eastern Countries is the same on the basis of the given sample. So on the basis of the given sample, Eastern and Western Countries on an average have the same level of development.

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### 3.4 Comparison of Unemployment of Eastern and Western countries

Here comparison of unemployment among 18 Eastern and 22 Western countries of the world is carried out in this section.

$x_1 \sim N(\mu, \sigma^2)$  and  $\mu_1$  is assumed to be as the unknown population mean for Western Countries and  $\mu_2$  is assumed to be as the unknown population mean for Eastern Countries. Here we test at 5% level of significance.

Here  $H_0: \mu_1 = \mu_2$  vs  $H_1: \mu_1 > \mu_2$  are tested

Here,  $n_1$  = number of Western countries

$n_2$  = number of Eastern countries

$x_1$  = sample mean of unemployment in Western countries

$x_2$  = sample mean of unemployment in Eastern countries

$s_1$  = sample variance of unemployment in Western countries

$s_2$  = sample variance of unemployment in Eastern countries

$n_1 = 22, n_2 = 18, x_1 = 8.8455, x_2 = 4.6722, s_1 = 5.7127, s_2 = 3.1581$

Assuming same population variance (homoscedasticity)

Now since  $\sigma_1$  and  $\sigma_2$  are equal, combining these two statistic can be used,

$S^2 = (n_1 - 1)s_1^2 + (n_2 - 1)s_2^2 \div n_1 + n_2 - 2$  as an unbiased estimator of  $\sigma^2$

$S^2 = (22 - 1) \times (5.7127)^2 + (18 - 1) \times (3.1581)^2 \div (22 + 18 - 2)$

$S^2 = 22.4969$

$S = 4.7430$

As the sample size is greater than 30, so Central Limit Theorem which is normally distributed is applied.

Here following test statistic is considered,

$Z = (x_1 - x_2) - (\mu_1 - \mu_2) \div s \sqrt{(1/n_1 + 1/n_2)} \sim N(0, 1)$  asymptotically.

Observed  $Z = (8.8455 - 4.6722) - 0 \div 4.7430 \sqrt{(1/22 + 1/18)}$

Observed  $Z = 2.7684$

$H_0$  is rejected at 5% level of significance if,

$$\text{Observed } Z > Z_\alpha$$

But  $Z_{0.05} = 1.64$

Therefore Observed  $Z > Z_\alpha$

So  $H_0$  is rejected at 5% level of significance.

Unemployment is greater in Western Countries than in Eastern Countries. So on the basis of the given sample there is under-utilisation of resources in Western Countries than the Eastern Countries.

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### 3.5 Comparison of Life Expectancy among Male and Female Population in the Western countries

Here Life Expectancies of the male and female population of the 22 Western countries are compared here.

Here,  $x_i \sim N(\mu, \sigma^2)$

Here,  $\mu_1$  is assumed to be as the unknown population mean for the female population of the Western Countries, whereas  $\mu_2$  is assumed as the unknown population mean for male population of the Western Countries. Here we test at 5% level of significance.

Here  $H_0: \mu_1 = \mu_2$  vs  $H_1: \mu_1 > \mu_2$  are tested

Here,  $n_1$  = number of Western countries

$n_2$  = number of Eastern countries

$x_1$  = sample mean of the female population in Western countries

$x_2$  = sample mean of the male population in Western countries

$s_1$  = sample variance of the female population in Western countries

$s_2$  = sample variance of the male population in Western countries

$n_1 = 22, n_2 = 22, x_1 = 82.0954, x_2 = 76.6772, s_1 = 2.8254, s_2 = 3.5165$

Assuming same population variance (homoscedasticity)

Now since  $\sigma_1$  and  $\sigma_2$  are equal, combining these two statistic following can be used,

$S^2 = (n_1 - 1) s_1^2 + (n_2 - 1) s_2^2 \div n_1 + n_2 - 2$  as an unbiased estimator of  $\sigma^2$ .

$S^2 = (22 - 1) \times (2.8254)^2 + (22 - 1) \times (3.5165)^2 \div (22 + 22 - 2)$

$S^2 = 10.1743$

$S = 3.1897$

As the sample size is greater than 30, Central Limit Theorem which is normally distributed is applied.

Here the test statistic,

$Z = (x_1 - x_2) - (\mu_1 - \mu_2) \div s \sqrt{(1/n_1 + 1/n_2)} \sim N(0, 1)$  asymptotically is assumed.

Observed  $Z = (82.0954 - 76.6772) - 0 \div 3.1897 \sqrt{(1/22 + 1/22)}$

Observed  $Z = 5.6337$

$H_0$  will be rejected at 5% level of significance if,

Observed  $Z > Z_\alpha$

However,  $Z_{0.05} = 1.64$

Therefore Observed  $Z > Z_\alpha$

So  $H_0$  is rejected at 5% level of significance.

Life Expectancy of female population is greater than life expectancy of the male population in Western Countries.

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### 3.6 Comparison of Life Expectancy among the Male and Female population of the Eastern countries

In this section Life Expectancies of the male and female population of the 18 Eastern countries are compared.

$x_1$  is assumed to be normally distributed with mean  $\mu$  and variance  $\sigma^2$ .  $\mu_1$  is assumed to be the unknown population mean for the female population, whereas  $\mu_2$  as the unknown population mean for the male population of the Eastern Countries. Here we test at 5% level of significance.

Here null hypothesis is  $H_0: \mu_1 = \mu_2$  and alternative hypothesis is  $H_1: \mu_1 > \mu_2$

Here,  $n_1$  = number of Eastern countries

$n_2$  = number of Eastern countries

$x_1$  = sample mean of the female population in Eastern countries

$x_2$  = sample mean of the male population in Eastern countries

$s_1$  = sample variance of the female population in Eastern countries

$s_2$  = sample variance of the male population in Eastern countries

$n_1 = 18, n_2 = 18, x_1 = 76.4389, x_2 = 72.2556, s_1 = 5.6468, s_2 = 5.03$

Assuming same population variance (homoscedasticity) and since  $\sigma_1$  and  $\sigma_2$  are equal, combining these two statistic,

$S^2 = (n_1 - 1) s_1^2 + (n_2 - 1) s_2^2 \div n_1 + n_2 - 2$  is derived as an unbiased estimator of  $\sigma^2$ .

Therefore,  $S^2 = (18 - 1) \times (5.6468)^2 + (18 - 1) \times (5.03)^2 \div (18 + 18 - 2)$

$S^2 = 28.5936$

$S = 5.3473$

As the sample size is greater than 30, Central Limit Theorem which is normally distributed, is applied.

Here the test statistic,

$Z = (x_1 - x_2) - (\mu_1 - \mu_2) \div s \sqrt{(1/n_1 + 1/n_2)} \sim N(0, 1)$  asymptotically.

Observed  $Z = (76.4389 - 72.2556) - 0 \div 5.3473 \sqrt{(1/18 + 1/18)}$

Observed  $Z = 2.3469$

$H_0$  will be rejected at 5% level of significance if,

Observed  $Z > Z_\alpha$

$Z_{0.05} = 1.64$

Therefore Observed  $Z > Z_\alpha$

Thus  $H_0$  is rejected at 5% level of significance.

Therefore, Life Expectancy of female population is greater than that of the male population in the Eastern Countries.

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### 3.7 Comparison of Life Expectancy of Female Population among Eastern and Western countries

Life Expectancies of the female population among 18 Eastern and 22 Western countries of the world are also compared in this section.

Here,  $x_i \sim N(\mu, \sigma^2)$

And  $\mu_1$  is assumed to be the unknown population mean for the female population of the Western Countries, and  $\mu_2$  to be the unknown population mean for the female population of the Eastern Countries. Hypothesis is tested at 5% level of significance.

Two hypotheses are  $H_0: \mu_1 = \mu_2$  vs  $H_1: \mu_1 > \mu_2$

Here,  $n_1$  = number of Western countries

$n_2$  = number of Eastern countries

$x_1$  = sample mean of the female population in Western countries

$x_2$  = sample mean of the female population in Eastern countries

$s_1$  = sample variance of the female population in Western countries

$s_2$  = sample variance of the female population in Eastern countries

$n_1=22, n_2=18, x_1=82.0954, x_2=76.4389, s_1=2.8254, s_2=5.6468$

Assuming same population variance (homoscedasticity) and since  $\sigma_1$  and  $\sigma_2$  are equal, combining these two statistic,

$S^2 = (n_1 - 1) s_1^2 + (n_2 - 1) s_2^2 \div n_1 + n_2 - 2$  is considered as an unbiased estimator of  $\sigma^2$ .

$S^2 = (22 - 1) \times (2.8254)^2 + (18 - 1) \times (5.6468)^2 \div (22 + 18 - 2)$

$S^2 = 18.6765$

$S = 4.3216$

Again Central Limit Theorem which is normally distributed is applied since the sample size is greater than 30.

Following test statistic,

$Z = (x_1 - x_2) - (\mu_1 - \mu_2) \div s \sqrt{(1/n_1 + 1/n_2)} \sim N(0, 1)$  asymptotically.

Observed  $Z = (82.0954 - 76.4389) - 0 \div 4.3216 \sqrt{(1/22 + 1/18)}$

Observed  $Z = 1.3735$

$Z_{0.05} = 1.64$

Therefore Observed  $Z < Z_\alpha$

So  $H_0$  is not rejected at 5% level of significance.

Thus on an average Life Expectancy of the female population of the Eastern and Western Countries are the same on the basis of the given sample.

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### 3.8 Comparison of Life Expectancy of Male Population among Eastern and Western countries

Finally, Life Expectancies of the male population among 18 Eastern and 22 Western countries of the world are also compared.

Again,  $x_i \sim N(\mu, \sigma^2)$

and  $\mu_1$  is considered as the unknown population mean for the male population of the Western Countries, and  $\mu_2$  as the unknown population mean for the male population of the Eastern Countries. Here testing is also carried out at 5% level of significance.

Here,  $n_1$ =number of Western countries

$n_2$ =number of Eastern countries

$x_1$ =sample mean of the male population in Western countries

$x_2$ =sample mean of the male population in Eastern countries

$s_1$ =sample variance of the male population in the Western countries

$s_2$ =sample variance of the male population in the Eastern countries

Two hypotheses are  $H_0: \mu_1 = \mu_2$  vs  $H_1: \mu_1 > \mu_2$

$n_1=22, n_2=18, x_1=76.6772, x_2=72.2556, s_1=3.5165, s_2=5.03$

Assuming same population variance (homoscedasticity)

And since  $\sigma_1$  and  $\sigma_2$  are equal, combining these two statistic,

$S^2 = \frac{(n_1-1)s_1^2 + (n_2-1)s_2^2}{n_1+n_2-2}$  is considered as an unbiased estimator of  $\sigma^2$ .

$S^2 = \frac{(22-1) \times (3.5165)^2 + (18-1) \times (5.03)^2}{22+18-2}$

$S^2 = 18.1525$

$S = 4.2605$

As the sample size is greater than 30, again Central Limit Theorem which is normally distributed is applied.

The test statistic,

$Z = \frac{(x_1 - x_2) - (\mu_1 - \mu_2)}{s \sqrt{1/n_1 + 1/n_2}} \sim N(0, 1)$  asymptotically.

Observed  $Z = \frac{(76.6772 - 72.2556) - 0}{4.2605 \sqrt{1/22 + 1/18}}$

Observed  $Z = 3.2653$

And  $Z_{0.05} = 1.64$

Therefore Observed  $Z > Z_\alpha$

Therefore  $H_0$  is rejected at 5% level of significance.

Thus Life Expectancy of male population in Western Countries is greater than Life Expectancy of male population in Eastern Countries.

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## Section 4: Conclusion

Throughout the paper, I have tried to analyze the level of development and presence of inequality. I have used **Testing of Hypothesis** to measure the level of development, standard of living and spatial inequality. Here, I have taken data on 18 Eastern countries and 22 Western Countries of the world to test a few hypothesis.

Human Development Index (HDI) of the Western countries is more than the Eastern countries indicating that Western countries have a higher level of social and economic development than the Eastern countries.

On an average, GDP per capita of Western countries and Eastern countries is the same on the basis of the given sample. On the basis of the given sample, we can analyze that the workforce of both the regions are more or less efficiently producing goods and services that consumers want. According to my analysis, Western countries have a higher standard of living than the Eastern countries as most of the Western countries have HDI more than 0.8 .

Unemployment is greater in Western countries than in Eastern countries, which indicates under-utilisation of labour force in the Western countries as they are capital-intensive in nature. Though Eastern countries have higher employment than the Western countries, but labour-intensive industries are what which is keeping the countries in the 'developing' track.

The Life Expectancy of the male population in Western countries is greater than the Life Expectancy of the male population in the Eastern countries. On an average Life Expectancy of the female population of the Eastern and Western countries are the same on the basis of the given sample. Life Expectancy of female population is greater than that of the male population in the Eastern countries. Life Expectancy of female population is greater than that of the male population in the Western countries. Female survival rate is more on an average than the male survival rate in the Eastern and Western regions.

Eastern countries have higher employment rate and hence it has lower regional inequality than the Western countries. Therefore spatial inequality in Western countries is higher than that of the Eastern countries.

According to the analysis, factors which may have contributed to increased regional inequality include IMF/World Bank structural adjustment programmes and lesser role of the public sector in economic development.

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# Micro, small and medium enterprises (MSME's) – will their journey be fruitful?

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## **Abstract**

In India, the tremendous growth in the Micro, small and medium enterprises (MSME's) sector has set an example for the world. It has been said that in most developing and developed countries, like India, this sector accounts for about two-third of the employment. Hence, it becomes a major contributor to growth. So, this paper is aimed at understanding the past of this sector in India and whether it bears a fruitful future. To begin with, a worldwide situation of the MSME sector gives an idea about its prospects as a part of the global economy. An overview to understand the categorization and components of this sector establishes the basis for further data-based analysis. Then we look at four sets of Data regarding this sector's contribution during 2000-2016 – Number of Units, Gross Domestic Product (GDP), Employment and Exports to focus on the existent situation of this sector. Analysis is done based on the respective data to highlight the possible high contribution this sector can have to push the economy forward whilst pointing out the problems it faces. With the problems, we also conclude that the sector has a high prospective for growth but requires improvement in technology and infrastructure.

**Keywords:** Micro Medium and Small Enterprises (MSME's), India, Overview, Contribution, Problems.

## **Section 1: Introduction**

In most of the countries, micro, small and medium-sized enterprises (MSMEs) account for a significant proportion of employment and growth. For e.g.- Small and medium-sized enterprises (SMEs) account for more than half of business sector output and employment in Europe.

Also, in a lot of countries, this sector outnumbers large companies by a wide margin and contributes towards a huge portion of the GDP. For example, Australian SMEs make up 97% of all Australian businesses, produced one third of total GDP, and employ 4.7 million people. Also, in Chile, in the commercial year 2014, 98.5% of the firms were classified as SMEs. In Tunisia, the self-employed workers alone account for about 28% of the total non-farm employment and firms with fewer than 100 employees account for about 62% of total employment.

Mostly in developing countries it must be noted that MSME's are the pathway to social inclusion, removal of poverty, rural area development and higher women employment rate as well. It also accounts

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for driving innovation and improving competition via a good quality and low cost production process. The mere existence of World MSME day on 27th June, announces its importance to the world, without a single doubt in mind.

However, this sector still faces various issues in departments of finance, transparency and trade. For e.g.: - since they rely majorly on bank credit and government support, during a period of depression or financial crisis, it is this sector that loses its ability to invest. They lack long term credit funding and security.

Moreover, the paper begins with Section 2 that covers the Research question, questioning the importance of the MSME sector while paying heed to its journey. Then, various points made by other researcher in their papers have been highlighted in Section 3, Literature review. Following which, Section 4 has the Methodology or process of making this whole paper has been detailed. With the focus being on the Indian MSME sector, an Overview of its existence has been also included in Section 5. After this, the required Data in Section 6 along with respective Analysis in Section 7 is done. Finally, the Conclusion as Section 8 ends the paper.

## **Section 2: Research Question**

This paper deals with the journey of the MSME's sector in India and whether it holds any importance for India going into the futureΔ

## **Section 3: Literature Review**

Shiralashetti (2012) said that MSME's play a vital role for the growth of the Indian economy. They are a fountain head of several innovations in manufacturing and service sectors, the major link in the supply chain to corporate and the PSUs. The author also used data from the Indian ministry to prove how the MSME sector has maintained a higher rate of growth vis-à-vis the overall industrial sector. The author also concludes that these enterprises are now exposed to greater opportunities than ever for expansion and diversification across the sectors and require promotion for rural India to progress.

Ministry of Finance (2013), talked about the significant role of the discussed sector in the domestic as well as global economy, with high revenue and employment opportunities. To quote "The MSME sector is one of the key drivers, for India's transition from an agrarian to an industrialized economy". The paper concluded by highlighting the various problems faced by the sector and a list of suggestions for improvement.

Chadraiah & Vani (2014) in India in the era of globalization says that the sector's significance attributes to its capacity of employment generation, low capital and technology requirement along with the use of traditional or inherited skill and local resources, mobilization of resources and exportability of products. The author highlights the importance of the MSME Development Act 2006, the importance of globalization and its impacts using pre and post reform data. The author concludes by saying "The MSMEs in India face a tough situation due to extreme competition from large industries due to withdrawal of subsidy, lack of infrastructure, anti dumping policy, challenges on product standardization, total quality management etc."

Kapila (2001) said that in the latter half of the 19th century, there was decay in India's traditional arts, crafts and industries and an increasing pressure on land along with huge unemployment. There was little attention paid to the rural or agricultural sector which used to mainly consider of the MSME sector. There was use of poor and traditional production techniques.

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#### Section 4: Methodology

This paper is based on secondary data which was collected from the website of the Indian Ministry of Micro Small and Medium Enterprises (MSMEs). The website provided data via official annual reports for each of the past ten years. Various books and journals like Uma Kapila's Indian Economy Since Independence (2001) published by Academic Foundation were also referred to. Then there was the process of compilation and comparison of the four data components used in this paper using MS Excel, where tables and trend diagrams were made, along with understanding the definition and categories of this huge sector. Four parameters were used viz. Number of Units, Employment, Export and Contribution in GDP for showing the importance and need of the sector via India's past experience. This data was then analysed to understand this sector and then a conclusion ended the paper, portraying the overall research covered in the paper.

#### Section 5: Indian Msme's – An Overview

The MSMEs sector constitute an important fragment of the Indian economy in terms of its contribution to the country's industrial production, export's, employment and creation of a consumerist base (Nagayya 2013). Micro, Small and Medium Enterprises (MSMEs) play a vital role for the growth of Indian economy by contributing 45% of industrial output, 40% of exports, employing 60 million people, create 1.3 million jobs every year and produce more than 8000 quality products for the Indian and international markets. (Shiralashetti 2012)

In accordance with the MSMED Act, 2006, the sector is classified as below,

**Table 1 : Classification of enterprises**

<b>MANUFACTURING SECTOR</b>	
<b>ENTERPRISE CATEGORY</b>	<b>INVESTMENT IN PLANT AND MACHINERY</b>
<b>Micro enterprises</b>	Less than or equal to 25 lakhs rupees
<b>Small enterprises</b>	More than 25 lakhs rupees and less than or equal to 5 crore rupees
<b>Medium enterprises</b>	More than 5 crore rupees and less than or equal to 10 crore rupees
<b>SERVICE SECTOR</b>	
<b>ENTERPRISE CATEGORY</b>	<b>INVESTMENT IN EQUIPMENT</b>
<b>Microenterprises</b>	Less than or equal to 10 lakh rupees
<b>Small enterprises</b>	More than 10 lakh rupees and less than or equal to 2 crore rupees
<b>Medium enterprises</b>	More than 2 crore rupees and less than or equal to 5 crore rupees

*Source: Annual report of the Ministry of MSME's of India 2012-13*

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The promotion, growth and development of these enterprises are mainly the responsibility of the state governments which in turn get continuous support from the National Ministry of Micro, Small and Medium enterprises. India offers numerous expansion and development opportunities to this sector which not only bring a rise in the country's GDP but also reduce regional disparities in India. This sector is an example of sustainability along with profitability with mostly labour intensive production.

### Section 6: Data

Data from the Annual reports of the Indian Ministry of MSME's has been used, as mentioned in the methodology above to show information regarding four parameters related to the MSME sector, which are, Number of units, Employment, Exports and GDP contribution.

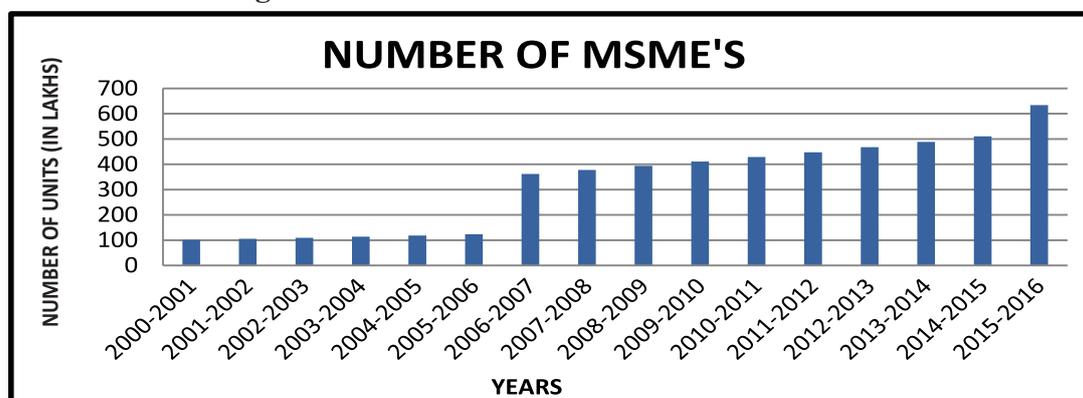
**Table 2 : Number of units of this sector in India**

YEAR	NUMBER OF MSME (LAKHS NUMBERS)	YEARLY GROWTH
2000-2001	101.1	-
2001-2002	105.21	4%
2002-2003	109.49	4%
2003-2004	113.95	4%
2004-2005	118.59	4%
2005-2006	123.42	4%
2006-2007	361.76	193%
2007-2008	377.36*	4%
2008-2009	393.7*	4%
2009-2010	410.8*	4%
2010-2011	428.73*	4%
2011-2012	447.64*	4%
2012-2013	467.54*	4%
2013-2014	488.46*	4%
2014-2015	510.57*	5%
2015-2016	633.88*	24%

Source: Annual reports of the Ministry of MSME's of India 2012-13, 2014-15, 2015-16

Note: \*signifies predicted data

**Figure 1 : Number of units of MSME's in India**



Source: Annual reports of the Indian Ministry of MSME's 2012-13, 2014-15, 2015-16

Note: Data from 2007 onwards is predicted.

The data gives an idea about the total number of firms existing in India as a part of this sector. We notice that there has been a steady rise from the year 2000 to 2006 where the number of firms goes up from 101.1 lakhs to 361.76 lakhs, which is more than a threefold jump. The growth rate portrays the change in the number of units after new data was collected in the census of 2006-07. There has otherwise been a steady and consistent growth rate of 4% throughout the years.

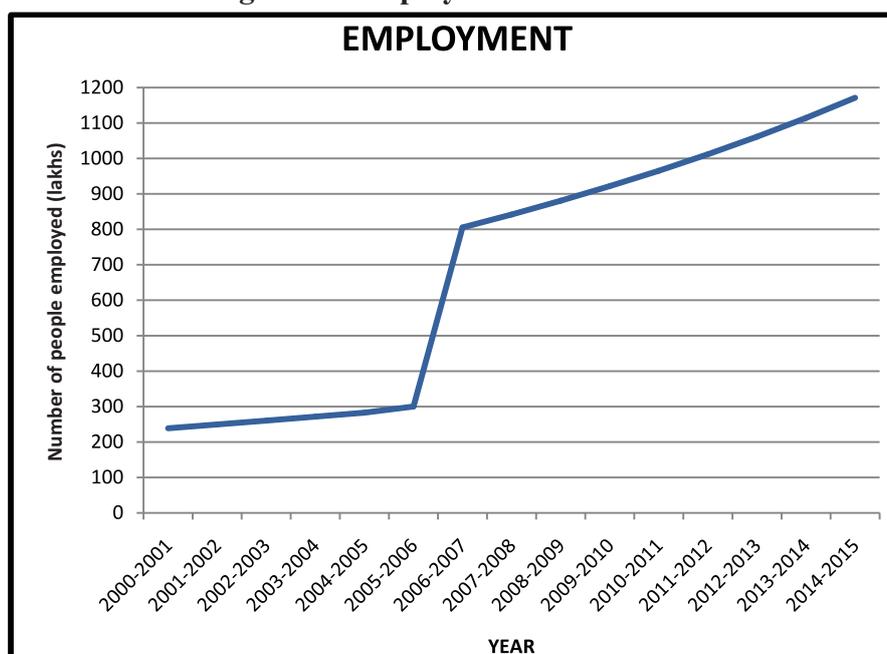
**Table 3 : Contribution of this sector to Indian employment**

YEAR	EMPLOYMENT (IN LAKHS)
2000-2001	238.73
2001-2002	249.33
2002-2003	260.21
2003-2004	271.42
2004-2005	282.57
2005-2006	299.85
2006-2007	805.23
2007-2008	842*
2008-2009	880.84*
2009-2010	921.79*
2010-2011	965.15*
2011-2012	1011.69*
2012-2013	1061.4*
2013-2014	1114.29*
2014-2015	1171.32*

Source: Annual reports of the Indian Ministry of MSME's 2012-13, 2014-15, 2015-16

Note: \* signifies predicted data

**Figure 2 : Employment in the sector**



Source: Annual reports of the Indian Ministry of MSME's 2012-13, 2014-15, 2015-16

Note: Data from 2007 onwards is predicted.

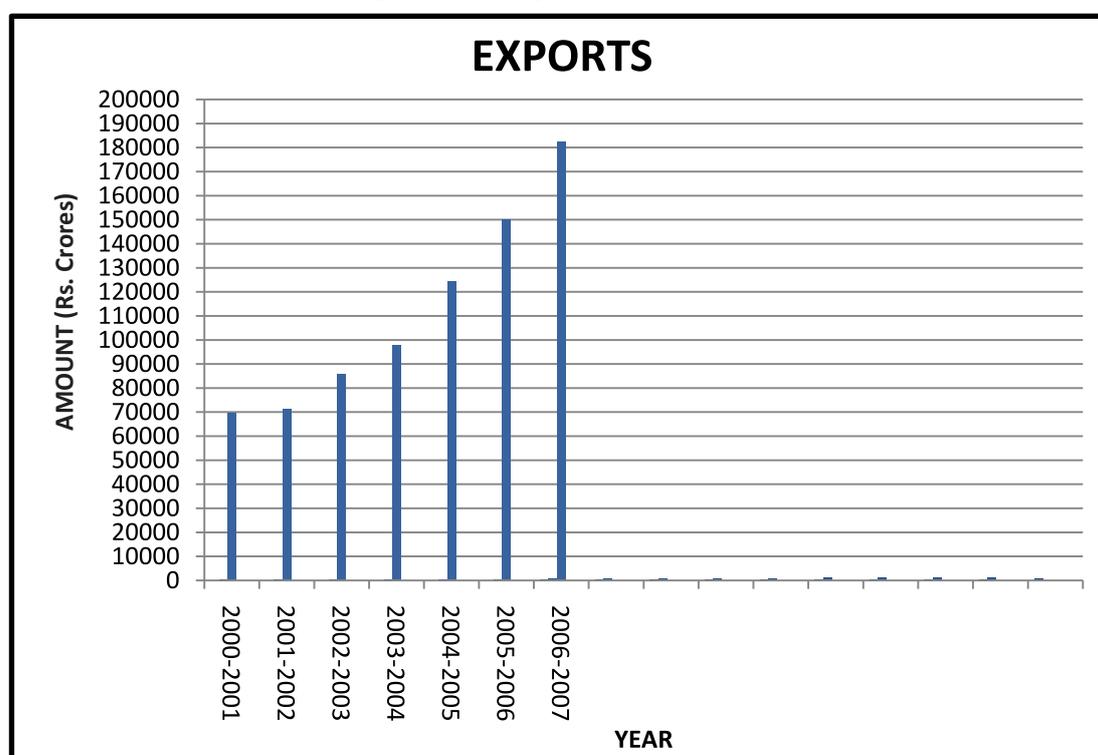
The data from the annual reports shows the steady growth in employment of the labour intensive industry from 2000-2006 and a sharp increase in the next year which can be linked to the sharp rise in the number of firms in the same year. It was due to the process of the 4th All India Census of MSME in 2006-07 that the MSME database was strengthened with data from more resources and firms, unlike the 3rd Census and hence there was a sharp rise in employment during the same year. It must also be noted that the predicted employment levels from 2007-2015 are showing an increasing trend proving of immense importance in the rural areas of India. As analysed by Shiralashetti(2012), the high growth in employment happens due to the higher growth rate of the sector as compared to the overall industry.

**Table 4 : Contribution of this sector in Indian exports**

YEAR	EXPORTS (Rs crores)
2000-2001	69797
2001-2002	71244
2002-2003	86013
2003-2004	97644
2004-2005	124417
2005-2006	150242
2006-2007	182538
2007-2008	202017

Source: Annual reports of the Indian Ministry of MSME's 2012-13, 2014-15, 2015-16

**Figure 3 : Exports of the sector**



Source: Annual reports of the Indian Ministry of MSME's 2012-13, 2014-15, 2015-16

Since data was only available for the restricted period from 2000-2007 regarding exports via the annual reports of the MSME ministry, not much can be said about current times. However, it must be noted that in the mentioned period, there is a positive growth rate allowing us to have positive hopes. This sector was a major global player for India after globalization.

**Table 5 : Contribution of the sector in GDP**

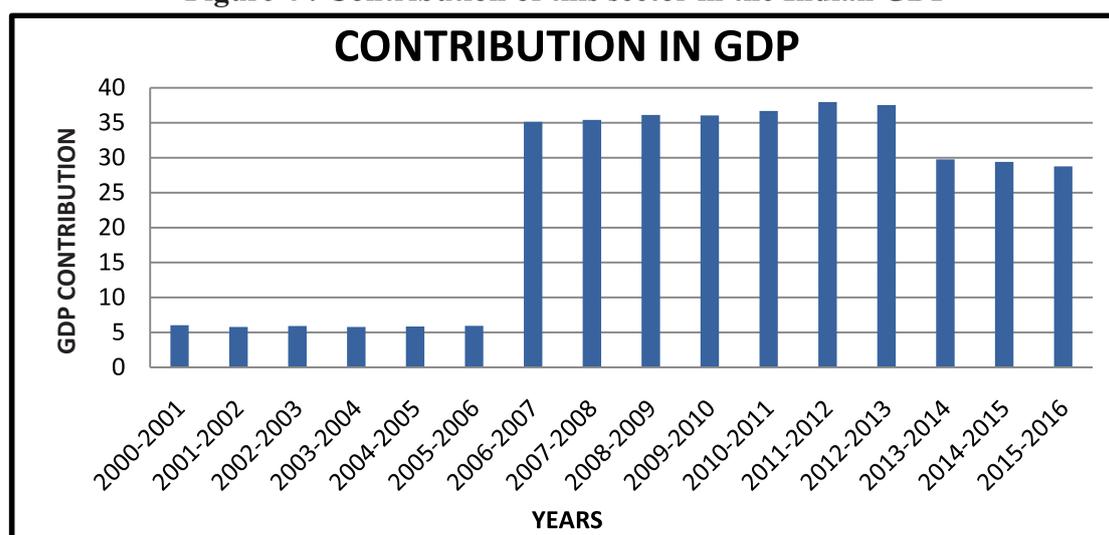
YEAR	CONTRIBUTION IN GDP	THREE YEAR AVERAGE
2000-2001	6.04	-
2001-2002	5.77	-
2002-2003	5.91	5.81
2003-2004	5.79	-
2004-2005	5.84	-
2005-2006	5.93	5.85
2006-2007	35.13	-
2007-2008	35.41	-
2008-2009	36.12	35.56
2009-2010	36.05	-
2010-2011	36.69	-
2011-2012	37.97	36.90
2012-2013	37.54	-
2013-2014	29.76	-
2014-2015	29.39	32.23
2015-2016	28.77	-

Source: Annual reports of the Indian Ministry of MSME's 2012-13, 2014-15, 2015-16

Note: Data from 2000-2006 is based on 1999-2000 prices.

Data from 2006-2016 is at 2004-2005 prices.

**Figure 4 : Contribution of this sector in the Indian GDP**



Source: Annual reports of the Indian Ministry of MSME's 2012-13, 2014-15, 2015-16

Note: Data from 2000-2006 is based on 1999-2000 prices.

Data from 2006-2016 is at 2004-2005 prices.

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It can be seen from Table 5 that the MSME's have been steadily contributing to the GDP of the country with only a few steady falls and mostly a steady growth rate. However, it must also be noted that the contribution has been on a substantially low level when compared to the rising number of firms and its increasing employment generation. Moreover, the three-year average portrays a variable and at times decreasing contribution scenario for the sector.

### **Section 7: Analysis**

With an increasing number of units functioning in this sector, there is a positive correlation of this sectors expansion and employment. This means that as the number of firms is increasing, so is the employment. Sector expansion and growth allows increasing returns of scale and reduced costs to come in play. Employment not only helps improving the levels of income of people but also improves their overall standard of living and an escape from the vicious circle of poverty. Moreover, a positive trend in both these parameters also focuses on how existence of specialization of labour in this labour-intensive sector is a possibility. Consistency in growth performance of the number of MSME industries proves the sustainability and diligence of the sector. A stable and good amount of contribution towards the Indian GDP of this sector portrays its capability to function and absorb shocks. Stability of the MSME sector with respect to its annual GDP contribution along with increasing number of units operating proves the constant demand of products that the sector fulfils. With India having a huge fiscal deficit and Balance of payment (BOP) crisis (Ministry of Finance 2017-18) the rising chunk of exports by this sector should not be ignored. Global marketing and trade via this sector would help the country's fiscal deficit and also provide foreign currency for imports. It is this sector which via its entrepreneurial base and innovation always exceeds expectations in employment, exports and GDP generation. However, too much stability also brings out a dire need of technological advancement and financial support. Many units of this sector still use traditional technology and are exploited by money lenders, even after proving their importance. They lack Banking support along with Government support to import better machinery. Hence, it is vital that any policy deficiency and infrastructural problem should be resolved and looked into by the Indian Government to allow this sector to prosper in the near future.

### **Section 8: Conclusion**

It is seen that the Indian MSME sector has seen tremendous improvement over the past few years in the 21st century. The fact that it is one of the few industries that has shown increase continuously in its main components proves its value. It was observed, how it is said that in developing countries, this sector is vital for growth and value generation. Along with that, high predicted Exports and GDP contribution for this sector, shows hope and a rising future ahead. Moreover, rising Employment and Number of Units shows that this sector capability to absorb labour and increase productivity in the process.

However, the amount of growth seems to be not fully achieved. This sector can work better and grow at a faster rate if various problems as analysed could be looked into and solved. This sector can be a major contributor to allow India's agricultural based underemployed population to shift to the industrial or agro-based industries sector. However, further research and work can be done to understand how to solve the financial and technological problems this sector faces along with how it could initiate a shift in the agricultural workforce.

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# Impact of Oil Price on Indian Economy

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## **Abstract**

In recent years the rapid economic growth of India leads to the rapid increase in the demand for crude oil and now India is the third largest consumer in the World. The problem is India has to import most of the oil it consumes which leads to severe consequences when the world oil price rises. This paper estimates the impact of oil price over India's economy over the years. The paper achieves this by gathering statistical data from the past years and thereby using econometrics model to calculate the results and then look through the various policies India has adopted in the Energy sector. Finally, the paper also looks into various short and long run policies that Government can adopt to combat the increasing demand for crude oil in India ensuring rapid sustaining economic growth in the future.

**Keywords:** Crude Oil, Inflation, GDP, Petroleum, Import.

## **Section1**

### **Introduction**

Since late eighteenth century and the beginning of Industrial revolution crude oil has become one of most basic global commodities. It kick started an era of establishment of crude oil industry throughout the world and it has continued to impact society, including economy, politics and technology. By the end of nineteenth century there were three major crude oil producers: Russia, Saudi Arabia, United States. Oil has become indispensable commodity and with the increase in demand for crude oil worldwide, the supply side of the crude oil has played a major role in shaping up the world economy and its every minute decision on part of the suppliers deeply affect every oil importing countries and their economic policies.

With over 150 countries worldwide importing oil every year, major oil exporters have become an important player in the international economic market. In the FY 2017 global purchases of imported crude oil totaled US\$ 873.4 billion (International Trade Center ITC, 2017). Although this figure is down as compared to 2013 when crude oil purchase was valued at \$1.652 trillion (ITC,2017), crude oil is still a major industry in the overseas business.

Asian countries did the highest dollar worth import of crude oil among the other continents in 2017 followed by Europe and then by North America. Asia imported about \$429 billion which accounted for 49% of world total and Europe imported a about 29.2% whereas North America did about 17.4%.

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Among the other continents South America imported about 1.8% and Africa about 1.3%. Last but not the least Australia and New Zealand consumer about 1.1% of the total global oil imports. (Source: Trade Map, International Trade Center,2018).

India ranked 4th among the countries that imported the highest dollar value worth of crude oil in FY2017 worth \$60.2 billion amounted to about 6.9% (ITC,2017) of the total global imports. On the domestic perspective India imported a record amount of 4.37 million barrels per day (bpd) in FY 2017 to meet the needs. India is the world third highest oil consumer and by the end of 2017 Iraq was the top suppliers to India with Saudi Arabia on the second and Iran on the third. In India petroleum and oil is situated on the top of the import list. Out of India's entire energy consumption, crude oil accounts 24%, Coal about 40%, natural gas 6% and other sources about 28% (Thompson Reuter,2017). As we can see coal and crude oil accounts for about 2/3rd of India's total energy consumption. As a result, any change in crude oil behavior over the world can seriously affect Indian economy and has affected us several times since Independence.

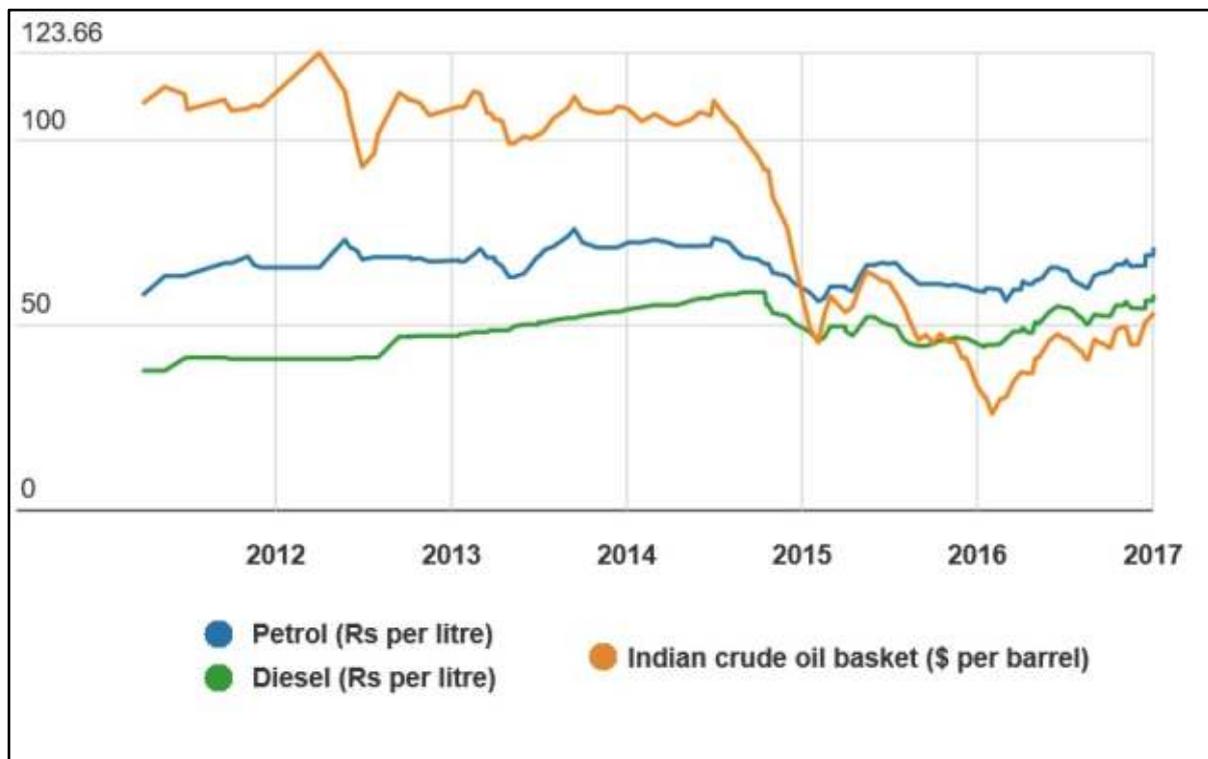


Figure 1: Petrol and Diesel prices in Delhi (2014) (source: Petroleum Planning & Analysis Cell (PPAC) of the Ministry of Petroleum & Natural Gas)

In Figure 1 we can see in recent years Crude oil price has drastically fallen to even below \$60 per barrels, but In India domestic oil price doesn't reflect the international phenomenon.

There are several reasons due to which the government has decide to keep up the oil prices. In the following Sections we shall see how the world oil price changes has affected India over the years and the economic policies adopted by India and whether they are effective or not in the short and long run.

In the following sections: Section 2 contains Research Question and Objectives, Section 3 contains

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Literature Review, Section 4 contains Data and Methodology, Section 5 contains Analysis, Section 6 contains Conclusion and the Bibliography.

## **Section 2**

### **Research Question and Objectives**

In this paper we are posing the question “whether a country like India can combat the negative supply shock due to world oil price fluctuations”.

In the upcoming Sections we will see: -

- How the change in world oil price has affected India’s various economic parameters over the years.
- The various counter measuring economic policies India has taken to negate any adverse effects on India and whether it has been effective or not.

## **Section 3**

### **Literature Review**

*“Strategic thinking is the art of outdoing an adversary  
Knowing that the adversary is trying to do the same”*

1) Hadia Hamdy Rashed (2017) in his research stated that in the determination of world oil price there are various factors that play a role. One of the main factors is the supply side of the oil industry. As we can know OPEC contributes about 82% into the world crude oil basket. It is obvious any OPEC oil supply policies would strongly determine the oil price and thereby affect the world economy. In the year 2014 OPEC decided not to cut oil supply and hence prevented oil price from rising massively. This behavior can be explained using Game Theory and the nature of OPEC itself.

OPEC is a cartel comprising of 14 countries, whose interaction determines the oil price. The best interest of all the members should be to freeze or cut in production. A freeze in oil supply would be the best way to stabilize the oil market as quoted by Alexander Novak- Russian energy minister. On the other hand, this freeze will send oil price sky rocketing if done right.

This causes a case of Prisoner’s Dilemma. If one country violates the term by increasing the oil supply, that country violating the agreement will benefit by selling more oil. If both violates, output rises and price stays low. If both abides price rise, OPEC collectively benefits.

Even though OPEC countries may agree to freeze output for their greater benefit, Game theory suggests that in such case of Prisoners Dilemma, it won’t happen (all countries would violate) and oil supply would not be frozen.

2) Anurag Goyal, Priyanshi Gupta (2015) in their paper stated that it had been predicted in 2013 that oil prices could rise to between \$150 to \$270 a barrel by 2020, mainly due to demand estimated in countries like India and China. It is increasingly important to study the oil-macroeconomic dynamics in these developing countries like India mainly due to following reasons: -

- India having one of the fastest growth rates, fuel consumption directly affects GDP.
- Critical effect of oil pricing on economic and investment activities due to deregulation of oil price by government.
- Oil is the main import of India and can severely cripple the Current Account Deficit (CAD).

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From the research it has been found that oil is procyclical to output, price level, stock index, gold and interest rate and is counter cyclical to money supply, net exports and exchange rate. Oil price is clearly inflationary which explains why oil price affects money supply and interest rate. Oil price even leads gold price and net exports as one third of India's net exports is oil.

Overall it has been seen that maximum impact of oil pricing fluctuation is felt on overall price level and net exports. Such vulnerability of India on oil price shock is not sustainable and thus it is utmost important to come up with domestic solutions and looking further into other sources if oil. It is also important to come up with a renewable source of energy as substitute. Energy subsidy with regulations, standards and targets directing towards increasing efficiency of use of crude oil are crucial to reduce India's dependency on oil imports.

- 3) Trinley Paldon (2015) in her paper tried to find the equilibrium relationship between the crude oil price and exchange rate of India. She found that in a world where almost everything is a by-product of crude oil, it isn't possible to avoid fully the usage of the commodity specially in a country like India. It is somewhat possible to mitigate the uncertainty of oil supply shock which can be done by exchange-based risk management and managing the extreme downside risk and stop the huge amount of budget deficits. India's exchange control policy is mixed i.e. government intervenes when there it reaches extreme levels otherwise it is flexible. Her paper suggests that this policy will always work out and won't lead to any issues with the exception of the lag period, i.e. the time between policy planning and its implication through the government.
- 4) Akansha Jain and Nitish Patil (2015) in their paper analyzed the impact of crude oil price on Indian economy. They concluded that over the course of time India's dependency on the import of crude oil has increased a lot and has peaked at 80% in recent times. Also, the sharp rise in Oil price in 2008 denoted that the oil market is really volatile and the future of oil price is really difficult to predict since there are several variables working together to affect it. Given the rapid increase in dependency of India on crude oil there are possibilities of inflation in the country, which will lead to government spending too much on subsidy, our exports becoming weaker, fall in investment and GDP will also be affected. To combat this, India needs to take long term measures for efficiency improvement in usage of energy like use of market linked relative price, minimizing of subsidy and finally improve the domestic production of crude oil via research and exploration.

## **Section 4**

### **Data and Methodology**

As we have seen, oil price is an important parameter in determining the trade balance, reserve position and Balance of Payment (BOP). Other important results due to oil price fluctuation is Inflation. Due to inflation purchasing power falls down, expenses increase, saving falls and thus economic activity decreases taking a hit at GDP growth rate.

Keeping these parameters in mind in this section we will be studying the following: -

- Calculate and analyze the impact of Crude oil price on Consumer Price Index (CPI)
- Calculate the impact of this change in CPI on GDP growth rate of India.

For the testing purpose we will be requiring Consumer Price Index, World crude oil Price, GDP growth

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rate of India. To carry out the test we will take a sample size of 21 years. Data shall be collected from years 1990 to 2010. Following Data of GDP growth, CPI and Inflation based on CPI has been taken from Open Data Source provided by World Bank (2018), the Consumer Price Index of India has a base year 2010.

The Crude Oil Price is based on WTI or NYMEX adjusted with inflation (average closing price).

**Table 1: GDP growth, CPI, Inflation, Crude oil price of India (source: World Bank)**

Year	GDP Growth Annual (%)	CPI (base 2010)	Inflation (CPI annual)	Oil Price Crude
1990	5.533	22.874	8.971	24.53
1991	1.057	26.047	13.87	21.54
1992	5.482	29.117	11.788	20.58
1993	4.751	30.97	6.362	18.43
1994	6.659	34.132	10.212	17.2
1995	7.574	37.622	10.225	18.43
1996	7.55	40.999	8.977	22.12
1997	4.05	43.937	7.164	20.61
1998	6.184	49.75	13.231	14.42
1999	8.846	52.073	4.67	19.35
2000	3.841	54.161	4.009	30.38
2001	4.824	56.157	3.685	25.98
2002	3.804	58.623	4.392	26.19
2003	7.86	60.854	3.806	31.08
2004	7.923	63.147	3.767	41.51
2005	9.285	65.828	4.246	56.64
2006	9.284	69.874	6.146	66.05
2007	9.801	74.325	6.37	72.34
2008	3.891	80.532	8.352	99.67
2009	8.48	89.292	10.877	61.95
2010	10.26	100	11.992	79.48

To continue to interpret and analyze the data we will be using the following tools and formulas-

- 1) Correlation Coefficient by Karl Pearson is used to measure the correlation between two variables X and Y. The correlation coefficient is denoted by 'r' which shows the linear relationship between the two variables. Its value lies between -1 to +1 which shows the degree of the relationship from perfect negative (-1) to perfect positive (+1). When 'r' is 0 then it means X and Y has no correlation at all.

Its formula is written as –

$$r = \frac{\sum XY - \frac{\sum X \sum Y}{N}}{\sqrt{\left(\sum X^2 - \frac{(\sum X)^2}{N}\right) \left(\sum Y^2 - \frac{(\sum Y)^2}{N}\right)}}$$

where N is the number of observations,  $\sum XY$  is the sum of product of X and Y

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$\sum X$  is the summation of X,  $\sum Y$  is the summation of Y,  $\sum X^2$  is the summation of squared values of X s,  $\sum Y^2$  is the summation of squared values of Y s.

- 2) We shall determine the influence of variable Y on X by fitting a time series classical linear regression model (CLRM) and use the following equation

$$Y_t = a + bX + e_t$$

$Y_t$  denotes the dependent variable, 'a' denotes constant quantity (intercept term), 'b' denotes coefficient of X, 'X' denotes the independent variable,  $e_t$  denotes the residual term of this model.

This model has the following assumptions: -

- The disturbance variable ' $u_i$ ' are identically independently distributed i.e.  $u_i \sim N(0, \sigma^2)$
- $E(u_i) = 0$ , i.e. Mean of  $u_i$ 's are zero.
- $V(u_i) = \sigma^2$ , i.e. constant variance known as homoskedasticity
- $Cov(u_i, u_j) = 0$ , denoting non-autocorrelation. ( $i \neq j$ )
- $Cov(u_i, X_i) = 0$ , denoting non-stochasticity.

- 3) For Testing part, we will be using t-test using formula: -

$t = \frac{\hat{b} - 0}{\text{Standard Error of } \hat{b}}$ , where we will compare the p value of the test with the significance level denoted by ' $\alpha$ ' to judge whether the null hypothesis  $H_0$  can be accepted or rejected.

All the following calculations are done using MICROSOFT EXCEL software.

## Section 5

### Analysis of Data

In this section we use the data collected in the previous part to meet the objectives of our project.

#### Section 5A

Calculate the impact of crude oil price on Consumer Price Index (CPI): -

Table 2: Crude oil Price and Consumer Price Index (CPI) for the following years

Year	(Y)	(X)	XY	X <sup>2</sup>	Y <sup>2</sup>
1990	22.874	24.53	561.09922	601.7209	523.219876
1991	26.047	21.54	561.05238	463.9716	678.446209
1992	29.117	20.58	599.22786	423.5364	847.799689
1993	30.97	18.43	570.7771	339.6649	959.1409
1994	34.132	17.2	587.0704	295.84	1164.993424
1995	37.622	18.43	693.37346	339.6649	1415.414884
1996	40.999	22.12	906.89788	489.2944	1680.918001
1997	43.937	20.61	905.54157	424.7721	1930.459969
1998	49.75	14.42	717.395	207.9364	2475.0625
1999	52.073	19.35	1007.6126	374.4225	2711.597329
2000	54.161	30.38	1645.4112	922.9444	2933.413921
2001	56.157	25.98	1458.9589	674.9604	3153.608649
2002	58.623	26.19	1535.3364	685.9161	3436.656129
2003	60.854	31.08	1891.3423	965.9664	3703.209316
2004	63.147	41.51	2621.232	1723.0801	3987.543609
2005	65.828	56.64	3728.4979	3208.0896	4333.325584
2006	69.874	66.05	4615.1777	4362.6025	4882.375876
2007	74.325	72.34	5376.6705	5233.0756	5524.205625
2008	80.532	99.67	8026.6244	9934.1089	6485.403024
2009	89.292	61.95	5531.6394	3837.8025	7973.061264
2010	100	79.48	7948	6317.0704	10000
<b>Summation</b>	1140.314	788.48	51488.938	41826.441	70799.85578

Here we take Crude oil Price as independent Variable X, and CPI (2010=100) as dependant variable Y.

Now using the above data and Karl Pearson's formula stated before we get:

$$\sum X=788.48, \sum Y=1140.314, \sum X^2=41826.441, \sum Y^2=70799.85578, \sum XY=51488.938$$

We have N=21 and we get r=0.832615

This signifies that there is a large positive correlation between Crude Oil Price and CPI of India.

Now we create a scatter diagram consisting two variables X and Y

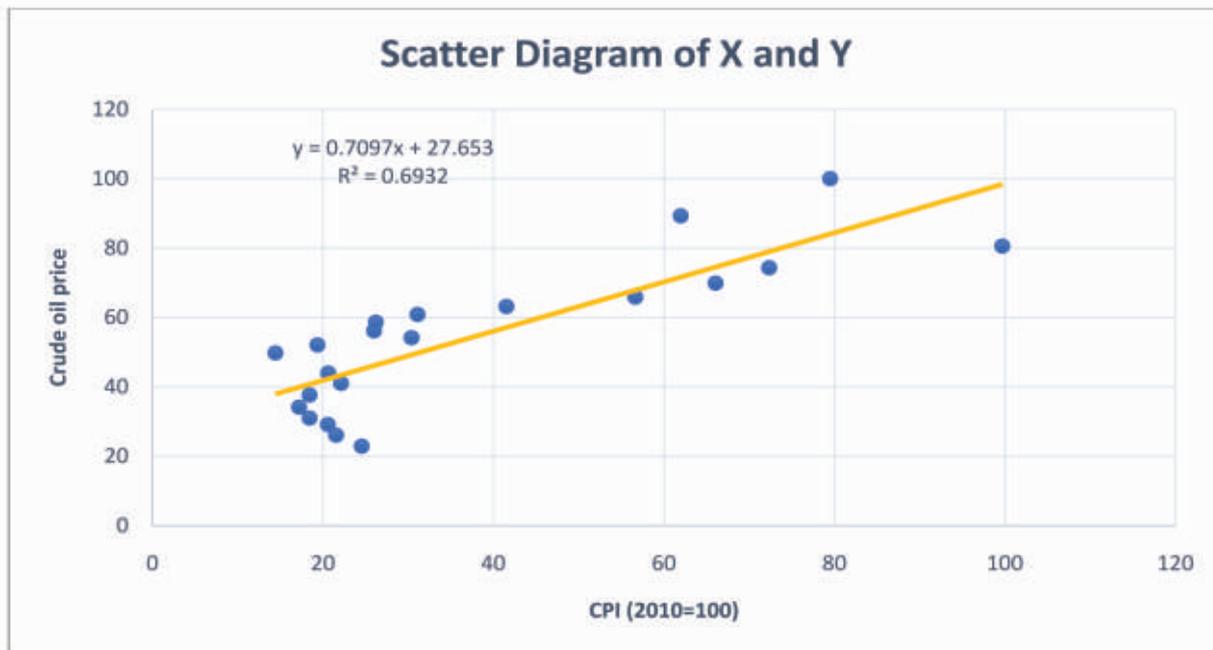


Figure 2: Scatter Plot of Crude Oil Price and CPI in India

Now using the Classical Linear Regression model, we have two variables similar to above calculations where X is independent variable of Crude Oil Price and Y is the dependent variable denoting CPI of India. We use the equation  $Y = a + bX + e_t$

The observed data is used to calculate the two parameters  $\hat{a}$  and  $\hat{b}$  called 'a hat' and 'b hat' showing the value of the parameters estimated from the model.

From the above diagram we can find that  $Y = 0.7097X + 27.653$ .

This denotes  $CPI = 0.7097(\text{Crude Oil Price}) + 27.653$  and the values of parameters  $\hat{a} = 27.653$  and  $\hat{b} = 0.7097$ .

This  $\hat{b} = 0.7097$  is basically the  $\frac{\text{Change in CPI}}{\text{Change in Crude Oil Price}}$  or simply  $dY/dX$ .

Analysing the above  $\hat{b} = 0.7097$  we can say that a 1-unit change in value of Crude oil Price will bring about 0.7097-unit change in CPI of India.

From the above graph we can see that all the changes in Y is not explained by change in X. This is evident as some of the points are away from the regression line in the scatter diagram. This means that the entire change in CPI of India is definitely only due to change in the Crude oil price.

This can be mathematically represented by the term ' $R^2$ '. This term is the ratio between the Explained Sum of Square (ESS) and Total sum of square (TSS).

In other words:

$$R^2 = \frac{\text{Explained Sum of Square (ESS)}}{\text{Total Sum of Square (TSS)}}$$

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There is also an unexplained part called Unexplained Sum of Square (RSS), and basically

$$TSS = RSS + ESS.$$

Explained Sum of Square =  $\sum(\hat{Y}_t - \bar{Y})^2$  where  $\bar{Y}$  is the Arithmetic Mean of  $Y$ .

$$\text{Total Sum of Square} = \sum(Y_t - \bar{Y})^2$$

This Unexplained part in the Regression model is the error term, the disturbance variable or residual value. This error is the deviation between the observed value of  $Y_t$  ( $t$  is the years) and the estimated value of  $\hat{Y}_t$  from the linear model.

$$e_t = Y_t - \hat{Y}_t$$

From the equation  $Y = 0.7097X + 27.653$  we can calculate all the values of  $\hat{Y}_t$  and thus find the error variable.

We find that,

$$RSS \text{ (sum of square of residuals)} = e_t^2 = 2723.969$$

$$TSS \text{ (total sum of squares)} = 8880.045$$

$$ESS \text{ (explained sum of squares)} = 6156.076$$

$$\text{Also, Standard error} = 11.9736$$

## Section 5B

Calculate the impact of this change in CPI on GDP growth rate of India: -

Table 3: Inflation based on CPI and GDP growth rate of the following years

Year	(X)	(Y)	(X <sup>2</sup> )	(Y <sup>2</sup> )	(XY)
1990	8.971	5.533	80.478841	30.614089	49.636543
1991	13.87	1.057	192.3769	1.117249	14.66059
1992	11.788	5.482	138.956944	30.052324	64.621816
1993	6.362	4.751	40.475044	22.572001	30.225862
1994	10.212	6.659	104.284944	44.342281	68.001708
1995	10.225	7.574	104.550625	57.365476	77.44415
1996	8.977	7.55	80.586529	57.0025	67.77635
1997	7.164	4.05	51.322896	16.4025	29.0142
1998	13.231	6.184	175.059361	38.241856	81.820504
1999	4.67	8.846	21.8089	78.251716	41.31082
2000	4.009	3.841	16.072081	14.753281	15.398569
2001	3.685	4.824	13.579225	23.270976	17.77644
2002	4.392	3.804	19.289664	14.470416	16.707168
2003	3.806	7.86	14.485636	61.7796	29.91516
2004	3.767	7.923	14.190289	62.773929	29.845941
2005	4.246	9.285	18.028516	86.211225	39.42411
2006	6.146	9.284	37.773316	86.192656	57.059464
2007	6.37	9.801	40.5769	96.059601	62.43237
2008	8.352	3.891	69.755904	15.139881	32.497632
2009	10.877	8.48	118.309129	71.9104	92.23696
2010	11.992	10.26	143.808064	105.2676	123.03792
Summation	163.112	136.939	1495.769708	1013.791557	1040.844277

Here we take Annual Inflation based on CPI as Independent Variable X and Annual GDP growth Rate (%) as Dependent Variable Y. To find out the relation between them we first use Karl Pearson's Correlation Coefficient. Using the above data and the Formula of the former we get: -

$$\sum X=163.112, \sum Y=136.939, \sum X^2=1495.7697, \sum Y^2=1013.7915, \sum XY=1040.84428$$

We have N=21 and we get  $r=-0.1371$

This value of r shows us that there is slight negative correlation between the two variable X and Y.

We also create a scatter diagram of X and Y

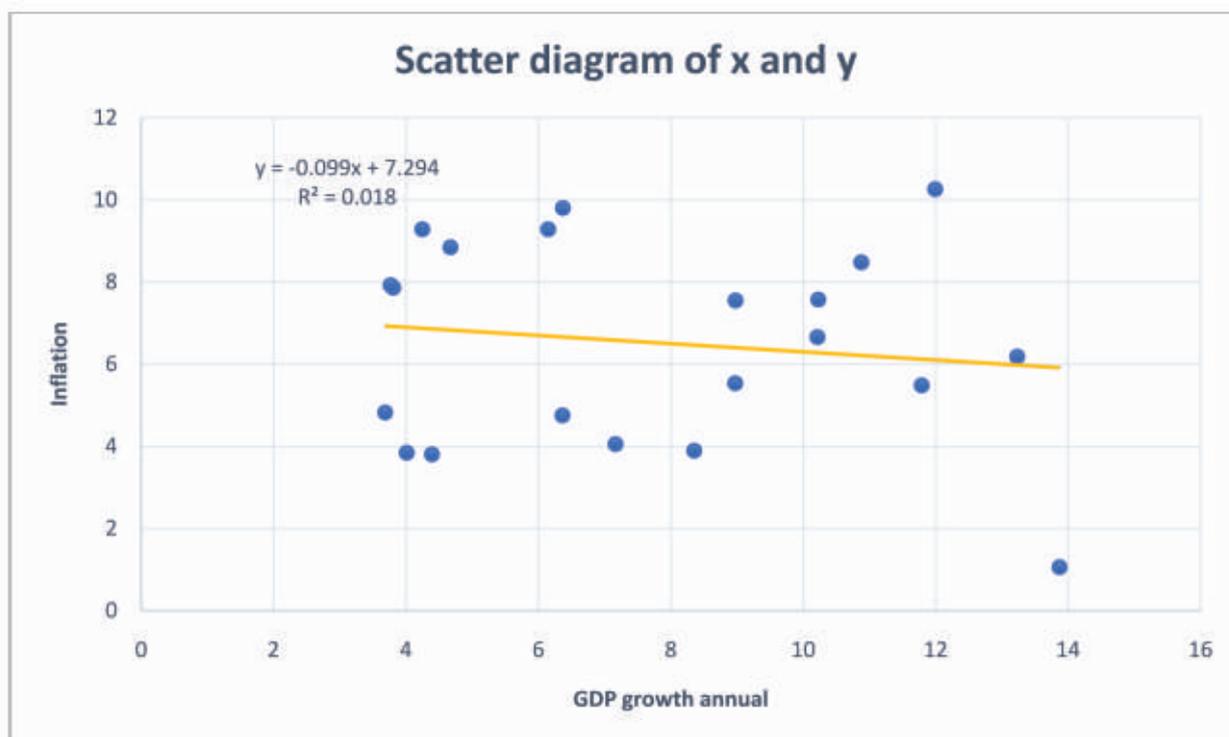


Figure 3: Scatter Plot of Inflation and GDP of India.

Now using the Classical Linear Regression model, we have two variables similar to above calculations where X is independent variable of Annual Inflation based on CPI and Y is the dependent variable denoting GDP growth Rate (%) of India.

We use the equation  $Y = a - bX + e_t$

The observed data is used to calculate the two parameters  $\hat{a}$  and  $\hat{b}$  called 'a hat' and 'b hat' showing the value of the parameters estimated from the model.

From the above diagram we can find that  $Y = -0.0996X + 7.2946$

This denotes GDP growth rate =  $-0.0996(\text{Inflation}) + 7.2946$  and the values of parameters  $\hat{a} = 7.2946$  and  $\hat{b} = -0.0996$

This  $\hat{b} = -0.0996$  is basically the  $\frac{\text{Change in GDP growth rate}}{\text{Change in Inflation rate}}$  or simply  $dY/dX$ .

Analysing the above  $\hat{b} = -0.0996$  we can say that a 1-unit change in value of Inflation rate will cause a -0.0996-unit change in GDP growth rate (fall in GDP)

From the above graph we can see that all the changes in Y is not explained by change in X. This is evident as some of the points are away from the regression line in the scatter diagram. This basically states the obvious fact that GDP growth of India is not entirely affected by Inflation and Inflation plays only a small part in affecting the GDP growth rate.

This can be mathematically represented by the term ' $R^2$ '. This term is the ratio between the Explained Sum of Square (ESS) and Total sum of square (TSS).

In other words:

$$R^2 = \frac{\text{Explained Sum of Square (ESS)}}{\text{Total Sum of Square (TSS)}}$$

There is also an unexplained part called Unexplained Sum of Square (RSS), and basically

$$TSS = RSS + ESS.$$

Explained Sum of Square =  $\sum(\hat{Y}_t - \bar{Y})^2$  where  $\bar{Y}$  is the Arithmetic Mean of  $Y$ .

$$\text{Total Sum of Square} = \sum(Y_t - \bar{Y})^2$$

This Unexplained part in the Regression model is the error term, the disturbance variable or residual value. This error is the deviation between the observed value of  $Y_t$  (t is the years) and the estimated value of  $\hat{Y}_t$  from the linear model.

$$e_t = Y_t - \hat{Y}_t$$

From the equation  $Y = -0.0996X + 7.2946$  we can calculate all the values of  $\hat{Y}_t$  and thus find the error variable.

We find that,

$$RSS \text{ (sum of square of residuals)} = e_t^2 = 118.555$$

$$TSS \text{ (Total Sum of Squares)} = 120.8253798$$

$$ESS \text{ (Explained Sum of Squares)} = 2.270344182$$

$$\text{The Standard error} = 2.497947$$

## Results

Analysis	Independent Variable (X)	Dependant Variable (Y)	Correlation coefficient	R <sup>2</sup>	TSS	ESS	RSS
<b>5A</b>	Crude Oil Price	CPI (2010=base)	0.832615	0.6932	8880.045	6156.076	2723.969
<b>5B</b>	Annual Inflation (CPI)	GDP growth rate	-0.1371	0.0188	120.825	2.270	118.555

Table 4: Brief results from above analysis.

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## Section 5C

After getting the results of the analysis from the previous two sections and calculating the Regression Functions, it would be meaningful to test their significance. We are mainly going to test the significance of the slope coefficient as denoted by 'b' in both of the sections. To do this we need two sets of hypotheses which can be written as: -

- Hypotheses A which states

$H_0: b = 0$ , denoting Crude Oil Price (X) has no impact on Consumer Price Index (Y)

v/s

$H_1: b \neq 0$ , denoting Crude Oil Price (X) has some impact on Consumer Price Index (Y)

We will be using T-Test to measure their significance and the T Statistic can be written as

$$t = \frac{\hat{b} - 0}{\text{Standard Error of } \hat{b}}$$

Here  $\hat{b} = 0.7097$  and  $SE_{\hat{b}} = 0.1083$

Value of  $t = 6.553$  and the p-value  $\approx 0$  (approximate)

Taking  $\alpha = 0.05$  and Comparing this value of 't' with  $t_{(21-2), 0.025} = 2.093024$

Here we can see that  $t_{(21-2), 0.025} (= 2.093024) < t (= 6.553)$

Hence, we can say that  $H_0$  cannot be accepted at 0.05 level of significance and,

We can say that Crude Oil Price (X) has some impact on Consumer Price Index (Y) with 95% of significance.

- Hypotheses B which states

$H_0: b = 0$ , denoting Inflation (X) has no impact on GDP growth (Y)

v/s

$H_1: b \neq 0$ , denoting Inflation (X) has some impact on GDP growth (Y)

Similarly, here  $\hat{b} = -0.0996$  and  $SE_{\hat{b}} = 0.165127$

Value of  $t = -0.6032$  and p-value = 0.553508

Looking at the p-value we can say that  $H_0$  can only be rejected at  $\alpha > 0.553508$ , i.e. we can say that Inflation (X) has some impact on GDP growth (Y) with roughly 45% of confidence.

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## Section 5D

From the above two analysis of data we can clearly see that

- Crude oil price does have an adverse effect on the price level of India (CPI)
- Inflation due to increase in CPI in turn has an adverse effect on GDP growth.

So, it is clear that crude oil supply price can have a considerable amount of shock on the growth rate and price level throughout the country. There is always an uncertainty in crude oil price for importing country like India. To meet the requirement of crude oil, various strategies need to be adopted by Indian Refiners and Explorers.

India is expected to be one of the largest contributors to non-OECD (Organisation for Economic Cooperation and Development) petroleum consumption growth globally. The Indian petroleum sector has gone through several structural changes in the last 25 years. Most of the stages of reforms has favoured private sector companies, denoting the loosening of Government control on this sector. The various phases of petroleum sector can be summarised into (source: Ministry of Petroleum and Natural Gas): -

- During early 60s the government did not have much control over pricing and a new committee under K R Damle (1961) has created to recommend new strategies.
- The committee wanted the (IPP) import parity price and it allowed the petroleum companies to price petroleum products less than their import price.
- Talukdar committee (1965) found that companies were using highest international oil price to price their products although lower rates were available.
- Based on this Government tried different policies but private companies threatened to reduce oil supply.
- Through mergers and takeovers, HPCL (Hindustan Petroleum) and BPCL (Bharat Petroleum) came into existence.
- Krishnaswamy Committee recommended Administered Pricing Mechanism (APM) in 1976
- APM was successful as public oil sector companies had larger stakes than their private counterpart.

During Deregulation Phase (NEP) petroleum sector went through several structural changes.

- First Phase (1998-2002) APM was dismantled and all petroleum products were decontrolled. In April 2001 government decontrolled Aviation fuel. The Government allowed petroleum products to be sold at market determined prices after permission of Ministry of Petroleum and Natural Gas. New Exploration Licensing Policy (NELP) was founded which allowed 100% FDI in exploration and production of Crude Oil and Natural Gases.
- Second Phase (2002-2010) led to emergence of only two subsidised petroleum, LPG and PDS kerosene (Public Distribution System). Other petroleum products prices have to be adjusted with IPP. Increase in oil price in late 2000s led to Government intervention to help increasing in under-recovery by oil companies, which was assisted by burden-sharing mechanism.
- Third Phase (2010 to January 2013) in which the Kirit Parikh Committee recommended deregulation

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of petrol and even diesel price, but due to political sensitivity the latter wasn't possible.

- Fourth Phase (January 2013 to September 2014) in which government allowed oil companies to increase diesel price by 40-50p/ month and was partially decontrolled. In case of domestic LPG, a direct subsidy policy was created in June 2013.
- Fifth Phase (September 2014 to now) only two petroleum products prices- PDS kerosene and LPG, are regulated by government.

From the above section we can see that the petroleum sector has been through a lot of structural change throughout over the years. The major results of these policies and programmes has the following implications: -

- Deregulation of the petroleum sector has the argument supporting it that it would lead to improvement of health of public sector oil firms.
- Private oil firms will flourish because of the policy level encouragement of the government.
- Deregulation has also led to private companies into oil exploration and production.
- But due to the behaviour of the private firms the public oil companies' performance has been slowed down which led to less healthy financial performance.



**Figure 4: India's oldest oil refinery located in Digboi, Assam (source: ATZ Assam)**

### **Investment and Policies in petroleum sector**

The petroleum and natural gas sector attracted FDI worth US\$ 7 billion between April 2000 and June 2018 (source: Department of Industrial Policy and Promotion). The major investments in petroleum industry in recent times are summarised in the following (source: IBEF): -

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Oil and Natural Gas Corporation (ONGC) has projected to invest US\$ 2.73 billion on drilling oil and gas wells in FY 2018-2019.

Both FDI and FPI will be possible worth US\$ 300 billion in India as the government wants to cut down oil imports by 2022 according to chairman of Ministry of Petroleum and Natural Gas, Mr Dharmendra Pradhan.

Saudi Aramco (Official Saudi Arabian Oil company) is planning on entering into a strategic partnership with India as they plan to invest in refineries and petrochemicals.

The Oil Ministry plans to set up bio-CNG plants and associated infrastructure to promote usage of clean and environment friendly fuel.

Government of India approves fiscal incentives to attract investment and technology in the petroleum industry which is going to lead to production of hydrocarbons worth US\$ 745.82 billion in the next 25 years.

In summary the Key Strategic point of India should be:

- a) Improving the availability of resources for sustainable development.
- b) Reforms and policies in energy sectors of India in both upstream and downstream companies making India as export hub for petrochemical product to improve foreign reserve.
- c) Initiative for creation of strategic reserve.

## **Section 6**

### **Conclusion**

There remains an uncertainty of the availability of crude oil supply which as we have analyzed can cause serious shocks to the economy of India

In section 5A the variance analysis we can see that the p-value is almost zero which is very small which means that the alternative hypothesis (H1) is strongly accepted. This suggests that it is true that the Crude oil Price has an inflationary effect on the price level of India.

In section 5B the negative Karl Pearson Correlation Coefficient (-0.1371) indicates the negative linkage between the inflation and the GDP growth. Even though the significance level of this claim is less it can't be denied that any level of inflation can slow down the entire economy of the country.

Oil Price shock has a very wide impact on not only Price level and fall in output but also fall in stock market, rise in interest rate, increase in gold price, fall in foreign exchange reserve, adverse effect on CAD etc.

Keeping all this in mind the government should adopt multilateral strategy for the oil companies to source raw material through long term contracts and even try to source the crude oil through acquisition of oil blocks in foreign countries. Apart from this both public and private investments are required for block exploration through the New Exploration License Policy (NELP) thereby increasing the pie in the energy sector by production, exploration, expanding refining capacity in India. As a result, exporting petroleum products and earning foreign exchange and thereby shielding the economy and exchange reserves during the uncertain crude oil price shocks. With the right tools and policies India can actually

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combat negative oil price shocks, thus maintaining stable price level and rapid growth of GDP in the future.

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# The Resource Curse: A State-wise Analysis of India

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## **Abstract**

Till a century ago, natural resources were considered the most important factor behind the growth of different economies. Now, however, with the advancement of technology, natural resources do not play as essential a role in economic development as they used to. In fact, some resource rich countries (e.g.: Venezuela) suffer from some of the lowest economic growth rates in the world, a phenomenon called the 'resource curse'.

The aim of this paper is to find out if the resource curse catches up with the 28 states of India, which we rank on the basis of three natural resources: minerals, forests and groundwater, and use Spearman's rank correlation coefficient as a measure to compare the resource endowments and the GSDP's. We conclude that Indian states show a general positive relation between resource richness and GDP, but we find some exceptional states that do not fit the trend. A case study compares two such states: Jharkhand and Gujarat, and accordingly comes up with policy prescriptions in aid of the economically and socially backward, but resource-rich states like Jharkhand.

**Keywords:** natural resources, economic growth, resource curse, Dutch disease

## **Section 1 : Introduction**

Till the 1930s, economists like Jacob Viner, William J. Baumol and Sir William Arthur Lewis considered the availability of natural resources, renewable or non-renewable, as an important determinant of productivity and growth of economies around the world. Indeed, developments of many countries around the world have been justified by the kind and size of resource base they have. Australia with its large reserves of gold and uranium, USA with coal and timber and Saudi Arabia with its oil reserves have all benefitted largely from the fortunate bounty of useful substances naturally available in their environment (Anthony, 2018).

With the benefit of hindsight, however, it has been observed that natural resources may act as an aid when it comes to economic growth, but is not necessary for an economy to succeed. Classic examples are Japan and Korea, which lately, by proving to be world class steel producers despite being completely dependent on iron ore imports, have transformed themselves into very high income countries despite being devoid of any significant physical advantage for development. This shows that the tremendous growth of certain resource rich countries like Germany, Britain and the United States in the 18th century

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had a lot to do with the high transportation costs back then. With the global reform in transportation and energy, and countries simply located in geographically advantageous positions no longer being the sole beneficiaries of their resource bounty, resource poor countries like Japan, Korea, Taiwan, Singapore and Hong Kong have emerged as world star players with some of the highest rates of economic growth. (IMF Fiscal Monitor, 2015)

On the other end of the spectrum, countries like Nigeria (with its large oil reserves), Sierra Leone and Angola (with their “blood diamonds”) have not prospered as much economically as compared to the resources naturally available to them. This phenomenon of resource abundant countries growing less rapidly than resource scarce countries was described by British economist Richard M. Auty in 1993 with the term “resource curse”. While the Resource Curse is neither irreversible or inevitable, and affects only certain types of countries under certain conditions, development economists around the world now see the discovery of large amounts of natural resources an invitation for conflict between factions fighting for the revenue which may take the form of armed conflicts in the resource rich regions, or, internal conflict between government ministries for access to budgetary allocations. Both these potential results erode a government’s ability to function effectively, making a country less democratic, more corrupt and hence less likely to prosper economically. According to one academic study, if the primary goods exports of a country constitute 5% of its GDP, it faces a 6% risk of conflict; whereas, when primary goods export makes up 25% of the GDP, the chances of conflict increase to 33%.

The most commonly quoted example for this is Venezuela, which has the largest proven oil reserves in the world, and still also faces the largest humanitarian crisis in the world. As Venezuela became the largest exporter oil in 1900’s, labour and investment became geared toward the abundant oil reserves and foreign currencies flooded domestic market. This led to the appreciation of its currency, which in turn weakened other industries like manufacturing and agriculture by making their exports unaffordable. As 98% of the country’s export earnings became dependant on oil, the economy became very vulnerable to even the smallest changes in oil prices (Venezuela facts and figures, 2017)

This brings us to another subset of the resource curse called the “Dutch Disease”, which “describes how the initial good fortune of an exhaustible natural resource find can turn sour in the long run. It has historically been considered an exchange rate phenomenon: world demand for a newly discovered natural resource inflates the discovering country’s currency and inhibits development of the non-resource traded sectors” (World Bank Policy Research Working Paper 6966).

Some countries have managed to keep the ills of the resource curse and the Dutch disease at bay: Saudi Arabia, by rebalancing its economy away from oil, Alaska, by giving some revenues back to residents, and Norway, which set up a sovereign wealth fund in 1990 to act as a cushion to balance trade deficits, when world oil prices are low.

With effects of the “resource curse” and the “Dutch Disease” in a cross-country set-up having been researched extensively over the last many years, this paper aims to examine its significance, if any, in the different states of India, which are widely heterogeneous in their distribution of natural resources like mineral wealth, forest area covers and groundwater resources.

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## Section 2 : Literature Review

**Richard M. Auty (1993)** refutes the claim that mineral wealth helps economies prosper and talks about how a large endowment of natural resources in a country can distort the incentives of the people and the authorities in such a way that these resources no longer remain an asset and in fact have a devastating impact on the developing economies. He makes his point using examples of six ore-exporters (viz. Peru, Bolivia, Chile, Jamaica, Zambia and Papua New Guinea) and also stresses on the need to avoid the Dutch disease.

**Jeffrey D. Sachs and Andrew M. Warne** in their paper show that economies with a high ratio of natural resource exports to GDP in 1971 tended to have low growth rates during the subsequent period 1971-89. They study the cross-country effects of resource endowments on trade policy, bureaucratic efficiency, and other determinants of growth and provide a theoretical model of endogenous growth to help explain the observed negative relationship.

**Xavier Sala-i-Martin and Arvind Subramanian (2003)**, in their paper, with reference to the said country, shows how some natural resources -oil, in the case of Nigeria- have a negative impact on growth because of their detrimental impact on the quality of the institutions in the country. In their paper, they offer a solution for the resource curse which involves directly distributing the oil revenues to the public.

**Michael L. Ross (2015)**, in his paper, provides robust evidence that one type of mineral wealth, petroleum, has at least three harmful effects: It tends to make authoritarian regimes more durable, to increase certain types of corruption, and to help trigger violent conflict in low- and middle-income countries. This essay reviews the evidence behind these claims, the debates over their validity, and some of the unresolved puzzles for future research.

**Bhagirath Behera and Pulak Mishra's 2012** paper was the first full-fledged research paper to examine the impact that the abundance of various natural resources in the different states of India has had on their respective economic development. It observes that the hypothesis of the resource curse is valid in the Indian states possibly because of weak institutions and policies.

**Amundsen, Kaja Volla (2014)**, in his paper aims to apply the existing literature on the resource curse to India, to try to explain some of India's divergent growth rates. He performs time-series cross sectional analysis between the 15 largest states in terms of the relation between their natural resource abundance and the growth in their GDP over the period from 1980 to 2010. He could not conclude if the low economic growth is due to natural resource dependence or other underlying causes. The paper concludes that the agricultural sector (which is the major industry in India), is a poorer fit to the resource curse than e.g. extractive resources such as petroleum and minerals, and also that the tertiary sector is the most detrimental to economic growth in India.

**Micheal Bruno, Jeffrey Sachs(1982)**'s model extends the principally static analyses of the "Dutch Disease" to date by allowing for: (1) short-run capital specificity and long-run capital mobility; (2) international capital flows; and (3) far-sighted intertemporal optimizing behavior by households and firms. The model is solved by numerical simulation.

### Research Questions and Objectives

India is one of the most resource rich countries in the world owing both to its location and its size as the

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seventh largest country. Its large resource base has been a contributing factor in its progress but as in any other country, has alone not been able to ensure economic prosperity. Moreover, the resources that the country is blessed with are heterogeneously distributed in different parts of it.

This paper is devoted to examine if heterogeneity has at all affected the per-capita gross domestic product (GDP) in the 28 states of India. The main questions this paper will attempt to answer are the following:

1. Is there any correlation between the gross domestic product of a state (GSDP) and its natural resource endowment in terms of its mineral wealth, forest cover and ground water availability?
2. How does the growth of the share of the manufacturing sector in the GSDP over the years relate to the growth of the mineral value in the different states?

### **Section 3 : Data and Methodology**

This paper has been compiled on the basis of secondary data collected from various Government of India websites. The findings of the paper have been based on data from the 2011-12 census (due to lack of availability of recent data).

The findings have been presented in a descriptive-cum-analytical manner with the help of basic statistical tools like tables and scatter diagrams, constructed in Microsoft Excel. Spearman's formula for rank correlation coefficient has also been used in order to find the extent of association between the abundance of the selected natural resources and the GDP of the 28 states of India. The said formula is given by:

$$r_R = 1 - \frac{6\sum d^2}{n^3 - n}$$

### **Section 4 : Data Analysis**

India's biggest blessing in terms of natural endowments is simply its massive geographical area (which facilitates agriculture), and the fact that it is surrounded on three sides by waterways (that facilitate international trade). In this paper we analyze the effect of three particular natural resources (which were chosen on the basis of ease of measurement and availability of data on official government sites), mineral resources (fuel and non-fuel), forest resources, and ground water, on the economic progress of the states.

#### **1. Mineral Resources**

Availability of minerals influences industrial and economic development by providing raw materials to the primary, secondary and tertiary sectors of an economy. "Mineral resources like iron and steel, aluminum, coal, etc., with their high linkage effects, create a basis of machinery on which modern manufacturing industry is based." (Amavilah, 2007). India possesses a range of essential mineral resources enough to make it industrially developed. It has the 4th largest iron ore reserves in the world, 7th largest manganese ore reserves and 5th largest bauxite reserves.

The following shows the monetary value of the minerals produced in each state as percentage of the total value of minerals produced in the country, and the SGDP of the states as percentage of the country's GDP in the year 2011-12.

**Table 1: Mineral Production and GSDP (2011-12)**

States	Value of production of minerals in state as percentage of total value	Rank	SGDP as percentage of total GDP	Rank
Andhra Pradesh	10.96	4	4.25	8
Arunachal Pradesh	0.19	18	0.11	26
Assam	5.29	8	1.48	17
Bihar	0.06	22	2.76	13
Chhattisgarh	8.08	5	1.60	16
Goa	3.57	11	0.52	21
Gujarat	11.84	2	7.54	4
Haryana	0.07	21	3.40	11
Himachal Pradesh	0.1	19	0.81	19
Jammu & Kashmir	0.08	20	0.79	20
Jharkhand	7.42	6	1.80	5
Karnataka	2.78	13	5.44	6
Kerala	1.44	16	3.86	9
Madhya Pradesh	5.26	9	3.72	10
Maharashtra	6.26	7	14.91	1
Manipur	0	27	0.14	25
Meghalaya	2.24	15	0.23	23
Mizoram	0	25	0.09	28
Nagaland	0	28	0.19	24
Odisha	13.01	1	2.50	14
Punjab	0.01	24	3.02	12
Rajasthan	11.22	3	4.44	7
Sikkim	0	26	0.10	27
Tamil Nadu	2.72	14	8.33	2
Tripura	0.21	17	0.30	22
Uttar Pradesh	3.57	12	8.04	3
Uttarakhand	0.04	23	1.17	18
West Bengal	3.76	10	6.22	5

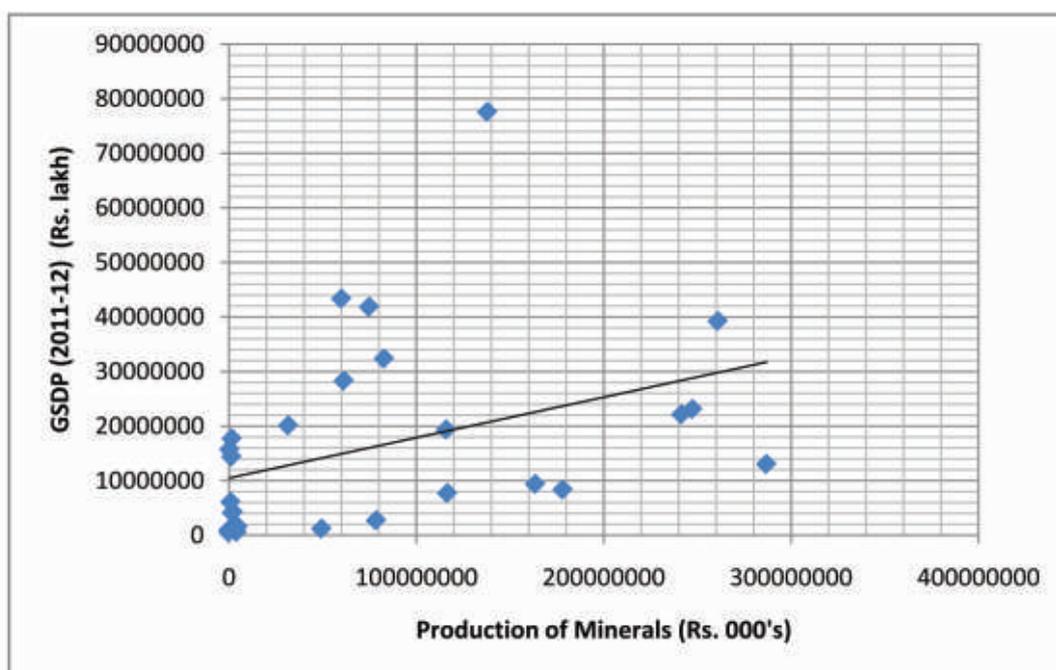
Source: Reserve Bank of India, Handbook of Statistics on Indian States

Source: Indian Bureau of Mines, Monthly Statistics of Mineral Production

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On calculating the Spearman's rank correlation here, we get the value of 'R as 0.61, which is definitely positive and not a very small value.

Based on the given data, if we plot a scatter diagram taking the value of production of minerals on the x-axis, and the states' GDP on the y-axis, we get the following scatter diagram [In all following scatter diagrams, the blue dots depict the resource-GDP combinations of the different states, and a straight line has been fitted through the diagram for an estimate of the general relationship]:



Here, even though we see a general positive relationship, i.e., a seemingly direct correlation between the availability of mineral resources and the GDP of states, evidently, there are exceptions.

For example, **Odisha** and **Jharkhand**, despite having some of the largest reserves of mineral resources in the country are still far behind most states in terms of GSDP, and as available data suggests, in terms of per capita income and poverty rates too.

**Maharashtra** though, with only moderate endowments of resources has a much higher GSDP. Since a single variable is not at all sufficient to discuss why these anomalies occur, we first take a look at the rest of our data before discussing the reason for the presence of these exceptions.

## 2. Forests

Forests contribute to economic growth, employment, food security, and energy generation, and are key to helping countries respond to climate change. Forests are an important source of both formal and informal jobs, particularly in rural economies where there are few alternative off-farm employment options (Forests and Economic Development, 2013). Forests generate services that sustain key sectors (agricultural, energy, water, mining, transport and urban sectors), by helping to maintain soil fertility, protect watersheds, provide habitat for a variety of species, and reduce the risk of natural disasters. Presently, forests generate an annual gross value add of just over US\$ 600 billion, about 1% of global GDP. (Forests Overview, 2018)

In India, distribution of forests across the country is very uneven. While 75% of the forests are located in Peninsular India and 20% in the Himalayas and Tarai region, the Gangetic plain is host to less than 5% of the entire forest cover of the country. (VK Puri, 2017)

The following table and scatter diagram show the relationship between forest cover and GDP in different states:

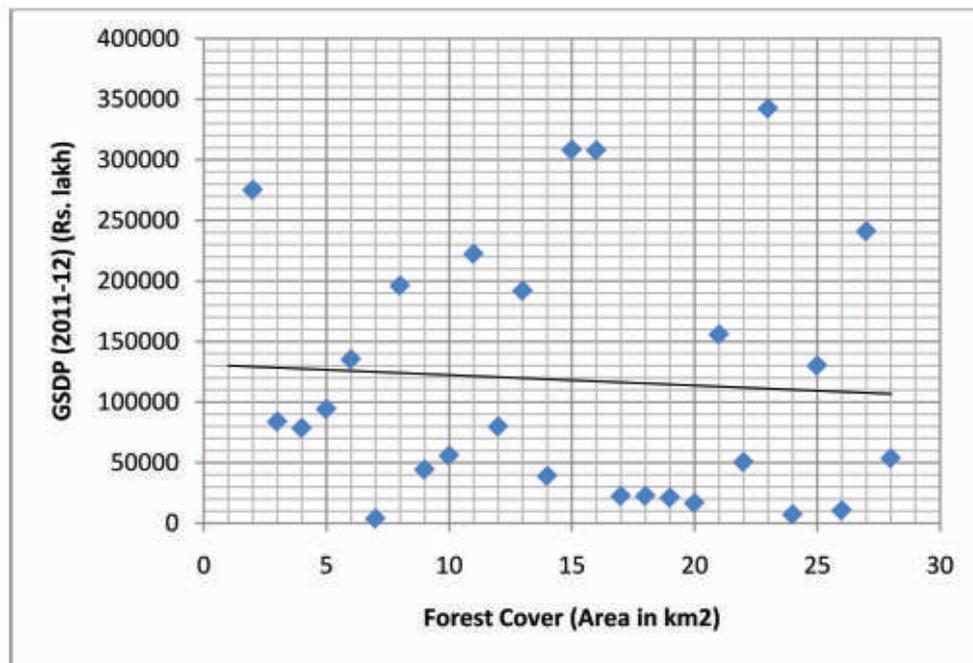
**Table 2: Forest Cover and GSDP (2011-12)**

States	Forest cover of state as percentage of total	Rank	SGDP as percentage of total GDP	Rank
Andhra Pradesh	11.23	6	4.25	8
Arunachal Pradesh	6.70	2	0.11	26
Assam	9.74	8	1.48	17
Bihar	4.00	24	2.76	13
Chhattisgarh	0.99	3	1.60	16
Goa	8.05	26	0.52	21
Gujarat	0.32	19	7.54	4
Haryana	2.11	28	3.40	11
Himachal Pradesh	0.23	18	0.81	19
Jammu & Kashmir	2.12	12	0.79	20
Jharkhand	3.26	11	1.80	5
Karnataka	3.32	7	5.44	6
Kerala	5.23	14	3.86	9
Madhya Pradesh	2.50	1	3.72	10
Maharashtra	7.32	4	14.91	1
Manipur	2.47	16	0.14	25
Meghalaya	2.50	15	0.23	23
Mizoram	2.76	13	0.09	28
Nagaland	1.92	21	0.19	24
Odisha	7.07	5	2.50	14
Punjab	0.25	27	3.02	12
Rajasthan	2.32	17	4.44	7
Sikkim	0.49	25	0.10	27
Tamil Nadu	3.41	10	8.33	2
Tripura	1.15	23	0.30	22
Uttar Pradesh	2.07	20	8.04	3
Uttarakhand	3.54	9	1.17	18
West Bengal	1.88	22	6.22	5

Source: Reserve Bank of India, Handbook of Statistics on Indian States  
Source: Indian State of Forest Report, Forest Survey of India

On calculating the Spearman's rank correlation here, we get the value of 'R' as 0.11, which, even if positive, shows a very weak relationship. On plotting a scatter diagram, the straight line fitted through the data, shows a weak relationship too.

This weak relationship discovered could be attributed to the relatively small forest cover "In India, per capita forest area is only 0.064 ha against the world average of 0.64 ha. (FAO). The productivity of our forests is only 1.34 m<sup>3</sup> /ha/year against the world average of 2.1 m<sup>3</sup> /ha/year." (Planning Commission, Government of India, 2008)



Even though this analysis presents a very unclear relationship, there are a few states like Jharkhand and Arunachal Pradesh which have vast covers of forests (in relation to their total geographic area) and still low GDPs and poverty rates of 36.96% and 34.67%, which are well above the national average of 21.92%. (Reserve Bank of India, 2012)

### 3. Groundwater Resources

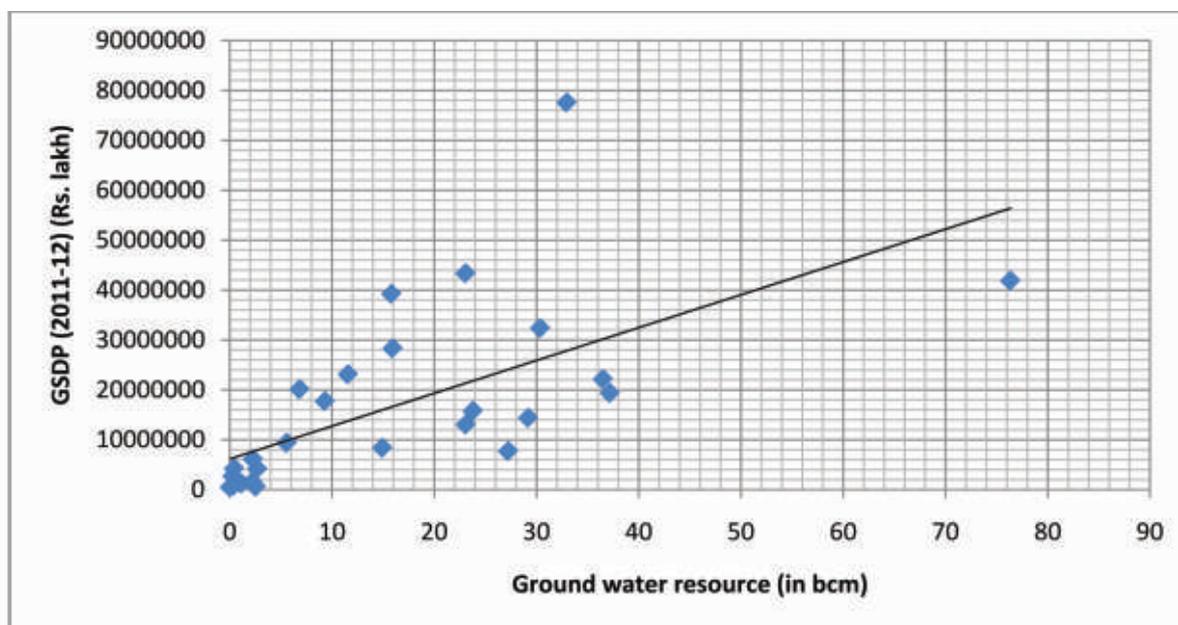
The importance of groundwater in the natural water cycle is evident in its growing use in all human activity sectors. Groundwater is a source of major wealth and well-being for a society, especially in a largely agricultural society like India's. The irrigation sector remains the main consumer of groundwater (92% of total annual ground water draft for all uses). In India, the Central Ground Water Board is vested with the responsibilities of assessing and managing the ground water resources of the country through ground water management studies, exploration, evaluation and monitoring of ground water regime. Data collected by the organization for the year 2012 is presented below:

**Table 3: Groundwater Resources and GSDP (2011-12)**

States	Annual Replenishable Ground Water Resource as percentage of total	Rank	SGDP as percentage of total GDP	Rank
Andhra Pradesh	8.45	3	4.25	8
Arunachal Pradesh	0.59	19	0.11	26
Assam	6.3	7	1.48	17
Bihar	6.75	6	2.76	13
Chhattisgarh	3.45	13	1.60	16
Goa	0.07	26	0.52	21
Gujarat	3.66	12	7.54	4
Haryana	2.15	15	3.40	11
Himachal Pradesh	0.1	23	0.81	19
Jammu & Kashmir	0.62	18	0.79	20
Jharkhand	1.29	17	1.80	5
Karnataka	3.69	11	5.44	6
Kerala	1.58	15	3.86	9
Madhya Pradesh	8.61	2	3.72	10
Maharashtra	7.63	4	14.91	1
Manipur	0.09	24	0.14	25
Meghalaya	0.27	22	0.23	23
Mizoram	0.01	28	0.09	28
Nagaland	0.08	25	0.19	24
Odisha	5.34	9	2.50	14
Punjab	5.5	8	3.02	12
Rajasthan	2.68	14	4.44	7
Sikkim	0.02	27	0.10	27
Tamil Nadu	5.34	10	8.33	2
Tripura	0.51	21	0.30	22
Uttar Pradesh	17.67	1	8.04	3
Uttarakhand	0.53	20	1.17	18
West Bengal	7.03	5	6.22	5

Source: Reserve Bank of India, Handbook of Statistics on Indian States  
Source: Central ground water board (CGWB), ground water resources

Here, the rank correlation coefficient is found to be 0.78, which is a fairly high positive value. Even the scatter diagram below shows an obvious positive relationship between the water resources and GSDP of the states.



Again, however, this set of data also shares in common the exception of Maharashtra with the other two sets of data, with Maharashtra having a GDP far above that of the rest of the states of India, despite not having a proportionately generous endowment of natural resources.

### Dutch Disease

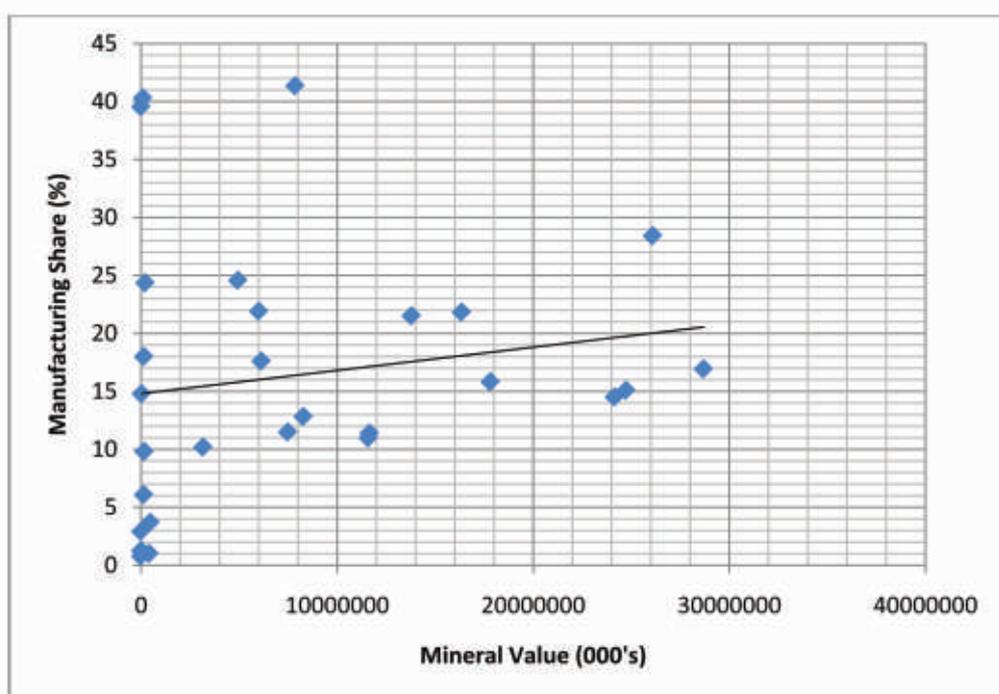
“If the development experience of the resource rich Indian states were characterized by a ‘resource curse’, an important indicator of the same would be decline in the share of manufacturing GVA” (Government of India, 2018). Based on the table, figure 4 shows the relationship between the value of mineral resources and the average share of manufacturing to the Gross Value Added in a state.

**Table 4: Share of Manufacturing in GVA of State and Value of Mineral Production**

States	Share of Manufacturing in GVA of state	Value of production of minerals in state as percentage of total value
Andhra Pradesh	14.5	10.96
Arunachal Pradesh	0.99	0.19
Assam	11.38	5.29
Bihar	6.07	0.06
Chhattisgarh	15.81	8.08
Goa	41.35	3.57
Gujarat	28.41	11.84

Haryana	17.98	0.07
Himachal Pradesh	24.35	0.1
Jammu & Kashmir	9.79	0.08
Jharkhand	21.82	7.42
Karnataka	17.59	2.78
Kerala	10.17	1.44
Madhya Pradesh	10.97	5.26
Maharashtra	21.5	6.26
Manipur	2.9	0
Meghalaya	24.55	2.24
Mizoram	0.76	0
Nagaland	1.25	0
Odisha	16.92	13.01
Punjab	14.78	0.01
Rajasthan	15.07	11.22
Sikkim	39.54	0
Tamil Nadu	21.9	2.72
Tripura	3.67	0.21
Uttar Pradesh	11.48	3.57
Uttarakhand	40.29	0.04
West Bengal	12.81	3.76

Source: Reserve Bank of India, Handbook of Statistics on Indian States



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As we can see, the relationship is rather weak. If at all there is one, it is positive and not negative, as the presence of a resource curse would have resulted in. On calculating the correlation between the two variables (mineral value and the percentage manufacturing share) in the different states, we get 0.16, which is too small a value to make conclusions.

### **Case Study: Jharkhand and Gujarat**

Given that all three of the correlation coefficients come out to be positive, we surely cannot suggest that the resource curse applies to all the states of India. However, it is evident from the scatter diagrams that there are a few states like Jharkhand (with its large forest and mineral resources but high rates of poverty), Odisha (again, having one of the largest mineral wealth), the north-eastern states (with large portions of their lands covered in forests), which do not quite follow the general positive trend. Then again there are states on the western border of the country like Gujarat and Maharashtra which have shown a much larger scale of development, without having been as replete with natural resources.

In this paper, we pick two such contrasting states, Jharkhand and Gujarat, and take a look at what caused this anomaly.

#### **Jharkhand**

Jharkhand is state reflecting poverty among plenty. As data collected shows, it has some of the largest mineral resource reserves in the country and also a large forest cover. It is anomalous that 36.96% of the population in Jharkhand lives below the poverty line and almost just as many close to the line (Source: RBI, Handbook of Statistics on Indian States). A host of reasons are responsible for this:

- i. **Political instability:** Since its formation in 2000, Jharkhand has 9 governments in function with 3 periods of President's rule. (States of India since 1947, 2017) No government has been long-lasting enough to make any significant change in the state. The lack of cooperation between the state and central government has always made it difficult to put the grievances and requirements of its population properly in front of the government. Even when done, management has been lacking. Moreover, Maoist led parallel governments have also severely hampered the stability of this region. Police violence is very common. Since 2000, countless people have been killed in 'encounters, arrested and seriously injured. (Jharkhand Human Rights Report (2000-11), 2011) This has created a sense of fear, terror and injustice amongst ordinary Jharkhandis as well as among potential investors.
- ii. **Corruption:** Corruption is rampant in Jharkhand and the fact that it is a mineral rich state makes it even worse with people in power (political or industrial) having the means to siphon off large sums of money from mineral production instead of having that money distributed among the population. This particular point is a very relevant example of what happens in many countries around the world suffering from the Resource Curse.
- iii. **Societal problems:** Jharkhand is among the bottom five states in terms of the Human Development Index (HDI) with a dismal score of 0.376.
  - a) **Malnourishment:** Ever since the state was created more than 100 people have been reported to have died out of acute hunger, of which 40 belonged to the indigenous Adivasi communities. (Jharkhand Human Rights Report (2000-11), 2011) The Jharkhand Social Welfare

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Department's own data states that there are 5.5 lakhs malnourished children. 56.5% of children below five years age are under weight and 70.3% are anemic.

- b) **Displacement of people:** The Indian People's Tribunal on Environment and Human Rights, reports a total of 6.5 million people being displaced in the name of development.

Similarly, in the last decade, around 30 lakhs people had to migrate from the state. According to a research centre, Indian Social Institute, 54.78% girls and women migrated from Jharkhand are working as housemaids. Out of these, 70% had to migrate before the age of 18. What is more disturbing is that a considerable percentage of these young women are forced to work as sex-workers.

- c) **Illiteracy:** Illiteracy, to some extent, can be pointed at as the root cause of all evil. Most of the state government schools are in really bad shape. Teachers were not paid their salaries for months, even years. There is widespread corruption in the recruitment process of school teachers. Lack of quality higher educational institutes is a major reason why the talented students are forced to go to other states. A large portion of the population is tribals, who have barely any access to education and therefore only survive on forest resources, which also they are not fully aware of the effective utilization of.

## Gujarat

- i. **Historical advantage:** The Western part of India is relatively prosperous thanks to stable state governments since independence. Also, states like Gujarat have had a slight relative historic advantage considering the fact that the Eastern region was always more affected by the British Raj, having continuously been under British rule ever since the Battle of Plassey in 1757. However, the Britishers focused on Ports on West Coast since they landed on the Western coast and it was convenient for them to import and export from west coast. (E.g.: Developing cities like Surat). Also, the West was never as severely affected by Naxalism as the East is till date.
- ii. **Presence of traditional mercantile class:** In Gujarat, the presence of a traditional mercantile class since antiquity has helped create an atmosphere of thriving economic activity. Moreover, liberalization of economy (although a bane for small scale industries) helped those who were ready to adjust with times: new expertise, better production techniques & the boom of economy trickled down on a vast segment of mercantile class of western India.
- iii. **Social Factors:** Caste plays a role too. Poverty and affluence in India are strongly distributed along caste vectors. By any measure, Scheduled Castes and Scheduled Tribes—a significant chunk of the population—are the most poorly served by the Indian state and uniquely vulnerable to chronic poverty. Gujarat has low concentrations of the SC/ST population, while the eastern coastal states like Jharkhand all have high concentrations. The HDI of Gujarat fares far ahead of that of Jharkhand's because of its better schooling systems and much higher literacy rate, and far less rates of malnourishment and child mortality.

## Section 5 : Conclusion and Policy Prescriptions

From the series of positively sloped diagrams that have been obtained in this paper, it definitely cannot be said that the hypothesis of the resource curse is valid in all Indian states. However, we have obtained

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several exceptions among the various states where the growth in GDP has not been large despite an abundance of natural resources (e.g.: Jharkhand, Odisha, the northeastern states). The reasons for the anomaly in one of these states, Jharkhand, have been discussed in the above study, and some recommendations in policies have been listed in the final section of this paper.

The reason the majority of states seem to escape the curse is because almost no state in India bases its entire income on the production of any one kind of commodity. In the countries frequently researched, like Venezuela and Angola, very large portions of the economy rely on the production and export of a single commodity (oil). Whichever person or group of people gets ownership or control of these resources gains a certain control over the economy and the people of the country, which results in a fall in the levels of democracy and the eventual emergence of some form or the other of autocratic rule, which hardly ever results in policies directed towards the betterment of the citizens.

### **Policy Prescriptions**

1. **Sustenance instead of exploitation:** Despite being a state with plenty, the resources in Jharkhand are subjected to mindless exploitation instead of being properly utilized in sustainable manners. Investment should be made in research regarding utilization instead of depletion. Forests in the state have huge potential. Forest products can be used to raise employment in say, wooden handicrafts, furniture etc. Planned plantations could also help.
2. **Education:** In states like Jharkhand, which have very low literacy rates, the first step towards advancing the states' economic growth and providing employment to a larger percentage of the population would be to build more schools and increase accessibility to them. Teachers need to be recruited in larger numbers (from other states too, if need be) and the requisite infrastructure needs to be provided.
3. **Infrastructure and Industry:** The infrastructural backwardness of Jharkhand negatively affects not the accessibility to educational institutes, but industrial development too. Industry cannot develop in the absence of a certain quality of roads and railways. Moreover, there are numerous plants and industries in this region which are shut down, for example, the Sindri fertilizer plant, ceramic factory in Sindri, etc. Reopening these would obviously be less tedious than setting up new projects.
4. **Agriculture:** There is potential for agricultural advancement, which has also been ignored by the government for years. Setting up facilities to educate and impart skills to residents in the field of agriculture could help tap the state's potential in it.
5. **Policy formulation:** Absence of policies, because of unstable governments, has always been a hindrance to development in states like Jharkhand. Time and consensus is required for proper policies to be formulated and implemented, especially policies that will attract FDI. The introduction of an SEZ would also go a long way in providing incentive to industrialists to set up businesses in the state.
6. **Tourism:** Tourism is an industry that remains severely under-explored in this state. Jharkhand is blessed with exceptional scenic beauty with waterfalls, forests and fauna. Promoting tourism could help raise revenue for the government to invest in infrastructure, education, etc.

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# Comparative Analysis of Face Recognition Algorithms using Machine Learning Approach: A Review

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## **Abstract**

Face Recognition is an important challenge in the field of Computer Vision. Given a set of images, or a video file, it is often important not only to detect the presence of faces in them, but also to identify them. Face Identification is one of the classification problems which can be solved using Machine Learning techniques. In this paper we study various existing algorithms that deal with the face recognition problem using machine learning approach. A comparative study on the performance of the different algorithms and their domain specific applications are discussed in this paper.

**Keywords:** Computer Vision, Machine Learning, Face Recognition, Face Identification

## **1. Introduction**

Automated Face Recognition is a significant problem to engage in, as it has a wide variety of applications especially in the field of security. Many biometric systems make use of facial recognition in order to provide or deny access to protected information. Another application of facial recognition, which is currently under development, is advertising.

Face Recognition is normally preceded by Face Detection [1]. Face detection is a computer technology being employed in an assortment of applications that finds human faces in digital images. Face detection can be considered to be an explicit instance of object class detection. In object class detection, the algorithm tries to find the spatial locations of all stipulated objects, irrespective of their size, in an image. In face detection the main task is to detect the presence of a face in an image and to highlight the pixels that belong to a human face. It is mostly used in biometric systems as a part of a Facial Recognition system.

Classification is a process in which objects are detected, recognized, differentiated and understood. Normally classification problems are dealt with machine learning techniques, namely supervised learning [2]. Object Recognition is a core problem of Computer Vision. It comprises of three steps –

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detection of specific objects in an image, followed by the mining of its features, and then based upon the extracted features, assignment of a label to the object. If a training set is available to help assign labels to the detected objects, then the Object Recognition challenge reduces to a classification problem. Since Face Recognition is the task of assigning an input facial image one label from a fixed set of categories, it falls under the purview of Object Recognition. The label could be the name of a person, or it could also be a Personal Identification Number (PIN).

This paper provides a critical analysis of various machine learning techniques that have been used to perform facial recognition tasks. Our next section is about an analytical discourse on various feature extractors, like Principal Component Analysis (PCA) [3], Linear Discriminant Analysis (LDA) [4] and classifiers like Support Vector Machines (SVM) [5], Artificial Neural Networks (ANN) [2] and Convolutional Neural Networks (CNN) [6]. A list of the data sets used, a summarized version of the methods, and the accuracy of each technique is given in a tabular format in Section 3. The summary of all the techniques can be used to identify research gaps and improve upon the existing algorithms. Section 4 provides a concluding statement and discusses the future research scope of the problem.

## **2. Existing Methodology**

This section comprises of two main domains- Face Detection and Face Identification. Face Identification is the primary concern of this review paper. Three important areas of Machine Learning - Artificial Neural Network, Support Vector Machine and Convolutional Neural Network, will be discussed in this paper. Existing algorithms of each related domain will be briefly discussed in this section. We start with the most famous face detection algorithm, and then turn our attention to the available machine learning solutions to the face identification problem.

### **2.1 Face Detection – Viola Jones Algorithm**

The Viola Jones Algorithm [1] was proposed in 2000. This algorithm is regarded as one of the best face detection techniques in use today, which made face detection a reality. The face detection technique categorizes images based on the value of minimal features. The most widespread motive for employing features rather than pixels directly is that the features have the ability to determine ad-hoc domain knowledge that is challenging to learn using a finite quantity of training data. The feature based system operates faster in contrast to a pixel based system. The simple features used are reminiscent of Haar Basis functions [1]. The three kind of features used are two rectangle feature, three rectangle feature and four rectangle feature.

The viola jones algorithm comprises of three parts:

1. Haar Cascade: Extraction of Haar like features.
2. Introduction of a new image representation called the “Integral Image” which allows the features used by the detector to be computed quickly.
3. A simple and efficient classifier which is built using the AdaBoost learning algorithm (also the machine learning method used in this system) to select a small number of critical visual features from an enormous suite of potential features.

What makes Viola-Jones algorithm really special is the fact that this method combines classifiers in a cascade which allows background regions of the image to be quickly discarded while spending more computation on promising face-like regions.

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## 2.2 Face Identification

The progress in the field of Machine Learning provides an interesting insight into the evolution of Face Identification algorithms. The very first systems were implemented using Artificial Neural Network, which soon paved the way for the use of Support Vector Machines as classifiers. Neural Networks soon made a comeback, rechristened as Deep Learning. Development of Convolutional Neural Networks gave computers the ability to deal with Face Recognition, not only in images belonging to the visual spectrum, but also in images that belong to the Near Infrared (NIR) and Thermal-InfraRed (TIR) domain.

### 2.2.1 Artificial Neural Network (ANN)

Neural networks-based methods are quite popular when it comes to general pattern classification. The learning ability of an Artificial Neural Network (ANN) is inspired by that of a human brain. Each node of an ANN corresponds to a neuron present in the human brain, with the interconnections being modelled on the synaptic connections between the neurons.

Neural networks were the first machine-learning technique applied to solve the problem of face recognition. Its learning ability was quite useful to study the features extracted by other techniques.

#### • Sex Identification

ANN were first used to identify the sex of the person present in the image. It was a common understanding that machines require at least 16x16 images of human faces to identify sex using various machine learning techniques. In paper [7], it is shown that a neural network using back-propagation learning technique can identify sex even from face-centre images, excluding outline, with incredibly low 8x8 or 8x6 resolution. The neural network extracts low frequency craniofacial [7] shape features to identify the sex.

#### • Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA) with ANN

ANN is mostly based on the features extracted by the feature extractors. PCA and LDA are two of the most famous feature extractors that are capable of classification on their own using the Euclidean distance metric. In paper [8], The Dataset of Faces was used to evaluate the performance of PCA, LDA and ANN as classifiers. It is seen that using LDA as an extractor with ANN as a classifier (LDA-NN) gives a much improved performance compared to PCA as extractor with ANN as classifier (PCA-NN), and PCA and LDA as classifiers themselves. LDA-NN has an accuracy of 95.8% [8].

#### • Sparse Representation based Face Recognition using Auto-Associative Neural Network (AANN)

Sparse Representation for Classification (SRC) is a methodology that works well when it is used with feature extraction methods like PCA, ICA, or TDA etc. [9]. For classification using machine learning, many features are concatenated and assigned with weights, or are addressed in a unified way so that the classifier performs better.

The two important stages for face recognition are, feature extraction from input image, and building a powerful classifier. The AANN algorithm discussed in paper [9], creates dictionary atoms from given training samples, and by using this discriminative criteria, errors can greatly be reduced. The idea here is to use multiple neural networks working together instead of a single deep neural network. Using

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multiple neural networks gives us the advantage of working with multiple order components of the features instead of only the second order feature components that are mostly extracted by the PCA algorithm. Combining similar features helps us to obtain a sparse representation of faces. PCA, LDA and the other algorithms mostly end up extracting features that are extremely correlated with other features, thereby increasing the computation cost. Experimental results have shown this system to be computationally less intensive and having similar accuracies when compared to PCA-NN and LDA-NN discussed previously [9].

### 2.2.2 Support Vector Machines

Before the advent of deep learning, Support Vector Machines (SVM) [5] were popularly used as an effective tool to perform general purpose pattern recognition. SVM is a binary classifier that can be extended to perform multi-class classification as well. The idea behind SVM is to find a hyperplane – a decision boundary surface that has maximum distance to the closest points on either side of the training set. These points are known as Support Vectors. The hyperplane acts as a boundary that separates the regions in an n-dimensional space. Points lying on one side of the plane are given one label, whereas points on the other side are given another label.

Support Vector Machines have been used extensively in the field of Face recognition. Two existing face recognition systems that make use of SVMs are:

1. Face Recognition with PCA and SVM
2. Face Identification using SVM and Fuzzy Kalman Filter

#### • Face Recognition with PCA and SVM

The technique discussed in paper [10] comprises of two parts: Feature Extraction through PCA; and classification through SVM. Once the features have been extracted, they are used to train the SVM. The trained SVM is then used to apply a label on the given input image. This paper trains three SVMs – one with a linear kernel, one with a polynomial kernel and one with a radial basis function. Experiments show that the SVM with the radial basis function gives the best performance of the three [10].

#### • Face Identification with SVM and Fuzzy Kalman Filter

One of the most important applications of face recognition is in surveillance systems. In surveillance systems, apart from face detection and identification, we also need to track the movements of the subject. The above mentioned problem is tackled in paper [11]. The paper [11] comprises of three parts – Face detection, Face Identification and Face Tracking.

The Face detection algorithm comprises of four sequential tasks – *colour skin separation, edge detection, oval model detection and feature extraction of human faces*. The colour skin separation component ensures that the recognition technique works on colour images as well. The oval model detection phase is included as most humans have an elliptical or an oval shaped face under normal condition.

The face identification algorithm is made up of 4 tasks – separation of high and low frequency band through Haar Wavelet transformation [11], feature extraction through PCA, classification of training set through SVM, and test image face identification through Euclidean distance metric. The fourth step is

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based on the logic that once the entire system has been trained, using Euclidean distance speeds up the entire identification process without using any additional overhead. The Euclidean distance metric is also used in the training phase to weed out unnecessary training examples.

The last component of paper [11] is face tracking through fuzzy Kalman Filter [11]. This particular filter introduces a certain amount of ambiguity and blur in the images, which is normal if the subject is in motion. This component makes the entire system more robust. The need of face tracking is also of great importance in robotic vision.

**Results:** Experimental results show that face identification works best when non-linear SVM is combined with Euclidean distance metric. Use of the Fuzzy Kalman feature has improved the face tracking performance in robotic systems [11].

### 2.2.3 Convolutional Neural Network

Convolutional Neural Networks (CNN) were designed to model the connection between the neurons present in the visual cortex, unlike artificial neural networks which was designed to be a general model of the human brain. This made CNNs a perfect choice for solving any Computer Vision related problem. CNNs were later modified to work on images belonging to various spectrums, making them highly reliable and multi-dimensional in nature.

#### • Visual Spectrum - DeepFace and Boost CNN Cascade Framework

The problem of face recognition can be divided into four main categories:

1. Detection
2. Alignment
3. Representation
4. Classification

With the advent of deep learning, neural networks again became a viable option to solve the problem of face recognition. AlexNet [12] and GoogleNet [13] are two of the most powerful CNNs in use today designed specifically for Image-related problems.

The problem with GoogleNet and AlexNet is that they are general-purpose CNNs, i.e. they are designed to detect and recognize any type of objects present in images. This general purpose nature may make them more flexible, but for face recognition, a highly customized system is preferred.

The two most famous CNNs designed specifically to solve the problem of face recognition are:

1. DeepFace
2. Boost CNN Cascade Framework

#### DeepFace

DeepFace [14] is a Deep Convolutional Neural Network that has been trained on an extremely large dataset. The depth of DeepFace makes it perfect to deal with large datasets: its performance increases with increase in the size of the dataset. To summarize, DeepFace comprises of two steps:

1. **Face Frontalization:** Aligning faces is very important, when it comes to normalizing the input. Existing face alignment techniques include using a 3D model of any given face, and extraction of special “Fiducial” Points on the face. Both methods have their own pros and cons, but DeepFace

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tries to overcome it by taking the best of both worlds, i.e. creation of a 3D model based upon the fiducial points themselves. DeepFace uses the technique of analytical 3D Face Alignment, also called frontalization. It makes use of simple fiducial point detectors, but they are used over several iterations, thereby refining the output. Fiducial points are extracted using a support vector regressor or a SVR. Once the Fiducial points have been extracted they are used to perform 2D Alignment. 2D alignment generates a 2D crop image which is then warped to the image plane of a 3D shape resulting in a 3D aligned version of the 2D cropped image. This is done with the help of extra 67 fiducial points. Also some residual values are added to them which helps to keep track of all discriminative factors. Piecewise affine transformation from 2D to 3D to 3D residual helps to achieve the frontalization which provides a lot of features to perform classification.

2. **Representation and Classification:** The structure of DeepFace includes C1 (convolution layer 1), M2 (max pool layer 2) and C3 (convolution layer 3) which are responsible for learning all low level features. DeepFace doesn't use more max-pool layers apart from M2 because that can cause loss in data and important features and important variations. The subsequent locally connected layers (LCL) L4, L5, and L6 learn different set of filters that capture of all possible variations in the given local region of an image. L6 is followed by 2 Fully Connected Layers (FCL) – F7 and F8. Their task is to find out the correlations between the features captured at different parts of the image. Output of F7 is the raw Feature Vector. Output of F8 is fed to a softmax classifier, whose job is to assign the label. DeepFace uses ReLU [14] activation function after each convolution layer and F7. ReLU brings in non-linearity and makes use of sparse features. The features are normalized in the range [0, 1] to make the system invariant to noise and illumination. The structure of the Network is shown in [14].

**Datasets:** The Datasets used for training and testing are Social Face Classification (SFC), Labelled Faces in the Wild (LFW), and YouTube Face set (YTF) [14]. SFC is used as training dataset, whereas LFW and YTF are used for testing. There is a huge amount of variety in the SFC dataset. Using it as the training set makes the classifier more invariant to noise and poses. More importantly if test and training set are taken from same dataset, then the algorithm becomes biased towards the data being trained upon, i.e. working well for training data but not for others. Hence it makes more sense to use different training and test sets.

**Results:** The DeepFace Network after training is tested on the LFW and YTF dataset. First the testing is performed without any alignment, with only 2D alignment and then with 3D modelling. The accuracy results are as follows:

- A. Without Alignment: 87.9%
- B. With 2D Alignment: 94.3%
- C. With 3D Modelling: 97.00%

A human was also included in the above test, and the human's accuracy was around 97.53%. This shows that DeepFace has achieved similar levels of recognition prowess as compared to human.

### **Boost CNN Cascade Framework**

Most CNNs can perform Face detection and identification with a high degree of accuracy, but all of them require a huge dataset to work with which sets back certain applications. Boost CNN Cascade

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framework was proposed to deal with the problem of unavailability of large datasets. The overall framework in paper [15], involves several shallow CNNs that are trained as weak classifiers, and later cascaded together to give an overall structure for face identification. If two faces are found to be dissimilar, then they are rejected by the shallow CNNs themselves without having the need of going deeper into the network.

The algorithm begins with a pre-training phase comprising of the following steps:

1. The face is first detected, and then resized to a size of 224 X 224. Facial landmarks are located using the joint cascade face detection and alignment technique. This is a combination of LBP, LPQ, and BSIF methods [15] that are used for feature description. Their outputs are concatenated to give a final feature vector used to detect landmarks on the face.
2. 5 landmarks are chosen as 5 region centres, and patches are then generated over them.
3. These patches are used to train the entire model. Class-ID and Personal Identification Numbers are used as class labels.

Once the network has been pre-trained, the FCL of the CNN is removed. Ten such CNNs are trained. During the testing phase different regions of the face are identified by different networks in the system.

Various controlled experiments are performed using the LFW and AT&T

databases [15]. The Boost CNN Cascade Framework has been found to be more efficient and faster compared to the human-designed descriptors. Combination of LBP, LPQ, and BSIF for face alignment and landmark detection has made the entire system's performance invariant to the size of the dataset.

#### • **Near InfraRed (NIR) Spectrum – NIRFace Net**

Both DeepFace and Boost CNN Cascade work on images belonging to the visible spectrum. However they can also work in NIR domain with negligible performance drop. Images taken in the NIR spectrum are unaffected by illumination. The problem of the above two techniques is that their training datasets comprises of images taken from conscious users. The conditions under which the photos were taken were customized to ease the feature extraction process. It has been seen that the performance of the above methods drop considerably when motion blur, Gaussian noise, Gaussian blur, and salt & pepper noise are introduced to the image.

NIRFace-Net [16] is a CNN designed specifically to deal with images belonging to the NIR spectrum, of users who weren't cooperative or aware at all times. CASIA-NIR database [16] is a medium sized collection of cooperative users faces captured in the NIR domain. Here motion blur, Gaussian blur, Gaussian noise and salt & pepper noise are introduced to the images of the above database.

The size of a CNN depends mostly on the size of the dataset. If the dataset is huge then we need a large sized network to deal with them. However when it comes to medium sized datasets, having shallow networks is far more advantageous. NIRFace-Net works on a medium sized dataset, hence it is shallow. NIRFace-Net, a modified version of GoogleNet comprises of 8 layers only, making it more compact. It uses a combination of 3X3 and 1X1 kernels instead of a large 5X5 kernel, thereby making it less computation intensive. The proposed structure is shown in [16].

Apart from the training set, 9 test sets were used. Results show proposed NIRFace-Net can achieve the

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highest identification rate among LBP+PCA [3][13], LBP Histogram [16], ZMUDWT [16], ZMHK [16] and GoogleNet [13] and is regarded as the most robust method. A comparison of the various techniques, and a breakdown of the various test sets is mentioned in [16].

#### • **Thermal InfraRed (TIR) Spectrum – ThermalFaceNet and RPS-Net**

The techniques discussed so far work only in the Visible and Near IR spectrum. The TIR spectrum comes into use when the visible and NIR spectrums are insufficient. TIR images have been shown to be more informative and useful under extreme conditions where light is insufficient, to see through disguises and skilled make-ups that can fool any human or other existing face identification algorithms working in visible image domain.

The real challenge of face recognition in TIR images is that its basic unit of information is temperature. Facial temperature can change due to a variety of factors, including emotions, body condition, geographical locations and time. A person's face can have multiple temperature distributions at different times. Hence extracting features with enough discrimination is a massive challenge.

Two of the most prominent techniques that deal with face recognition in TIR images are:

1. ThermalFaceNet
2. RPS-Net

#### **ThermalFaceNet**

ThermalFaceNet [17] is one of the first CNNs designed to work on the problem of Face Identification in TIR based images. The CNN model used is inspired by the Siamese CNN model [17]. Once the CNN model is trained on the training dataset, it is used to identify faces in test images. The test image is fed to the CNN, and a feature vector is generated as output. The distance of this feature vector is compared with those generated for each class in the training set. The label of the class, whose feature vector is at minimum distance from the feature vector of the test image, is assigned to the test image. The distance metric used here is the cosine distance metric [17].

ThermalFaceNet has been shown to be better than the existing and popular state-of-the-art VGG-19 Network [17]. A comparison of their performances using the FMR1000, ZeroFMR and EER indicators are shown in [17].

#### **RPS-Net**

AlexNet, GoogleNet, DeepFace, DeepID [18] and ThermalFaceNet are all examples of CNNs with a linear structure [19]. Regional Parallel Structure based Convolutional Neural Network (RPS-Net) comprises of multiple convolution nets placed parallel to each other. This parallel structure allows us to extract various multi-scale feature information, something that cannot be done in a linear structure.

The RPS-Net, discussed in paper [19], is made up of 3 cascaded components:

1. **Initial Edge Feature Extraction:** This part is made up of cascaded convolution and max-pool layers. ReLU activation functions are used after each convolution layer to bring in non-linearity to the entire matter. Its output are the initial low-level features.
2. **Regional Parallel Layer:** This layer comprises of three convolution channels. The task of this layer is to extract the multi-scale feature information. Features in the Neighbour region and Features in the

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Local region are detected here. Channel 1 is devoted to neighbour features, while the remaining two channels are devoted to the local region. Channel 1 works on the initial features extracted in the previous layer, whereas channel 2 and 3 work on the original image itself with different kernel sizes. All 3 layers work in parallel to extract multi-scale features that make the entire classification task simple.

3. **Feature Vector Classification:** The multi-scale features extracted in the previous stage are combined to form a feature vector. This feature vector is huge and is not sent as an input to the classifier. In turn it is sent to the fully connected component part of the CNN. The output of this FCL is considered as the final feature vector.

Dropout layers are added to reduce over-fitting. The advantage of the dropout layer is that it makes the classifier more sensitive to the features themselves rather than the collective effect of the features, making the classifier more accurate.

**Dataset and Results:** The dataset used is the IRIS Thermal face Dataset [19]. 10% of the training set is taken as the validation set. The RPS-Net is compared with other existing systems. It is seen that the network works better on Thermal-IR images in comparison with other systems [19].

#### • Fake versus Real Faces - CGFace

The task of face identification does not stop at assigning labels to faces detected in images. The real challenge lies in differentiating real face images from computer generated photo-realistic facial images. It is difficult for humans to perform this distinction. Generative Adversarial Networks (GANs) [20] are a set of algorithms that have been designed to generate fake images. With time, the quality of fake images has improved to a degree that it has become impossible for humans and computers to differentiate between them.

CGFace [20] is a model that has been designed to detect and recognize fake facial images and identify faces present in the real ones. The CGFace model extracts the characteristic features of CG Images using a customized CNN. The problem with existing Fake Face detecting systems is that they are trained on a particular fake image dataset, but cannot perform well when provided with image from different dataset. CGFace Model is implemented using two customized GANs – PCGAN and BEGAN [20]. Use of two customized datasets generalizes the model, which in turn improves its accuracy on real-life test images.

The CGFace Model comprises of 5 Convolution Layers, 3 Max-Pooling Layers and 2 Fully Connected Layers. The Output layers basically specifies whether the faces in the image are real or computer generated. There is a dropout layer that deals with overfitting, and a Batch Normalization layer inserted before the FCL. This layer was inserted to optimize the performance of the model by adding noise to the training images.

The biggest problem being faced by most CG Face detection systems worldwide is the lack of a benchmarked dataset of real and fake images. The existing datasets are highly imbalanced, with 95% of the images being real. The CGFace model uses Gradient Boosting to deal with the Imbalanced data problem. The two algorithms used are XGBoost and AdaBoost. The basic idea behind these algorithms is that they are a collection of multiple decision trees working in tandem with a small subset of the entire dataset. These subsets of the dataset are far more balanced compared to the entire dataset, as the ratio

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between the numbers of fake images to real images is not skewed as it is in the overall dataset.

Experimental results have shown that CGFace has a 98% accuracy when it comes to detecting real images from fake ones [20].

### 3. Comparative Analysis

Methods Used	Image Spectrum	Dataset used	% Accuracy
PCA, LDA with Artificial Neural Network	Visual	Dataset of Faces	95.80%
Sparse Representation with AANN	Visual	LFW and GT	92%
PCA and SVM	Visual	Cambridge ORL	98%
SVM and Fuzzy Kalman	Visual	Customized Dataset	95%
DeepFace	Visual	SFC, LFW, YTF	97.35%
Boost Cascade CNN Framework	Visual	LFW and AT&T	97.06%
NIRFace-Net	Near Infrared	CASIA-NIR	97.86%
ThermalFaceNet	Thermal Infrared	Customized Dataset	89.67%
RPS-Net	Thermal Infrared	IRIS	96.19%
CG-Face	Computer Generated Images	PCGAN and BEGAN	98.00%

### 4. Conclusion and Future Work

In this paper we have studied and explored the various machine learning techniques that were developed to effectively deal with the face recognition problem over time. The ideas discussed were not limited to images belonging to the visual spectrum, but were expanded to include the Near-IR and Thermal-IR domain as well. A comparative analysis is provided where accuracy and computational costs of the Face Recognition Algorithms are extensively studied. Based upon this study it was found that deep learning techniques have a lot to offer in this respect, however even they are held back from achieving their full potential by issues pertaining to the availability of a proper dataset, and computational costs. It is a long road before CNNs can be used in real life applications where the performance is limited by the upper bound on costs and the need to provide output within a certain time frame.

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# A Technical Investigation on Handwriting Analysis to Predict Human Behaviour and Personality

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## **Abstract**

Handwriting can thoroughly depict personality characteristics of a human being. It carries considerable information that explains different emotional states of a writer. Graphology is an art that uses numerous scientific methods to evaluate different features of handwriting and identifies a variety of personalities. This paper investigates different handwritings, analyses different features in detail, and identifies classes of personality traits based upon these features, various methods used for measuring the features and a framework for an automated tool.

**Keywords:** Handwriting Analysis, Graphology, features, personality traits

## **1. Introduction**

Each and every human being on earth has different nature. This can be predicted by analyzing the handwriting because brain, the versatile organ, is directly linked with nature of writing. Since human brain has a major impact in case of handwriting, it can be labelled as “brain writing” [1]. Handwriting experts or Graphologists uses different features like zone, baseline, slant, size, spacing etc. which are extracted from a given handwriting to identify personality traits separately. However a particular handwriting is often found to have a mixture of various types of the same feature, which needs to be considered. Handwriting of a person often varies based on mood, situations, time of the writing, handedness (left or right), and availability of space for writing and many more.

Some prominent features have been considered by standard algorithms to measure human characteristics. Several researches have been made to design an automated tool to predict human behaviour. Machine learning techniques like ANN, k-NN algorithms are used to implement this automated tool to find out characteristics of a personality efficiently [2][3]. However 100% accuracy is not easy to obtain. A constant research is necessary to achieve better accuracy considering all possible driving factors.

This paper is subdivided into four sections; investigations on various feature for handwriting analysis

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and its variations and related personality traits, discussed in Section 2. Relevant sample handwriting is also given in this section. Section 3 covers different existing methodologies in brief along with a flow diagram stating a framework of the automation tool. Section 4 concludes the paper with a direction of future work.

## 2. Feature Analysis

The main idea behind Handwriting Analysis comes from the study of various features, like baseline, zone, pressure, size, word spacing, slant, connections and many others which can identify human characteristics, mood, behaviour, sex of a person, even lying tendency. To understand different behavioural characteristics, it is very significant to analyse and understand handwriting features and its variations. Some features with possible samples are discussed below.

**2.1 Zone**– A line of hand written text is partitioned into three parts namely upper zone, middle zone and lower zone. The individual letters are divided into three zones to better understand the writer’s thinking and personality. Baseline forms an invisible line between middle, upper zone and lower zone; shown in Table 1. The middle zone should be half the size of the upper and lower zones [2][4]. A typical example is illustrated in Figure 1.

Types of zones	Letters	Characteristics
Upper zone	b,d,h,k,l and t	Future, Fantasy, Illusions, Cultural aspirations, Intellectual.
Middle Zone	a,e,i,o,u,c,m,n,r,s,v,w and x	Present, Realistic, Practical, Emotional expression, closeness.
Lower Zone	g,j,p,q,y and z	Past, Attitude towards home life, Biological needs, Sensual perception.

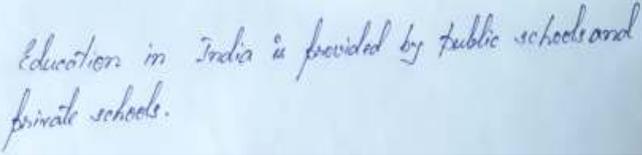
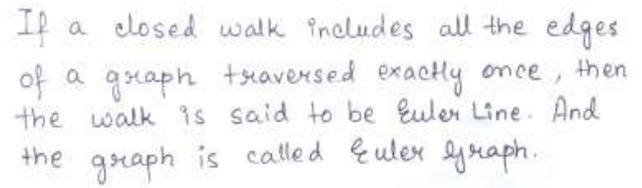
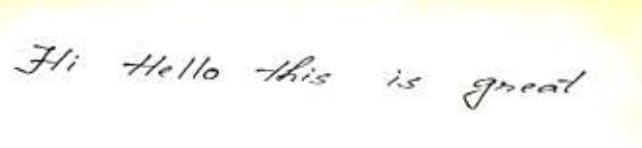
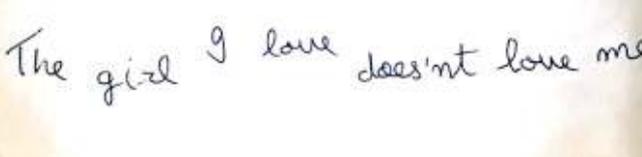
**Table 1: Zone explanation chart**

The letter "f" is the only alphabet which falls under all three zones.



**Figure 1: Different Zones**

**2.2 Baseline-** Baseline is referred to the imaginary line when one writes on a blank white paper. Baseline, often called the ego-adjustment line, gives information about attitude towards goal, energy, and emotional strength as well as it indicates a person's mood, moral, social control, temperament, flexibility. Baseline can be broadly classified into three categories that is, ascending baseline, straight baseline, descending baseline [5][6]. These baselines along with their characteristics, samples are explained in Table 2

Baseline	Pattern	Characteristics	Example
Ascending baseline		<ul style="list-style-type: none"> <li>• Optimistic</li> <li>• Over-disciplined</li> <li>• Ambitious</li> </ul>	
Straight baseline		<ul style="list-style-type: none"> <li>• Stable</li> <li>• Controlled</li> <li>• balanced</li> </ul>	
Descending baseline		<ul style="list-style-type: none"> <li>• pessimistic</li> <li>• depressed</li> <li>• tired mentality</li> </ul>	
Wavy baseline		<ul style="list-style-type: none"> <li>• Person is out of his limits</li> <li>• Emotionally unstable</li> </ul>	

**Table 2: Different Baselines and characteristics**

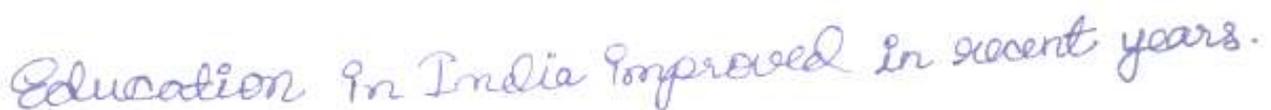
**2.3 Slant-** Slant, angles formed with respect to baseline, basically reveals emotional state of a person. Based upon the angles formed with respect to baseline, slant can be broadly classified into three parts, that is, vertical slant (having 90 degree slant), rightward slant (having lesser than 90 degree slant) and leftward slant (having greater than 90 degree slant). It has been observed that, around 77 percent of individuals write with a right slant, 15 percent with left slant and remaining 8 percent write vertically [3] [5]. Different slants along with their characteristics and possible samples are shown in Table 3.

Types of slant	Characteristics	Example
Vertical slant	<ul style="list-style-type: none"> <li>• Steady and calm</li> <li>• Reserved</li> <li>• Self-reliant</li> <li>• Diplomatic</li> </ul>	I love my country
Leftward slant	<ul style="list-style-type: none"> <li>• Introverted</li> <li>• Self-centred</li> </ul>	I lost my dog
Rightward slant	<ul style="list-style-type: none"> <li>• Extrovert</li> <li>• Future-oriented</li> <li>• Affectionate</li> <li>• Emotionally driven</li> <li>• Demonstrative</li> </ul>	India is great
Unstable slant	<ul style="list-style-type: none"> <li>• In-Disciplined,</li> <li>• Unbalanced,</li> <li>• Nervous</li> <li>• Unpredictable</li> </ul>	The driver drives consciously.

**Table 3: Different Slants and characteristics**

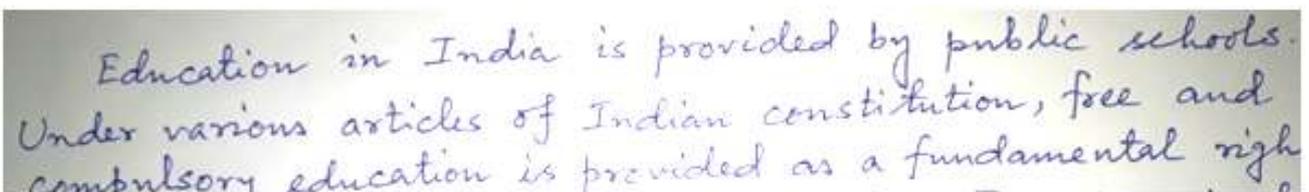
**2.4 Pen-pressure** -Pen-pressure, the force applied to the writing space by the writer, reveals that how much energy we are currently devoting in our general life. Along with that, mental illness, nervousness, frustration, physical illness, all of these can be determined from this feature. The different type of pen-pressure that we use generally can be of following types:-

**2.4.1 Heavy pressure** - It indicates that the person is active, energetic, determined in nature. They generally express their feeling in a strong way. Sometimes, they are stubborn, angry, anxious, forceful, aggressive, inspiring in nature. Figure 2 shows a typical sample with heavy pen pressure.



**Figure 2: Heavy Pressure**

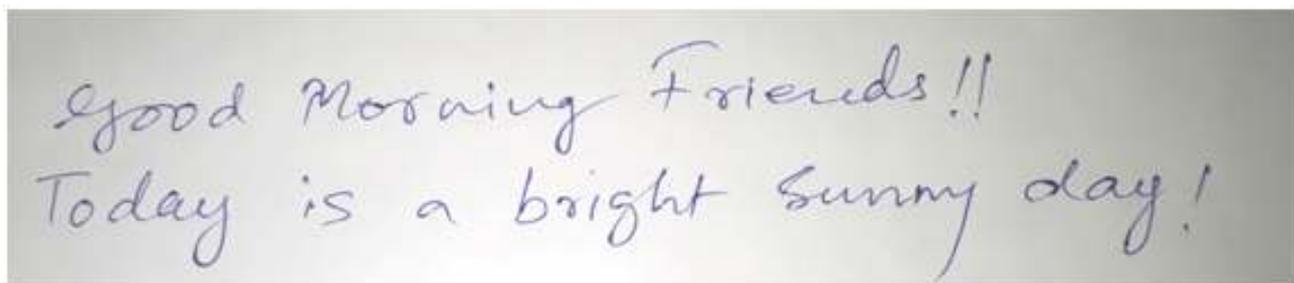
**2.4.2 Medium Pressure**- This indicates that the writer carries average level of emotions. Any emotional incidence keeps a moderate kind of impact on this kind of people. Figure 3 gives an idea of moderate pen pressure.



**Figure 3: Medium Pressure**

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**2.4.3 Light Pressure-** A sick person may write in light pressure. A follower personality is observed in this kind of writers. A passive, gentle, calm, less intense characteristic is depicted from such handwriting. This kind of pressure is shown in Figure 4.



**Figure 4: Light Pressure**

**2.4.4 Uneven pressure-** A nervous, worried personality always uses uneven pressure. While being nervous, an uneven pressure is observed rather than smooth and even pressure. However, some kind of jerking will be there in this kind of pressure [5], shown in Figure 5.



**Figure 5: Uneven Pressure**

**2.5 Letter Size-** Size of letters signifies whether the person is introvert or extrovert. However letter size of an individual may vary depending on size of paper on which the person is writing, it also depends on the person's mood while writing; these data are considered to be biased data. We will not consider such special cases while analyzing. Depending on the size of letters, it can be categorized into overly large handwriting, large handwriting, medium handwriting, small handwriting, overly small handwriting (or microscopic handwriting). It is often observed that Actors, salespeople, and politicians write large-sized letters, since they are extrovert by nature as well as their profession make them so whereas, mathematicians or scientists have small handwriting [5]. Different sizes of letters along with their features are shown in Table 4.

Size of handwriting	Characteristics	Comparison of different sizes
Overly large	<ul style="list-style-type: none"> <li>• Exhibitionists</li> <li>• obsessed</li> <li>• Hyperactive</li> </ul> <p><b>Positive qualities</b></p> <ul style="list-style-type: none"> <li>• Leadership</li> <li>• Courage</li> <li>• Generosity</li> <li>• Ambitious</li> </ul> <p><b>Negative qualities</b></p> <ul style="list-style-type: none"> <li>• Impractical</li> <li>• Extravagance</li> <li>• long-sightedness</li> </ul>	
Large handwriting	<ul style="list-style-type: none"> <li>• Attention-seeker</li> <li>• Extrovert</li> <li>• Socially active</li> <li>• Loud</li> <li>• Big planner</li> <li>• Luxurious</li> <li>• Self-centred</li> </ul>	
Medium size	<ul style="list-style-type: none"> <li>• neither extrovert nor introvert</li> <li>• socially active</li> <li>• average concentrators</li> </ul>	
Small size	<ul style="list-style-type: none"> <li>• Introvert</li> <li>• Good concentrators</li> <li>• May have low self-esteem</li> </ul>	
Overly small	<ul style="list-style-type: none"> <li>• Deep thinker</li> <li>• Extremely introverted</li> <li>• Great IQ level</li> </ul>	

**Table 4: Different Sizes and characteristics**

## 2.6 Word Spacing and Line spacing-

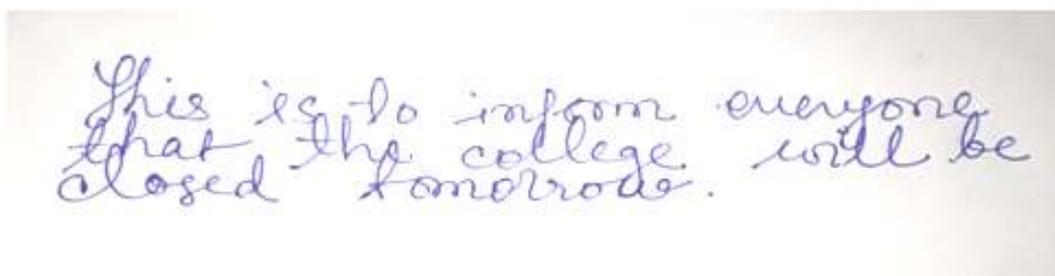
**2.6.1 Word Spacing-** It indicates the distance that the writer wishes to maintain with the society as well as emotional comfort with others and territorial boundaries [5]. In Table 5 detailed explanation of word spacing is shown.

Spacing between words	Characteristics	Example
Narrow spacing	<ul style="list-style-type: none"> <li>• self-interested</li> <li>• Attention-craver</li> <li>• Egoist.</li> </ul>	
Very wide spacing	<p>Writer maintains his distance from the society and surroundings, this may be either due to an inner need for privacy or to a tendency toward isolation or sometimes compelled by difficulty in communicating with others.</p>	

**Table 5: Word spacing and characteristics**

**2.6.2 Line Spacing-** Consistent and moderate line spacing signifies that the person is well organised and have clear thinking. The writer also maintains a moderate interaction with the surroundings as well as has harmony and flexibility in personal life.

If the writing is more crowded and tangled, the writer's thoughts and feelings are considered to be confused. The inner pressure of many emotional reactions put this type of individual in constant need of expressing himself in words, actions, projects etc. Such writers are characterized as lively, forceful, and often creative, besides these they can suffer from a lack of clarity of purpose or from jumbled ideas and poor concentration. Machine-like placement of letters, words, and lines on the page indicates conscious control on the part of a writer who is in fear of losing control in the society or surroundings. The person usually hides behind the carefully arrangement of “beautiful” letter forms and well planned spaces [5]. In Figure 6, tangled and crowded line spacing sample is shown.



**Figure 6: Tangled and Crowded Line Spacing**

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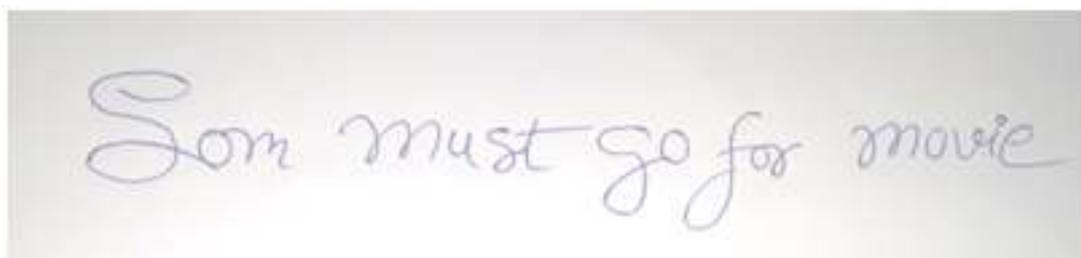
**2.7 Connections-** The connective pattern or form in a person’s handwriting is a significant feature that interprets certain characteristics of an individual. In order to study an individual’s handwriting, there are four common connective forms. They are as follows:

**2.7.1 Garlands-** The most common type of connection between letters is the cup shape of the garland which is curved at the bottom and opens at the top. It can be found in all three zones as well as in between letters, within letters, even at the beginnings and endings of words. The garland is a soft, easily stroked connection that describes whether the writer is “people oriented” or friendly, affectionate and flexible [4]. Figure 7 shows a typical sample of a garland.

The image shows the sentence "I have a younger sister" written in a cursive script. The letters are connected in a way that forms a cup-like shape at the bottom, which is characteristic of a garland connection. The connections are soft and fluid, typical of a friendly or affectionate personality.

**Figure 7: Garlands**

**2.7.2 Arcades-** The inverted garland is termed as arcade, shown in Figure 8. Basically it is a shape like an arch curved on top and open at the bottom. In the alphabet m, n, s and h have the most obvious arcade formations. The writers with this feature in their handwriting have both positive and negative qualities. Its positive qualities include politeness, formality, and perfection while its negative qualities include insincerity, liar or fraud [4]. They can be considered as constructive thinker. They establish a connection with others but may lack natural interaction and so they hardly disclose themselves.

The image shows the sentence "Som must go for movie" written in a cursive script. The letters are connected in a way that forms an inverted arch shape at the top, which is characteristic of an arcade connection. The connections are sharp and angular, typical of a formal or perfectionist personality.

**Figure 8: Arcades**

**2.7.3Angles-** Many writers invest energy while writing fast that often produces abrupt changes of direction creating an angle at the baseline and sometimes at the top of the letter, shown in Figure 9. This makes a sudden change of direction as well as a pause before the writing can start. An angle basically interrupts smooth flow of thought and action, these results in an abrupt manner. They usually view multiple approaches to solve any problem. Writers who use angles are generally aggressive and stubborn, competitive, determined, sharp-minded and are serious towards their work. They try to impose their views on others instead of getting influenced by others. They don’t deviate from their objective. However there are some tension, determination, and steadfastness within them. Its positive qualities include masculine traits, awareness and facing of conflict, objectivity, reliability, and hardworking, while its negative qualities include resistant to others’ ideas or wishes, tenseness, hardness and sharpness, cruelty and lack of compromise, and such people are sadist [4].

sharp and straight

**Figure 9: Angles**

**2.7.4 Threading-** Thread writing or wavy writing is one of the most commonly used connection techniques in English, shown in Figure 10. An individual may use threading due to tiredness, fatigue, sadness, impractical, inconsiderate, laziness or may be just being unaware of the spelling. When the writer is tired get unable to invest energy for the sake of proper writing, so the writer must seek minimum friction with pen. These people manifest their tiredness as they write or from the beginning to the end. It may be also due to the fact that one does not want others to decipher the content of writing. In this case the person considered to be evasive and sneaky and not truthful [4].

apparently

**Figure 10: Threading**

**2.8 Characteristics of the letters f, i and t-**

The letter f represents the planning ability and organization of a person. The formation of letter ‘i’ provides sufficient accurate information about the writer. The ‘i’ is the only letter in English Language that refers solely to the writer [2][4]. Table 6 shows some common types of the letter ‘f’ with their features. Similarly Table 7 shows some common types of the letter ‘i’ with their features.

Formation of f	Features	Example
Narrow upper loop	Mean-minded	
Angular Point	Uncompromising	
Angular Loop	Aggressive when someone interferes	
Cross form	Concentrated	
Balanced	Well organised	

**Table 6: Different types of ‘f’ and its characteristics**

Formation of i	Features	Example
High, Flying dot	Attention seeker, impatient, enthusiast.	
Round, justly placed dot	Conscious and concentrated.	
Absence of dot	Casual and careless.	
Circle	Attention seeker, disturbed, hatred for monotony, artistic.	
Left-faced dot	Neurotic	
Right-faced dot	Attentive	

**Table 7: Different types of ‘i’ and its characteristics**

The lower case letter ‘t’ in an individual’s handwriting resembles a lot of natures of that person in a pretty good accuracy. There are different ways by which people write the lower case letter ‘t’, by writing the stem, doing the t bar as well as entry and exit of the letter. This interprets a specific personality trait of a person [4]. The letter ‘t’ is shown in Table 8.

Position of t-bar	Characteristics	Example
Wavy bar	<ul style="list-style-type: none"> <li>fast and intuitive mind</li> <li>good nature</li> </ul>	
Crossed above the middle zone but not at the loop	<ul style="list-style-type: none"> <li>Moderate self esteem</li> <li>Practical</li> <li>Most commonly found</li> </ul>	
Crossed very low on the Stem	<ul style="list-style-type: none"> <li>Low self esteem</li> <li>Lack of confidence</li> <li>Orthodox</li> </ul>	
Crossed above the stem	<ul style="list-style-type: none"> <li>Impractical</li> <li>Speaks a lot instead of doing</li> </ul>	
Heavy Descending T-bars	<ul style="list-style-type: none"> <li>Bossy nature</li> <li>Violent force.</li> </ul>	
Clubbing in T-bars	Force of will is hostile and aggressive.	
Absence of t bar	Careless	

**Table 8: Different types of ‘t’ and its characteristics**

### 3. Existing Methodology

Over the years numerous graphologists carried out many researches to identify and categorize human behaviour and distinguish quality or characteristics by analysing individual’s handwriting. However, manual analysis of handwritten text is a tedious job. Hence researches proposed computerized system where digitised version of handwritten text is fed to an automated tool to achieve desired result. Several Machine Learning techniques like ANN and k-NN [2][3] have been proposed by researchers to speed up the process of accurate recognition. However it has been observed that all the handwriting features, its variations and other factors that play a vital role in determination of personality traits could not be covered completely by the above mentioned techniques. Most papers worked with the more prominent features like baseline, slant, pen pressure and types of characters like ‘f’, ‘i’, ‘t’.

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### 3.1 Measuring Techniques

Some of the standard features measuring techniques used are as follows:

- i. **Polygonalization**– This technique is mostly used to measure baseline. A closed polygon is drawn around the lines in the scanned image of a sample handwritten text [3]. The slope which is found using the coordinates of the polygon helps to determine baseline. It is also used to determine letter slant [7].
- ii. **Thresholding**- This technique helps to determine pen pressure. Thresholding is performed by first scanning an input image and converting into binary image. Grey level pixel values in the image that are below a particular threshold are assigned to pure black (denoted as foreground pixels) and those above the threshold are assigned to pure white(denoted as background pixels). This threshold value which is obtained using grey level histogram partitions the foreground and background of the grey level image. This threshold value denotes pen-pressure, higher the threshold value, lower the pressure. Pen pressure also measured by thinness or thickness of stroke [7].
- iii. **Template Matching**- This method is used for identification of extracted character by matching them with template images. This matching is done using correlation, Hamming distance (finding number of substitutions required to map an extracted character with that of a matching template) [7].
- iv. **Slant Measuring** - Here, vertical lines are drawn through every letter, between the letter's lowermost and uppermost point. Slope of line gives the slant for that particular letter. An average of all the slopes gives the slant of the entire writing. In paper [1], the angle formed between the letter (down stroke) and the baseline is calculated for measuring slant. Template matching and concept of hamming distance can also be used to determine character slant [7].

### 3.2 Classification Techniques

After measuring the features, the Feature Vector Matrix is formed which is the mathematical representation of a sample handwritten text in the form of identified feature vectors [3].

A separate class is created for each feature or characteristic corresponding to a particular trait based on analysis by graphologist. Machine Learning techniques are used to train database by feeding it with various sample handwriting and their corresponding Feature Vector Matrix. This trains the system with various template images. A supervised machine learning algorithm helps to map new samples to existing pre-specified classes of personality traits.

In [3], it is seen that whenever new sample handwriting is fed to the system for analysis, first its Feature Vector Matrix is created and using similarity matrix method, its similarity with the trained dataset is calculated. k-NN (k-nearest neighbourhood) Classifier or ANN (Artificial Neural Network) are used to map the sample handwriting to the most appropriate class possible. The result produced is fed back to the training dataset for continuous up gradation on the learning improving accuracy for future predictions.

However, it is found that often sample handwriting includes mixture of two or more writing styles. To classify such handwriting combination of different features is needed. Here, Artificial Neural Network comes into play which considers different combinations of traits which are analysed to predict personality. Some Rule-base formulation, i.e. If-then rules is applied to check and combine different parameters and their values to satisfy a particular trait.

In paper [2], some selected features are evaluated and during pre-processing, values are assigned to them. All these values are fed to the ANN. The learning algorithm used is standard back propagation algorithm and the neural network used is Feed Forward Network.

### 3.3 Framework

A fully automated tool for Handwriting Analysis requires a sequence of steps to be followed. To make good analysis, a system should be provided with diverse sample handwriting dataset. Information from handwriting greatly varies based on different categories. When a system is trained with sample handwriting belonging to varied age group, gender, handedness, profession, demography, etc, the database becomes rich for further analysis purpose. Scanned images from handwriting sample are generally fed to the system as input. Several pre-processing tasks need to be performed on the scanned images which prepare the image for further segmentation and feature extraction. Features once extracted are evaluated by the system using Machine Learning techniques and classified based on the system's trained dataset. A flow diagram of the proposed system is shown in Figure 11.

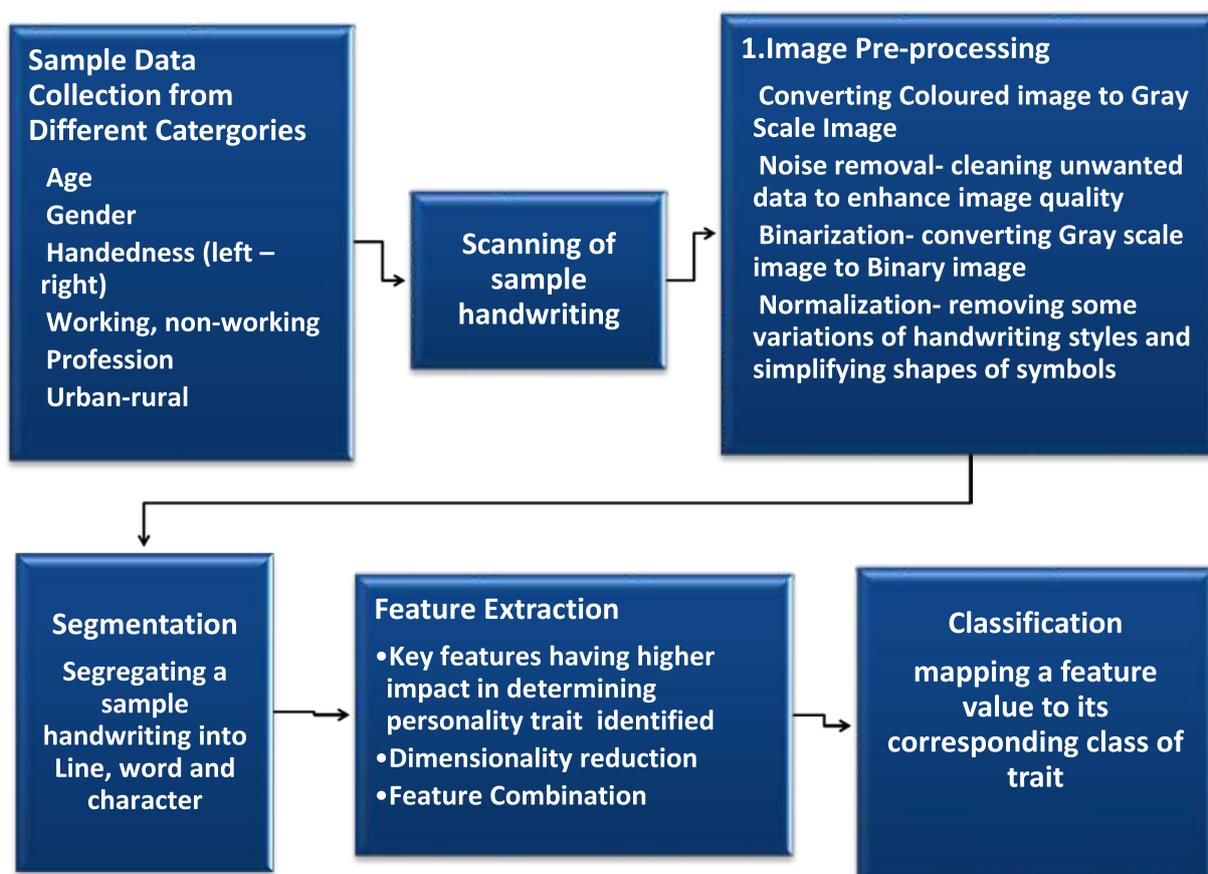


Figure 11: Flow Diagram of Automated Handwriting Analysis Tool

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#### 4. Conclusion and Future Scope

Graphologists can recognise human behaviour by analysing the features and characteristics of individual's handwriting. However, the inaccuracy made by human beings can be overcome with the help of an automated tool which can detect human behavioural aspects accurately and more efficiently. Handwriting analysis has a great impact on different areas of the society. It can be used to recognise a person with lying tendency, to measure individual's honesty as well as to identify depressed people with suicidal tendency [4]. Moreover it can be used in medical diagnosis, psychology, forensic studies and many more.

The automated system should work accurately irrespective of any languages and should work on both online and offline mode. An individual may have multiple characteristics against the same feature. So the system must be designed to act accordingly handle multiple characteristics of the same feature. All possible features like styles (cursive, printed pattern writing), speed, strokes, etc. need to be incorporated in implementing the system in order to achieve 100% accuracy.

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