

# Differentiability of Inverse Matrices

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## 1. INTRODUCTION

Consider a  $m \times m$  matrix  $A$  consisting of elements  $a_{ij}$  as independent variables. Let  $f(A)$  be a  $l \times l$  non-singular matrix with its elements as functions of  $a_{ij}$ . Okamoto (1), Memon and Okamoto (2), and Siotani (3) evaluate the effects of differential operator  $\partial/\partial a_{ij}$  on some matrices  $f^{-1}(A)$  at  $A = I_{(m)}$ ,  $m \times m$  identity matrix, for purpose of obtaining asymptotic expansions of certain probability distributions. Normally one inverts a matrix before applying differential operator. This paper proposes a method to deal with problems of this nature without inverting matrices. Some illustrations for use in multivariate statistical analysis are given.

## 2. NOTATIONS

For convenience we write  $f_{i_{23} \dots n}$  to indicate the functions  $f(A)$  effected by first, second,  $\dots$ ,  $n$ th differential operator  $\partial/\partial a_{ij}$  no matter what  $i, j$  may be in each operator. For  $n_i \geq 1$  of  $n$  operators,  $x(n_i)$  denotes  $n_i$  operators following above order.  $F_r$  and  $F_r^{-1}$  are the values of  $f_r(A)$  and  $f_r^{-1}(A)$  at  $A = I_{(m)}$  respectively.

## 3. THEOREM

If  $f(I_{(m)}) = I_{(l)}$  and the derivatives involved in the following expression exist, then

$$F_{i_{23} \dots n}^{-1} = \sum_{p=1}^n (-1)^p \sum_{n_1, n_2, \dots, n_p} F_{x(n_1)} F_{x(n_2)} \dots F_{x(n_p)}$$

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where the sum  $\sum_{n_1, n_2, \dots, n_p}$  extends over all possible partitions  $x(n_1), x(n_2), \dots, x(n_p)$  of  $n$  operators,  $n_i$ s varying such that

$$\sum_{i=1}^p n_i = n.$$

*Proof:* Using the first operator on  $f(A)$   $f^{-1}(A) = I_{(l)}$  and then substituting  $A = I_{(m)}$ , we get

$$F_1^{-1} = (-1)F_1. \quad (1)$$

Applying now the second operator on  $f_1^{-1}(A) = -f^{-1}(A)f_1(A)f^{-1}(A)$  and using (1), we have

$$F_{12}^{-1} = (-1)^2(F_1F_2 + F_2F_1) + (-1)F_{12}. \quad (2)$$

Similarly,

$$\begin{aligned} F_{123}^{-1} = & (-1)^3(F_1F_2F_3 + F_1F_3F_2 + F_2F_1F_3 \\ & + F_2F_3F_1 + F_3F_1F_2 + F_3F_2F_1) + (-1)^2[(F_{12}F_3 \\ & + F_{13}F_2 + F_{23}F_1) + (F_1F_{23} + F_2F_{13} + F_3F_{12})] \\ & + (-1)F_{123}. \end{aligned} \quad (3)$$

Continuing above, by induction we obtain the result.

*Corollary.* If  $f_{ij}(A)$  is a zero matrix for all  $i, j$  then

$$F_{i_{23} \dots n}^{-1} = (-1)^n \sum_{\underline{n}} F_1 F_2 \dots F_n$$

where the sum  $\sum_{\underline{n}}$  is over all  $\underline{n}$  permutations.

*Applications.* Some functions of covariance matrix  $A$  appearing in multivariate statistical analysis (1), (2) and (3) are considered below to illustrate the use of above theorem.

(i) Let us find the effect of  $\frac{1}{2}(1 + \delta_{rs}) \partial/\partial a_{rs}$  on

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- e. Have five years of experience in accounting or a graduate degree in accounting which required four years of study (Articles 24, 26 and 28).

Accountants who have Bachelor degrees in accounting without experience and intend to practice professional accounting may be registered in the list of working assistant accountants. During the first two years, working assistant accountants can practice the profession by joining a firm of working accountants. After two years of experience the working assistant accountant has the right to practice the profession for his own subject to some limitations. Other registered accountants who have Bachelor degrees in accounting without experience and not intending to practice the profession are listed in the register of non-working assistant accountants (Article 27, 36 and 37).

3. Members of the Organization of Libyan Accountants and Auditors cannot combine their practice of the accounting profession with the following activities:

- a. Any public service unless a permission is granted.
- b. Commercial business.
- c. Any activities contrary to the integrity of the profession (Article 25).

4. Non-Libyans cannot establish their own public accounting firms in Libya. All existing branches of foreign accounting firms in Libya had to terminate their practices within one year from the enforcement of Law No. 116 of 1973 (Articles 23 and 71).

5. All members of the Organization of Libyan Accountants and Auditors should undertake all obligations that may be imposed on them by law and the ethics of the profession. However, a professional code of ethics has not yet been established (Article 49).

6. It is illegal for the members of the Organization to use advertising techniques or utilize mediators in order to practice the accounting profession in Libya.

In conclusion, Law No. 116 of 1973 enhanced the development of Libyan accounting

profession substantially. The Libyan public accounting firms have been increased in number and size. The Organization of Libyan Accountants and Auditors was established and many of the Libyan accountants applied for registration in this organization. By the end of the summer of 1976, there were 71 working accountants, 6 working assistant accountants, 32 non-working accountants and 34 non-working assistant accountants. Most of the working accountants are practicing the profession in their own accounting firms employing other non-Libyan accountants mainly from Egypt.

## 6. CONCLUSION

The Libyan authorities, like other nations of today, has been modifying many aspects of life by enacting laws and regulations that would satisfy the country's changing needs. The Libyan Commercial Code, the Income Tax Law, Law No. 116 of 1973 regulating the accounting profession, and petroleum regulations had a major impact upon many aspects of accounting in Libya. In addition, compliance with these laws and regulations encouraged Libyans to keep proper accounting records and increased their needs for professional accounting services.

Judging by characteristics of the well-established professions, one can say that accounting as a profession in Libya is a new-comer. The profession is still in a developing stage and needs many improvements. Law No. 116 of 1973 was the first attempt to organize the public accounting profession in Libya and to establish the Organization of Libyan Accountants and Auditors. However, little has been done by this organization for professional development. The Libyan chartered accountants remain without a code of ethics. There are no professional developments in the areas of accounting standards, auditing standards and training programs. Perhaps the time has come to direct the organization's efforts toward the accomplishment of its professional objectives.

2. Every company should submit to the Libyan Secretary of Petroleum at the end of each year a statement including the general program it intends to carry out during the following year.

3. Every company must keep accurate financial records to be open for inspection by the Libyan petroleum authorities.

4. Geological and geophysical documents related to the land within the concession area must be kept accurately by each company.

5. Whenever oil or gas is discovered, a report must immediately be sent to the Libyan Secretary of Petroleum.

6. Every company must submit every year to the Libyan petroleum authorities the following financial reports:

- a. Balance sheet as of December 31 from each year and related detailed schedules.
- b. Profit and loss account for each year.
- c. Public accountant's audit certificate.<sup>26</sup>

In general, the Libyan Petroleum Law and regulations have a major impact upon the development of accounting in Libya. Many good accounting practices applied by the Libyan Petroleum Companies were established by these legislations. The ideas of consistency and accounting period were introduced to the literature of accounting in Libya. In addition, the application of these laws and regulations increased the need for the services of public accountants in Libya.

## 5. THE REGULATION OF THE ACCOUNTING PROFESSION

Law No. 116 of 1973 was the first legislation to regulate the accounting profession in Libya. This law was divided into eight chapters: (1) the Establishment of the Organization of Libyan Accountants and Auditors, (2) Registration of Accountants, (3) Exercise

of the Profession, (4) Fees, (5) Pension and Contribution Fund, (6) Obligation of Accountants and Auditors, (7) Penalties, and (8) General and Transitional Provisions.

A general review into Law No. 116 of 1973 reveals that the most significant development in the accounting profession was the establishment of the Organization of Libyan Accountants and Auditors. Specifically, the most important features of this law are as follows:<sup>27</sup>

1. The Organization of Libyan Accountants and Auditors should be established to accomplish the following objectives:

- a. To organize and develop all matters related to the accounting profession, and to enhance the professional ability of its members.
- b. To hold conferences and seminars, to follow up the progress in the field of accounting, and to carry out educational and training programs.
- c. To establish for its members a retirement pension fund.
- d. To increase cooperation between its members, reserve their rights, and defend their legitimate interests.
- e. To take action against members who violate the traditions of the profession (Article 3).

2. Members of the Organization are classified into two lists of working and non-working accountants. Each group is further divided into accountants and assistant accountants. Any accountant who wants to be registered in the list of working accountants must:

- a. Be a Libyan.
- b. Have a Bachelor degree in accounting.
- c. Be enjoying his political and civil rights.
- d. Have a good conduct, reputation and respectability required for the profession.

<sup>26</sup> *The Libyan Petroleum Law No. 25 of 1955 as amended through Feb. 12, 1970. Clause 20, The second Schedule*, pp. 44–45. Also, *The Unified Financial Declaration for the Libyan Petroleum Companies*, op. cit., p. 3.

<sup>27</sup> The following section is based on The Libyan Secretary of Justice, *Al-Jaridah Arrasmiah "The Official Gazette, Law No. 116 of 1973 to organize the Accounting Profession in Libya* (No. 7: February 1974), pp. 251–268.

any year shall not be less than 55 percent of his annual profit. The holder should pay a surtax to the Libyan Authorities in cases where his total payments were lower than 55 percent of his annual profit. In cases where a concession holder's payment exceeds 55 percent of his profit he will be entitled to deduct such excess from any payments in the following years (Article 14).

According to the Libyan Petroleum Law, the Secretary of Petroleum or any other appropriate Secretary has the right to issue additional regulations needed for the implementation of this law. Nine regulations were enacted through August 1973. They cover many important matters concerning the oil industry in Libya, such as: (1) petroleum zones, application for permits, and consideration of these applications; (2) assessment and payment of rents, taxes and royalties; (3) utilization of pipeline facilities; (4) determination of operating expenses and overheads; (5) exploration and production procedures; (6) storage and transportation; (7) safety of employees; (8) posted prices; (9) conservation of petroleum resources; and (10) financial and administrative matters.

The petroleum law and regulations have significant inputs in the practice of accounting in Libya. A great deal of the petroleum accounting practices are developed by the Libyan petroleum legislations. In addition, oil companies are required by law to maintain and furnish for the Libyan state a number of accounting reports and records.

Profits for any oil company are defined to mean all incomes resulting from its operations in Libya after deducting the following elements:

1. Operating expenses and overheads, the details of which are defined in the Libyan Petroleum Regulations. Examples of these items are salaries, usual costs of maintaining and repairing assets, fees, rents, royalties, travelling expenses, insurance premiums, costs of welfare and educational activities and any other expenses which are approved

by the Libyan petroleum authorities before expending.<sup>22</sup>

2. Depreciation of all physical assets in Libya at the rate of 10 percent and amortization of all other capital expenditures at the rate of 5 percent on straightline basis. The undepreciated balances of physical assets permanently put out of use may be charged against income in the year in which such assets are scrapped or sold.

3. Twelve and one-half percent of the value of crude oil exported calculated on the basis of current posted prices.<sup>23</sup>

In addition to the above requirements, the Libyan Petroleum Law and regulations provide that sound accounting practices widely used in the oil industry should be adopted by the Libyan Petroleum companies on a consistent basis. Whenever more than one accounting practice prevails the Libyan petroleum authorities have the right to decide which practice is to be applied by the petroleum companies.<sup>24</sup>

Petroleum companies working in Libya are required to keep and submit to the Libyan petroleum authorities certain financial records and reports. Most of these documents must be in particular forms as specified in the Unified Financial Declaration published by the Libyan Secretary of Petroleum.<sup>25</sup> These records and reports include the following:

1. Every company must furnish to the Libyan Secretary of Petroleum during the first quarter of each year a report concerning the progress of operation in its concession area during the preceding year.

<sup>22</sup> *The Libyan Petroleum Law No. 25 of 1955* as amended through February 12, 1970 (Article 14 and supporting clauses No. 7 and 8). Also Regulation No. 9, on Financial, Administrative and Technical Control for the Preservation of Petroleum Wealth, pp. 8-11.

<sup>23</sup> *The Libyan Petroleum Law No. 25 of 1955* as amended through February 12, 1970 (Article 14).

<sup>24</sup> *Ibid.*

<sup>25</sup> For a complete description of the financial forms and reports see *The Libyan Secretary of Petroleum, The Unified Financial Declaration for the Libyan Petroleum Companies* (Tripoli: Secretary of Petroleum).

- c. Every individual responsible for the management of business firms who fails to keep the accounting books and records required by law is liable to a maximum fine of 1,000 Libyan dinars.
  - d. Anyone who prepares untrue accounts, books, reports, or balance sheets is subject to imprisonment for one year, a fine of 500 Libyan dinars, or both penalties. In addition, a compensation equivalent to three times the unpaid tax should be paid by the liable person to the tax department.
2. The increasing emphasis on taxation as a state tool for financing and the increasing efforts to stop tax evasion have resulted in an increase in the demand for professional accounting services. Reasons may be outlined as follows:
- a. Many taxpayers do not understand how to prepare their income tax returns in accordance with the Libyan Income Tax Law.
  - b. In order to avoid income tax assessment on the bases of estimation, taxpayers turn to professional accountants for help in maintaining proper accounting records.
  - c. Tax returns and financial statements audited by chartered accountants usually are acceptable by tax officials without any significant delay.

#### 4. THE INFLUENCE OF THE PETROLEUM LAW AND REGULATIONS<sup>21</sup>

The Libyan Petroleum Law was enacted in 1955, and has been amended several times to satisfy the changing social, economical and political environment of the country. This law includes 25 articles providing provisions for many aspects of the oil industry in Libya. The first article of this law states that all petroleum in Libya in its natural condi-

tion is the property of the Libyan State. No person can explore, mine or produce petroleum in any part of the country unless authorized by a permit or concession issued under the Libyan Petroleum Law. Matters in relation to granting and cancelation of concession agreements must be submitted by the Secretary of Petroleum to the General Popular Committee for study and making a final decision (Articles 1 and 2). Eligible applications are only considered for granting permits or concessions. In determining the eligibility of any applicant the Secretary of Petroleum usually take into account the following matters (Article 5):

1. The furtherance of the public interest.
2. The applicant's compliance with relevant Libyan laws and regulations.
3. The applicant's previous operations in the petroleum field.
4. The applicant's experience in the conduct of similar operations.
5. The applicant's technical and financial ability to explore and develop the granted concession.

As far as fees, rents and royalties are concerned, the holder of any petroleum concession must pay the Libyan state the following:

1. An initial fee of 100 Libyan dinars for each 100 square kilometers upon the grant of the concession.
2. An annual rent up to 5,000 Libyan dinars to be determined on the basis of geographical zone, age of the concession, and exploration of oil in commercial quantities.
3. A royalty of 12.5 percent of the value of the total field production (on the basis of posted prices) after deduction of any quantities used by the concession holder in conducting his operations in Libya (Article 13).

In applying the above rules, the total annual amount of rents, royalties and any other taxes paid by a concession holder in

<sup>21</sup>This section based on the Libyan Petroleum Law No. 25 of 1955 as Amended through February 12, 1970; and the Libyan Petroleum Regulations as Amended through August 12, 1973.

panies; (5) Penalties; and (6) Final Provisions.<sup>16</sup>

In the absence of an organized accounting profession, the Income Tax Law has a significant impact upon the practice of accounting in Libya. It appears that many business firms incorporated tax regulations as well as LCC requirements in the external financial reporting.

According to the present Income Tax Law No. 64 of 1973, taxable income for any business enterprise is considered to be that income resulted from operation of taxpayer after deducting all costs proved to be actually expended for the sake of obtaining such income. In addition, the gains arising from the sale of the activity or any single asset should be considered a taxable income. In this way the Libyan tax regulation does not include any explanation in association with terms such as income before extraordinary items, income after extraordinary items, income from continuing operations and income from discontinuing operations.<sup>17</sup>

A general review of the Libyan Income Tax Law reveals that particular items may be deducted from income for the income tax purpose. These items include the following:

1. Depreciation of all assets utilized in producing the income at a fixed annual rate specified for each group of assets.
2. Bad debts.
3. Premiums paid in interest of the employees under the social security system. Deductions should not exceed 10 percent of total benefits received by employees during the taxable year.
4. Taxes and fees paid by the taxpayer in relation to his activities other than taxes imposed by this law.
5. Donations made to charities not exceeding two percent of the annual net income.

6. Amortization of organization costs on straightline base.<sup>18</sup>

Amounts which are not charged to annual income should not be deducted from the taxable income. Particular items of this kind are as follows:

1. Amounts expended on increasing or improving the assets in a permanent manner.
2. Personal and family expenses.
3. Amounts withheld by the taxpayer as a reward for his work or the work of his wife and minor children.
4. Reserves to face losses of future decline in prices or any other obligations dependent upon certain future conditions.<sup>19</sup>

Whenever a taxpayer suffers a loss during any taxable year, such loss shall be included in the expenses of the subsequent year and deducted from its profits. If the profit is not sufficient to cover the loss entirely, the balance may be carried forward for a maximum time of five years.<sup>20</sup>

A general investigation into the Libyan Income Tax Law reveals that in addition to its impact upon the Libyan accounting practices, the law has other contributions in the development of accounting and accounting profession in Libya. Some of the most important contributions may be summarized as follows:

1. The tax law encourage Libyan taxpayers to keep proper accounting records for the following reasons:
  - a. Whenever there are no proper accounting records taxable income can be overestimated by tax officials.
  - b. Complaints about tax assessments based on estimates are not accepted from any business firm without supporting proper books and accounting records.

<sup>16</sup>This section based on the Law No. 64 of 1973, *Issuing the Income Tax Law* (Tripoli: Dar Al-Fikr Library), pp. 3-60.

<sup>17</sup>*Ibid.* (Articles 55 and 65).

<sup>18</sup>The Libyan Income Tax Law No. 64 of 1973 (Articles 55 and 56).

<sup>19</sup>*Ibid.* (Article 57).

<sup>20</sup>*Ibid.* (Article 59).

is purchased. When recorded, the purchased goodwill should be amortized in subsequent years by a suitable amount estimated by the directors and the boards of auditors.<sup>8</sup>

*Legal Reserve.* The Libyan Commercial Code requires that five percent of the annual net profit for every corporation must be retained as legal reserve. However, legal reserves cannot go beyond one-fifth of the capital of any corporation.<sup>9</sup>

*Invested Capital.* According to the provisions of the Libyan Commercial Code, the legal capital of any corporation may be increased or decreased in accordance with some conditions. New shares cannot be issued until those which have been issued are fully paid. Capital may be increased by transferring the surplus of reserves to capital and distributing stock dividends among shareholders in proportion to the number of old shares held by them.<sup>10</sup>

The invested capital of any corporation may be decreased in cases where capital exceeds the needs of the company or the company suffered an accumulated loss of more than one-third of the legal capital. In both cases, the action must be approved by the general assembly of the shareholders or by a court decision. However, creditors have the right to object to capital reduction through the courts.<sup>11</sup>

*Distribution of Profits.* The Libyan Commercial Code provides that founding members of a corporation may participate in the annual net profits for a maximum time of five years. In all cases profits distributed to founders and directors should not exceed ten percent of annual net profits after deduction of legal reserves. The rest of the annual net profits is distributed among the shareholders.<sup>12</sup>

### 3. THE INFLUENCE OF THE INCOME TAX LAW

Income tax laws in Libya were introduced for the first time by the Italian colonization in 1923. As the Central Bank of Libya put it in one of its economic bulletins:

*Libya witnessed this type of financial obligation for the first time in its history in 1923. The Italian government introduced this tax (applied in Italy during that period) first in Tripolitania by the provincial decree No. 501 - collection (a) issued on the 26th May, 1923, after Tripolitania had been divided into three regions for tax purposes . . .*<sup>13</sup>

In 1937 income tax was introduced in Cyrenaica and the Italian laws of taxation were modified to meet the special needs and conditions of the economic environment in Libya. In 1952, the first Libyan government revised all tax laws and a new tax law for Cyrenaica was promulgated. Fezzan in the south also had its first income tax law in 1953.<sup>14</sup>

In this way, different tax law originally exported from Italy, existed throughout the country. Abolition of these uncoordinated weak laws and promulgations of one unified code of taxation for the whole of Libya became an urgent necessity. Therefore, the first unified Libyan income tax law was enacted in 1968.<sup>15</sup>

The present Income Tax Law No. 64 of 1973 was enacted on September 19, 1973 to nullify the old Income Law No. 21 of 1968. The new law consists of six parts (130 articles): (1) General Provisions; (2) Specific Tax; (3) General Tax on Income; (4) Tax on Com-

<sup>13</sup>Central Bank of Libya, *Economic Bulletin* Sept.-Dec. 1971, p. 154.

<sup>14</sup>Mohammed Ghobashy, "Some Aspects of the Structure of Taxation in Libya," *The Libyan Economic and Business Review* 2 (Autumn 1966): 93.

<sup>15</sup>For an interesting analysis for some aspects of the 1968 Income Tax Law see Misbah Oreibi, "The New Income Tax," *The Libyan Economic and Business Review* 5 (Spring 1969): 43-56.

<sup>8</sup>*Ibid.* (Articles 574, 575 and 576).

<sup>9</sup>*Ibid.* (Article 577).

<sup>10</sup>*Ibid.* (Articles 586 and 590).

<sup>11</sup>*Ibid.* (Articles 593 and 594).

<sup>12</sup>*Ibid.* (Articles 496, 579, and 581).



## 2. THE INFLUENCE OF THE COMMERCIAL CODE<sup>3</sup>

The Libyan Commercial Code was enacted on November 28, 1953 and has been amended partially from time to time in order to satisfy the changed needs of the society. This code consists of seven books: (1) Merchants and Commercial Activities; (2) Commercial Contracts; (3) Banking Transactions; (4) Negotiable Instruments (Bonds); (5) Commercial papers; (6) Commercial Companies; and (7) Bankruptcy and Its Preventive Procedures.

The Libyan Commercial Code has a major impact upon many aspects of accounting in Libya. In some of its parts the Code discusses matters of accounting such as accounting records, valuation of assets and liabilities, legal reserves, invested capital and the distribution of profits.

*Accounting Records.* According to the first book of the Libyan Commercial Code every businessman must keep at least the following records:

1. The Journal: This book should include all daily transactions related in any way to the enterprise business activities.
2. The Inventory and the Balance Sheet Book: This book must include an annual inventory list; a profit and loss account and a balance sheet.<sup>4</sup>
3. Files: Every business enterprise must maintain in special files copies from letters and telegrams received or sent out in relation to conducting its business activities.<sup>5</sup>

All these books and files must be kept free from blank spaces, marginal notes, erasures and insertions between the lines. Before entries are made pages of the two account-

ing books must be numbered and signed by an official from the Court of First Instance. Books and files also must be preserved in good order for a period not less than five years after their current year.<sup>6</sup>

In addition to maintaining the above books and files each business in the form of a corporation is required to keep the following records: (1) register of shareholders; (2) register of bonds; (3) register of minutes of the general meetings; (4) register of minutes of the directors' meetings; (5) register of minutes of the board of auditors; (6) register of minutes of the executive committee's meetings; and (7) register of minutes of the bondholders' meetings.<sup>7</sup>

*Valuation Rules.* According to the Libyan Commercial Code every corporation has to follow specific rules in the valuation of its assets and liabilities. Whenever these valuation rules cannot be followed reasons should be disclosed in the annual report for the shareholders. Some of the important valuation rules are as follows:

1. Fixed assets must be valued at original cost, and each financial year the value must be reduced by related depreciation for that year. The accumulated depreciation should be reported as a liability.
2. Inventory should be valued at the "lower of cost or market" rule.
3. Trade marks shall not be valued higher than their cost or purchase price. The value of these assets are amortized each financial year in accordance with their useful life.
4. Debts should be valued at their estimated realizable value.
5. Organization and development costs may be capitalized with the consent of the board of directors. In this case, the capitalized values should be amortized in a period not exceeding five years.
6. Goodwill cannot be recorded unless it

<sup>3</sup>This section based on *The Libyan Commercial Code of 1953* (Tripoli: Dar Al-Fikr Library, 1972), pp. 5-396.

<sup>4</sup>*Ibid.* (Article 58).

<sup>5</sup>*Ibid.* (Article 59).

<sup>6</sup>*Ibid.* (Articles 60 and 64).

<sup>7</sup>*Ibid.* (Article 57).